Global Text

Information Technology for Management

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To Scott and Jonathan

PREFACE

TO THE STUDENT

Information technology surrounds you—on your campus and in local businesses. When you order merchandise over the telephone, chances are your sales representative is using an information system to check inventory and to trigger the shipment of your goods. Increasingly you will order products using the Internet, dispensing with the telephone and becoming a participant in electronic commerce. When you use an automatic teller machine, make an airline reservation, or rent a car, information technology (IT) is working for you again.

Information technology is pervasive in modern organizations—from the largest manufacturing firms to your corner drugstore, and the stakes are high, as businesses confronted with global competition strive to succeed. Some organizations will flourish; others will fail. Those that succeed will understand how to use and manage information technology to their advantage.

The purpose of *Information Technology for Management, Seventh Edition,* is to help you learn enough about technology to play an active role in managing information technology. It is important to understand the strategic uses of IT and how to apply technology when developing a corporate strategy. You will see how creative organizations have integrated technology with strategy, allowing them to gain and sustain a competitive advantage. What role does the Internet play for your firm? What are the advantages your business can obtain from implementing Intranets and Extranets? How does technology facilitate the operations of global firms?

You will also see how to use information technology to transform the organization and to create new lines of business and new relationships with other firms. The text stresses how you as a manager can use information technology-enabled organizational design variables to create new organizational structures, including the T-Form firm. This new structure takes advantage of electronic communications and linking, technological matrixing, technological leveling, virtual components, electronic workflows, production automation, and electronic customer-supplier relationships to create a flat organization closely linked to other organizations. It uses technology to reduce the number of administrative levels, to decentralize decision making, and generally to design a highly efficient and effective organization.

You will learn how to exploit technology to enhance your professional and personal productivity. Information technology is a resource. It enables you to redesign the organization, change the firm's relationship with customers and suppliers, as well as its communications patterns. Technology is a variable that you as a manager will be able to manipulate to effect significant improvements in what the organization and its employees can accomplish.

A theme throughout the book is that information technology brings change to organizations, individuals, work groups, relationships among companies, and even national governments. Information technology provides the manager with a powerful resource for bringing about change.

Once you have completed your course, look through a newspaper or business publication. You will be surprised at your understanding of many of the issues raised in articles dealing with information technology.

In sum, this text is designed to prepare you for the important role of managing information technology, to give you and your company a competitive edge.

TO THE INSTRUCTOR

This book is designed for business students with no particular background in information systems. Its primary goal is to help prepare students to assume an active and significant role in the management, design, and use of information technology. This edition stresses the changes enabled by IT. Each chapter begins with a short Focus on Change because technology is creating dramatic changes in the way individuals, work groups, organizations, and even governments function.

The Objectives of This Text

During the past decade, computers and communications technologies have proliferated in offices and homes. Organizations distribute the responsibility for technology to all levels of management and to different geographic locations. As a result, managers from supervisor to CEO encounter information technology on a daily basis. Every day managers make decisions that determine how much value the firm obtains from its investment in technology.

Organizations have the opportunity to become more efficient and competitive. Skilled and creative managers are required to accomplish these goals. Today's MBAs need the knowledge and confidence to deal with issues related to technology.

They must apply technology aggressively if they are to compete successfully in our global economy. They must take advantage of the ability that IT gives them to change the way work is done, communications patterns, and the very structure of the organization.

One of the most important parts of using the technology is the design of information systems. Much of the distribution of technology to users results from the rapid diffusion of personal computers or workstations. Applications once considered personal are being shared across networks. Knowledge workers access a number of different applications on different computers through a LAN and the Internet.

Knowledge workers may design systems for themselves alone, or they may be one of many users of a system designed by others. The design of multiuser applications is much more complex than the design of a personal computer system for an individual user. Many more people are involved in the process, each with unique and often conflicting needs and expectations.

Recent graduates are likely to find themselves on design teams for multiuser systems. *Thus, it is critical that a course in information systems prepare students to play an active role in the development of new applications that will affect their productivity and their company's competitiveness.*

Based on the discussion above, this book is designed to help students meet these three major objectives:

1. To understand the emerging technological issues facing management so students can effectively manage information systems in organizations
2. To play an active role in applying technology through the analysis, design, and implementation of multiuser systems that will meet the information needs of the organization
3. To learn how to use technology to transform the organization and create new relationships, structures, and entirely new organizations

ORGANIZATION

The text is organized into six major parts to help students meet these objectives:

Part One The Role of Managers in Information Technology

The purpose of Part One is to emphasize to students the value of information as a corporate asset and illustrate the myriad information systems applications they will face as graduates. Frameworks help them understand the role of technology in business.

Part Two Organizational Issues

In Part Two we deal with the impact of information technology on the organization. The book stresses the use of IT design variables in creating new kinds of organization structures. In particular, I advocate developing T-Form organizations in order to be successful in the highly competitive environment of the twenty-first century. This section also discusses how the firm can use technology as part of its strategy to gain a competitive advantage. This discussion of key managerial issues surrounding the technology and its application helps motivate student learning.

Part Three Information Technology

Important managerial decisions increasingly require an understanding of the technology. Therefore, graduates need to have knowledge of hardware and software fundamentals. In Part Three I have included the technical information I consider most important and relevant to future managers.

Part Four Systems Analysis and Design

Poorly designed systems are responsible for many information system problems. When information needs are not met, users are alienated and the value of the system diminishes. Part Four prepares graduates to participate in the development of multiuser systems and make an immediate contribution to their employer.

Part Five Exciting Directions in Systems

Part Five deals with alternatives to traditional transactions processing applications such as decision-support systems, expert systems, groupware, multimedia, and artificial intelligence. An understanding of these emerging applications offers students great potential to enhance their organizations' competitiveness.

Part Six Issues for Senior Management

At the end of the text, we return to the issues facing management currently. Managers need to be concerned with security and control, and how to achieve the maximum benefits possible for the firm's investment in technology. Part Six encourages students to evaluate the problems—and opportunities—that changing societal conditions and technological advances will create for their businesses. The table below arrays our three objectives against the six major parts of the text.

Part		Managing technology	Applying technology	Transform the organization
One	The role of managers in IT	[X]	[ ]	[X]
Two	Organizational issues	[X]	[X]	[X]
Three	Information technology	[X]	[X]	[ ]
Four	Systems analysis and design	[X]	[X]	[X]
Five	Exciting directions in systems	[X]	[X]	[X]
Six	Management control of IS	[X]	[ ]	[ ]

Note that the first objective—managing information technology—is a theme woven throughout every chapter. To manage technology effectively, students must understand its strategic significance and potential impact on the organization. In addition to these underlying organizational issues, managers must understand the related technical issues.

The second objective—learning to apply technology through a systems analysis and design team—is supported by Parts Two, Three, Four, and Five. These parts cover the fundamentals of systems development from a managerial perspective. Using the Simon Marshall case, which is found throughout the book, students complete the logical design of a system. This exercise encourages students to confront the myriad decisions and trade-offs that constitute the design of a multiuser system and gain a "real world" understanding of what otherwise would remain abstract.

The third and final objective—transforming the organization—is a theme throughout the text. It is a significant component of Parts One, Two, Four, and Five. In one sense, the entire text is devoted to preparing students to use technology to change the way organizations are structured and operate.

Learning Tools for Your Students

The text has a number of features designed to facilitate student learning, including the following:

- *Management Problems and topical vignettes* Most chapters contain Management Problems and topical vignettes. Management Problems are "minicases" for students to ponder alone or in groups; some instructors use the problems to stimulate class discussion. The vignettes illustrate the many different ways that information technology is used. They are intended to help the student become more creative in discovering how to benefit from information systems.
- *Chapter Summary* A summary of each chapter in the form of a numbered list containing the most important points in the chapter is found at the end of each chapter.
- *Implications for Management* Another feature is a paragraph after the Chapter Summary that contains my thoughts on the implications of the chapter material for a manager. This personal statement explains the importance of the material the student has just read.
- *Chapter Projects* Most chapters contain a Chapter Project. The projects are designed to help students apply concepts discussed in the chapter. Some projects require the student to conduct research or contact an organization to find out more about its information processing. I usually use one of the systems design projects as a group assignment. Students report that the experience of designing the logic of a system helps pull together much of the material in the course.
- *The Simon Marshall case* Several of the chapter projects involve the Simon Marshall case. There is a systems analysis and design problem for Simon Marshall that involves PCs, a server, a local area network, a mainframe data source, and a satellite distribution system. This assignment, carried out as a group project, helps students master the technical and design material in the text.

Instructor's Manual

The *Instructor's Manual* contains a course outline, teaching hints, and answers to selected questions. Also included are a discussion of all the Management Problems and sample course syllabi.

OVERVIEW OF THE SEVENTH EDITION

The seventh edition of *Information Technology for Management* reflects current thinking about the role of IT in management. In particular, it stresses the fact that managers implement new technology to change something: the organization, the nature of work, relationships with other organizations, or some other facet of business. The student should look at IT as a resource that he or she can employ to make major improvements in the organization.

Compared with the previous edition, the seventh edition contains less emphasis on the technical details and more on the managerial issues of IT and state-of-the-art topics. The tremendous growth of the Internet and Web has had a major influence on the text. Material on the value of information technology and how management should decide on IT investments is greatly expanded. There are also many new topical vignettes in each chapter.

Over the years, we have seen major changes in the way leading firms use information technology. Transactions processing systems helped improve efficiencies. Strategic systems provide some companies with a competitive advantage. Now, with workgroup technology, group DSS, and extensive connectivity, we have the ability to use IT to *transform the organization.* This theme of change is reflected throughout this current edition.

The text has been extensively updated to reflect advances in technology and in its application. There are many more examples of applications and systems in the text to supplement the topical vignettes that are ruled off in the text.

The first chapter sets the stage for the text and attempts to motivate students to study information technology. The next two chapters discuss the nature of information and frameworks for IT. Frameworks help students understand the role of technology in the firm.

Chapter 4 is extremely important; it discusses the impact of information technology on the organization. Consistent with the theme of change, the chapter presents examples of how technology has dramatically changed organizations. It also presents an approach to actively using technology in the design of new organizational forms. Chapter 5 on the strategic use of IT stresses the difficulty of sustaining an advantage once it is achieved. This chapter also contains a lengthy description of a firm that has used the technology over the years to develop a clear competitive advantage. The section on the issues in managing information technology is now clearer and more streamlined.

Globalization is now a major trend in business. Trade barriers are falling, and firms are expanding their markets beyond their own borders. Chapter 6 explores the implications of globalization for information technology. What can IT contribute to the international firm? What are the special IT problems created by trying to operate globally?

Part Three of the text is devoted to information technology; it attempts to provide the student with sufficient familiarity with technology so that he or she can make good management decisions.

Chapter 8 places the different types of computers available today in perspective. It discusses the different generations of Intel chips and the features that are used to increase the speed of these processors. I have attempted to provide a balanced and realistic picture of the role and future of mainframes, both in this chapter and throughout the text. Chapter 9 contains a discussion of the major operating systems choices today: Windows 98, Unix, and Windows NT.

Chapter 10 presents the fundamentals of database management and describes how the organization uses a DBMS for transactions processing and to extract information to be used in managing the firm. The chapter also stresses how the student can use a DBMS for his or her own personal productivity.

Chapter 11 on communications emphasizes the role of this technology in transforming organizations. The chapter features more material on networks and connectivity along with examples of how firms are using communications technology in creative ways. Chapter 12 on networks covers topics ranging from EDI to the Internet. Networks are one of the fastest growing phenomena in the field, and this chapter tries to excite the reader about their potential. Chapter 12 contains much new material on electronic commerce and the new models of business that IT enables.

There is a great deal of confusion about what kind of architecture is best for a given application or organization. Chapter 13 attempts to clarify any confusion the student may have about people who use the different types of technology described in earlier chapters. This chapter discusses the role of large, medium, and small computers and illustrates them with examples of different systems, ranging from a centralized, mainframe airline reservations system to a highly decentralized, client-server system at Chevron Canada. New to this edition is a discussion of Travelocity, a Web site that allows a user with a browser to connect to an existing mainframe reservations system.

A key objective of the text is to prepare students to apply technology through participation in systems analysis and design projects. We have encountered users who developed their own systems on PCs that served as the specifications for the same system to be developed for the entire corporation! The manager who understands how to build systems is at a distinct advantage.

Chapter 15 introduces systems analysis and design while Chapter 16 covers some design details. One of the highlights of this section is the appendix to the chapter. This appendix presents a high-level design for a system for the Hardserve company. There are complete DFDs for the retail store component of the system and for the subsystem in the company's warehouse. This in-depth example should provide students with a good understanding of the output of the design process and the way in which one describes a system. A second example of object-oriented design for a hypothetical community hospital is also in an appendix to this chapter.

Chapter 17 talks about enhancements to the traditional life-cycle approach to developing a system, especially packages and prototyping. Chapter 18 is devoted to the popular topic of business process reengineering. This chapter presents two examples of process reengineering and two examples where IT design variables have been used to reengineer the entire organization.

Implementation is concerned with how you bring about change in the organization. You are trying to see, at the level of the individual system, that systems provide the maximum return from the firm's investment in IT. In using IT design variables, you are likely to be trying to change the structure of the entire organization, a major challenge. Chapter 19 is devoted to implementation; it is still true that systems are underutilized and that users take advantage of only a fraction of the capabilities of existing, installed technology. Chapter 19 integrates research findings to produce an implementation framework to help the student understand and manage this process.

When the first edition of this text was published, there were no hands-on users outside of the IS department. We have moved from no contact to terminals to workstations on the user's desk. Chapter 20 discusses the range of knowledge worker interaction with technology and suggests ways to encourage it. The evolving model of *client-server computing* means that users on workstations will obtain the data and programs they need to answer their questions from the server.

Chapter 21 describes how IT can be used in nontraditional ways to enhance the effectiveness of individuals and organizations. The DSS part of the chapter contains examples of how these applications contribute to improving productivity. Material on EIS and group DSS is also found in the chapter. Groupware is one of the most exciting applications for transforming organizations and is discussed in this chapter. A section on multimedia stresses how this technology can be used for business, as opposed to entertainment, purposes.

Chapter 22 on intelligent systems contains an in-depth example of an expert system we developed at the American Stock Exchange. There is also material on neural networks and coverage of case-based reasoning and genetic algorithms.

Part Six deals with management issues. Chapter 24 includes a discussion of several different models of IT in the firm and an in-depth discussion of the role of the CIO. It also contains guidelines or steps for diagnosing and improving the IT effort in an organization. New to this chapter is an extensive discussion of how the firm can make decisions about investing in information technology, including coverage of the IT Value Equation and the IT Investment Equation. Chapter 25 presents framework for categorizing social issues and a discussion of ethics. It also includes a discussion about living with future technology.

CONCLUSION

This seventh edition of the text is intended to help your students appreciate the contribution of information technology and learn how to manage it.

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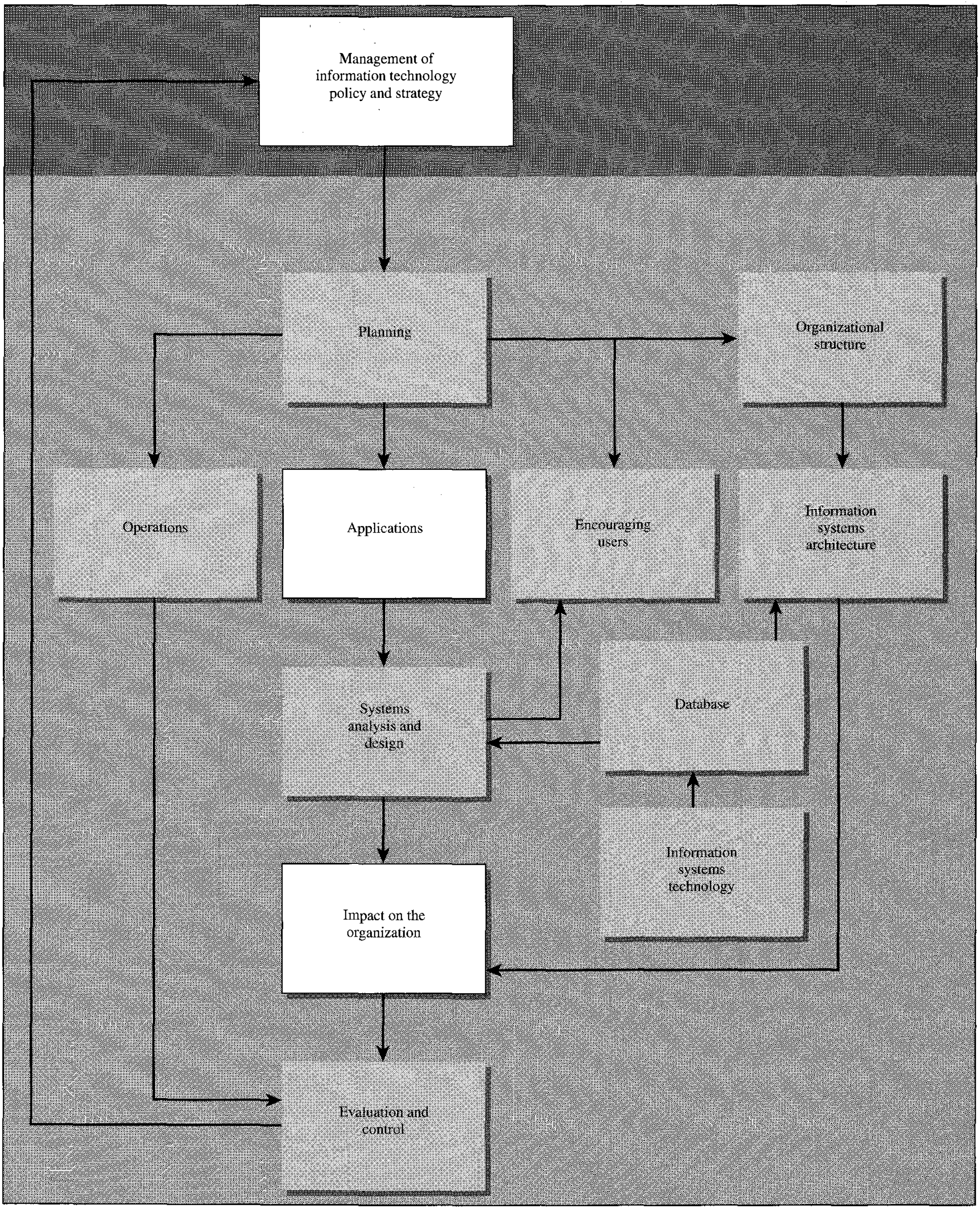
CONTENTS

PART TWO

Organizational Issues



Management of information technology policy and strategy
Planning
Organizational structure
Operations
Applications
Encouraging users
Information systems architecture
Systems analysis and design
Database
Information systems technology
Impact on the organization
Evaluation and control

PART ONE

THE ROLE OF MANAGERS IN INFORMATION TECHNOLOGY

In the first part of this text, we define an information system and see how information technology is transforming organizations. Managers have developed creative applications of technology that have altered the way members of the organization work and communicate, how customers and suppliers relate, and even how firms are structured.

What is the nature of information? How do individuals interpret data to become information? We will examine decision making in some detail because one objective of an information system is to provide information that supports decision making. With this background, we examine frameworks for information systems—frameworks that provide a conceptual model that aids in the design of systems. Part One includes a scenario showing the wide variety of information systems existing today.

Figure 1 depicts the process of managing information technology. This figure will appear in each part of the text to provide an introduction to the topics covered in the corresponding chapters. The figure shows that management must first determine a policy and strategy for information technology.

Managers should develop a plan for systems. The plan is likely to suggest new structures for the organization, and it should at least deal with how information services are to be organized. The plan will have an impact on the firm's operations. For example, a plan that includes electronic connections to customers will change the way orders are processed.

The plan will identify new applications areas for technology, meaning it will indicate new opportunities for the use of information technology. The plan may assign a high priority to applications that serve customers or to those that automate a factory. In today's environment, it is likely that the plan will contain ideas on how to encourage users to apply technology to solving their own problems.

The development of an information technology (IT) architecture is closely related to the structure of the organization. Will the firm use a variety of computers from different vendors? Will its computers be networked? Will it have an Intranet as well as Internet connections? Who will manage individual computer installations, and who will authorize expenditures on systems? What kind of communications technology will be used to provide connectivity among different locations and users?

The way the firm develops systems is by conducting systems analysis and design. The design of applications has an impact on users since they will be trying to access data in a new system. The entire area of information technology, computers, communications devices and networks, and databases supports the firm's information systems architecture and systems analysis and design.

The kinds of systems that are created and the architecture developed for them will have a dramatic impact on the organization. Firms that plan well and develop creative applications will find they have transformed all or some significant aspects of their business.

The final management activity is the evaluation and control of information technology in the organization. Does the organization obtain a return from its investment in the technology? Are information systems (IS) under management's control, or is the IS effort fragmented and uncoordinated? All these aspects of the process of managing information technology are discussed in different parts of the text.

In this first part of the text, we discuss the nature of information and different types of applications. Our objective is to develop a common definition of an information system and a shared understanding of the nature of information and types of systems. We shall see how technology can lead to major changes in an industry, within an organization, in the economy, and in government policies. This section of the text sets the stage for the rest of the book.

Using Technology to Transform the Organization

Outline

The Senior Manager
Information Technology in the Workplace
A Visit to Brun Passot in France
What Is Information Technology?
Transforming Organizations
Information Technology and the Manager
The Challenge of Change
Six Major Trends
A Preview of the Book

Focus on Change

The study of information technology is the study of change. Throughout the book, each chapter begins with a short section emphasizing the types of changes associated with the technology and application it enables. This chapter presents an overview of technology and the way it transforms organizations. As you read about Brun Passot in France, think of how its business has changed as a result of electronic ordering. An experiment with technology was successful, and it influenced the company's strategy—how it was going to compete in the marketplace. The combination of strategy and information technology helped Brun Passot grow its business. Even though a pioneer, the company itself constantly confronts technological change; it must develop plans for accommodating the Internet as it potentially eclipses the French Minitel system. All of the technology impacts described in this chapter illustrate the tremendous changes associated with IT.

THE SENIOR MANAGER

> "A CEO who is not totally knowledgeable about information systems—how to invest in them and how they help the business—just isn't competent. . . . If you look at most successful companies, the senior officers really understand IT." Harvey Padewer, CEO of Aquila Energy, a $4 billion Kansas City company.[1]

This CEO understands the role and importance of information technology in managing a twenty-first century organization. Is he alone? A recent survey by a Chicago-based consulting firm found that:

- Information technology and data management are the top priorities for CEOs in the survey.
- Ninety percent of the respondents cited information technology as essential in every way or very important for the future success of their business.
- One-third cited the use of new technologies as the top critical success factor for the future.
- Twenty-six percent attributed their company's current success to using new technology efficiently and to leadership in IT; 33% believe that using new technologies and new IT applications are the critical factors for future success.
- Fifty-eight percent of the respondents identified loss of competitive advantage as the main consequence of not keeping pace with IT, and 13% predicted bankruptcy as a possible outcome.

The purpose of this book is to help you learn about information technology so you can contribute to the success of your firm. Several experts have suggested that there are two kinds of companies—those that know how to manage technology and use it to advantage and those that are no longer in business. A thorough knowledge of information technology should help you remain competitive and maximize your contributions to the firm.

INFORMATION TECHNOLOGY IN THE WORKPLACE

We are living in revolutionary times, a revolution brought on by dramatic advances in **information technology.** If the steam engine, a new form of power, and mechanization created an Industrial Revolution over 150 years ago, computers and communications equipment have produced a Technology Revolution in the last half of the twentieth century. During the Industrial Revolution, there were

[1]Interview in *Computer World,* October 19, 1998.

three principal innovations: (1) the substitution of machines for human skill and effort, (2) the substitution of inanimate for animal sources of power—the steam engine—creating an unlimited source of energy, and (3) the substitution of new raw materials, especially minerals, for vegetable and animal substances (Landes, 1998). The Industrial Revolution changed the nature of work and led to dramatically higher standards of living.

Note the importance of innovation in the Industrial Revolution. In the Technology Revolution we have seen the rapid adoption of many innovations including mainframe computers, minicomputers, personal computers, networks, the **Internet** and World Wide Web, assembly language, higher level languages, fourth generation languages, spreadsheet programs, word processors, packaged programs, and Web browsers. In the Technology Revolution, companies use IT as a new source of energy for processing and accessing information. This technology helps the organization collect, store, retrieve, and apply knowledge to solve problems; IT converts the raw material of information into useable knowledge. The Technology Revolution, like the Industrial Revolution, has changed the economy, creating new industries and ways of doing business.

The **computer** has been called "the machine that changed the world." We believe that information technology has and will continue to revolutionize management. To name a few contributions, IT

- Provides new ways to design organizations and new organizational structures.
- Creates new relationships between customers and suppliers who electronically link themselves together.
- Presents the opportunity for electronic commerce, which reduces purchasing cycle times, increases the exposure of suppliers to customers, and creates greater convenience for buyers.
- Enables tremendous efficiencies in production and service industries through electronic data interchange to facilitate just-in-time production.
- Changes the basis of competition and industry structure, for example, in the airline and securities industries.
- Provides mechanisms through groupware for coordinating work and creating a knowledge base of organizational intelligence.
- Makes it possible for the organization to capture the knowledge of its employees and provide access to it throughout the organization.
- Contributes to the productivity and flexibility of knowledge workers.
- Provides the manager with electronic alternatives to face-to-face communications and supervision.
- Provides developing countries with opportunities to compete with the industrialized nations.

A major objective of this text is to communicate the excitement and opportunities provided by this revolution in information technology.

But to obtain the benefits described above, one has to be able to manage the technology. In the mid-1990s, two senior managers lost their jobs over information technology. The long-term chairman of Macy's department stores retired because,

A System and a Disaster

Oxford Health Plans is a successful health maintenance organization (HMO) in the New York area. The firm went public in 1991, and its stock price enjoyed steady growth. In 1997, however, problems with a new computer system led to significant losses, $120 million in the fourth quarter on top of $78 million in the third quarter. When the company announced its second quarterly loss, its stock price was 75 percent lower than its previous high. It was unable to send out monthly bills for many of its customers, and the company could not track payments to hundreds of doctors and hospitals. During the year, uncollected payments from customers rose to $400 million, while Oxford's unpaid bills to (caregivers) rose to over $650 million.

The problem began when Oxford started planning a system, based on the Oracle database management system, when it had a little over 200,000 members. By the time the system went live three years later, the HMO had 1.5 million members. The company tried to convert to the new system all at once. While the computer system labored under the load, Oxford management continued its aggressive drive to sign up new members. The new system was intolerant of errors that were accepted in the old one. As a result, an account with thousands of participants might have been rejected for an error in any member's record.

Some customers refused to pay the HMO after not being billed for months so Oxford had to write off over $100 million in uncollectible bills. The HMO's failure to pay its bills also angered care providers: At one point it owed Columbia University $16 million and Cornell $17 million for medical services. Oxford lost track of its actual medical costs—information a health care provider needs to set reserves and project liabilities.

While organizations have been implementing IT since the 1950s, we still seem to repeat many of the same problems. Oxford is a clear case of a management failure rather than a technology failure.

though a great merchant, he never developed the skills for choosing computer systems or analyzing a balance sheet. The chief executive of the London Stock Exchange resigned over the failure of the Exchange to complete its Taurus paperless settlements system. The Stock Exchange had spent over $100 million and estimated that it would take three more years and twice the initial investment to finish the project (other financial institutions are thought to have invested even more than this amount in the system).

At a recent NYU seminar, Hugh McColl, the chairman of NationsBank, responded to the question, "What keeps you awake at night?" by saying: "At NationsBank, we're spending $500 million a year on software, and about $1.9 billion in total technology costs. I look at those numbers and I worry that when we get there, we'll be at the wrong place, that we don't have it right, that we should have invested in another kind of technology, or just a better mousetrap of some kind" (*Stern Business,* 1997). In 1998 NationsBank and Bank of America merged. Before any savings from eliminating duplication, the new bank will have a combined IT budget of about $4 *billion.* The new bank faces a major challenge in managing technology and obtaining value from this huge investment.

A Virtual Manufacturing Company

Have you ever heard of Solectron? It is a major manufacturer, but you will not find its name on any products. Solectron is a virtual supplier for a large number of other companies. It manufactures computers, printers, cellular phones, and other electronic goods. It does not manufacture "off-brand" products either; its customers include IBM, Hewlett-Packard, and Cisco Systems. Solectron is not an overseas company; it is a U.S. manufacturing company with over 5600 employees in California.

Solectron is so efficient that HP, IBM, and Texas Instruments are turning over their factories to the company, including their employees. European companies like Telefon AB, L. M. Ericsson, and Nokia outsource some of their production to the U.S. Even Mitsubishi sold some production lines in Georgia to Solectron and contracted with the firm to make cellular phones on the lines.

Outsourcers like Solectron can get a product into production quickly to meet changing market demands. Ingram Micro, Inc. is a distributor of computer products; it recently hired Solectron to develop and run 11 plants worldwide to build personal computers. Solectron's annual revenues are around $5 billion. While Solectron does have some production overseas, it has added employees and expanded products at factories it purchased from IBM, HP, and Texas Instruments.

The company is a study in efficient manufacturing practices. It invests heavily in training for its employees, even offering language classes for immigrant workers. While wages are not extremely high, promotion comes quickly; one year 25 percent of the company's California workers were promoted. The company buys $3 billion worth of components, giving it some of the best prices. It has lean operating margins, spending 90 cents for a dollar of revenue. Solectron relies on high volume and control of its overhead to make a product.

The company is obsessed with quality; it cannot afford to lose a customer or spend a lot of time reworking products with flaws. Each week 150 customers grade the company on quality. A score below a B- requires managers to present a remedial plan to senior executives and the customer within three days.

We often talk of virtual companies, but forget that they must have outsourcers who provide the services that are virtual. Solectron is an excellent example of one company that is successful as an outsourcer in the highly competitive manufacturing industry.

Fortunately, there are many IT success stories. A good example is Kennametal Inc., a leading producer of metal-working and mining tools. This company quietly spent the 1980s investing heavily in new technology to reverse a market slide and stave off powerful foreign competitors. This strategy ". . . propelled it into the ranks of the nation's 500 largest companies. . . . Kennametal's rebound provides a case study of how even companies in stodgy, slow-growing businesses can use information technology to improve their efficiency and provide new services that turn customers into partners. . . . The investment in information technology has allowed it to serve customers more quickly and reduce inventories. The computer systems have also been used to offer customers additional services, like tool management support. Kennametal now stocks and manages the tool storage areas for some customers." (*New York Times,* May 6, 1992)

A manager must have a number of skills to succeed in the competitive, global economy that characterizes the end of the twentieth and the beginning of the twenty-first century. One of the most important is an understanding of and ability to manage information technology. The purpose of this text is to prepare you for this important managerial role.

A VISIT TO BRUN PASSOT IN FRANCE

Even a relatively small company can use information technology to gain a competitive advantage. Brun Passot is one of four major competitors in the French office supplies industry; however, these companies have a combined market share of only 25 percent. There are some 5000 office products distributors in France! The fall of trade barriers among European Community nations has meant that French suppliers now have to compete with British, German, and even U.S. firms.

Brun Passot started as a family firm in 1949. By the early 1990s with 160 employees it offered 12,000 products to 6000 customers, delivering to up to 15,000 locations. From 1970 to 1992 its sales rose from 15 million to 254 million French Francs (FF). In 1980 Brun Passot decided that it could distinguish itself from competitors by offering customers the opportunity to purchase items electronically. By 1983 the company developed Bureautel, a system that ran on Minitel, the French national videotext network and allowed customers to place orders electronically. Brun Passot's own employees could also inquire against its inventory and obtain sales and cash flow information from the system.

In 1989 the company enhanced this system by issuing a credit card with a predefined maximum purchase limit per customer department. As the customer placed orders, their value was subtracted from the credit card. The card was not actually used for payment, but as a way to let customer personnel order supplies without generating a purchase order or getting management approval. The system made it easier to order from Brun Passot. The card also helped customers maintain control over their department budgets for office supplies.

By 1985 large customers encouraged Brun Passot to develop a personal computer (PC) based system for them. This system was cheaper for customers than Minitel; they could centralize ordering even though requests were generated from multiple locations. As the capacity of the French telephone system grew, this system was expanded to provide color photos of each of Brun Passot's 12,000 products. In 1989 Brun Passot developed the capability of electronically sending product files, delivery status reports, purchase quotes, shipping notices, invoices, payments, and e-mail messages to clients. (Unfortunately, the company had to print paper invoices, too, since the French justice system did not recognize electronic invoices.)

Brun Passot estimates its investment in these applications at FF550,000 with ongoing operating costs of about FF100,000 covered by fees paid by users. By 1992, 40 percent of Brun Passot's orders were electronic. Before the end of the decade, the company expects the number of non-Minitel electronic orders to double. The introduction of these systems simplified procedures and freed 25 people to do more selling and visit customers. Since it is easier to predict customer demand, stock turnover has risen from 9 to 16 times a year; inventory management costs have also dropped 7 percent (Jelassi and Figon, 1994).

Brun Passot presents a successful application of technology. It shows that a company does not have to be in the "Fortune 500" to take advantage of IT. The company realized as it faced increasing competition, technology might help it differentiate its services from others in this crowded industry. *It successfully managed the development of multiple applications of technology.* Management had to do more than just create systems. It changed the way the firm operated to take advantage of the capabilities provided by electronic links to customers. Brun Passot recognized that a computer is more than a computational device; modern information technology provides novel opportunities for communications. As technology contributed more and more to the firm, management began to see electronic commerce as a part of Brun Passot's strategy: Information technology and strategy became intertwined. Today Brun Passot faces the opportunity (and the threat) of the Internet as it must prepare for electronic commerce on a new medium as well as maintain its existing Minitel applications.

Throughout the text, we shall see examples of firms that have developed creative applications of technology to give them an edge on competitors. These cases illustrate the firms' ability to manage technology and to use IT to transform the very structure of the organization.

WHAT IS INFORMATION TECHNOLOGY?

Information technology refers to all forms of technology applied to **processing,** storing, and transmitting **information** in electronic form. The physical equipment used for this purpose includes computers, communications equipment and networks, fax machines, and even electronic pocket organizers. Information systems execute organized procedures that process and/or communicate information. We define information as a tangible or intangible entity that serves to reduce uncertainty about some state or event.

Data can originate from the internal operations of the firm and from external entities such as suppliers or customers. Data also come from external databases and services; for example, organizations purchase a great deal of marketing and competitive information. Brokerage firms provide a variety of research on different companies to clients.

An information system usually processes these data in some way and presents the results to users. With the easy availability of personal computers, **users** often process the output of a formal **system** themselves in an ad hoc manner. Human **interpretation** of information is extremely important in understanding how an organization reacts to the **output** of a system. Different results may mean different things to two managers. A marketing manager may use statistical programs and graphs to look for trends or problems with sales. A financial manager may see a problem with cash flow given the same sales data. The

MANAGEMENT PROBLEM 1-1

Marsha Jackson is a recent MBA graduate with a degree in marketing. She has accepted a position with General America, a large firm selling a number of consumer products. Her first assignment is to conduct research on the sales of one of her company's products versus sales of competing products.

This division is responsible for sales of over-the-counter drugs such as headache remedies, indigestion cures, and similar products. In business school, Marsha had worked with a personal computer in her MBA program and was happy to see that General America had a local area network (LAN) for the marketing department. When Marsha looked for data on competing brands, however, she found that the marketing department subscribed to several different services that provided sales results for over-the-counter drugs. Some of her fellow workers had private databases, and a few even keyed data into their PCs from lengthy printouts they had purchased.

Marsha feels that there must be a better way to conduct market research, particularly given the fact that the department has a LAN with a lot of capacity. What solutions to this problem can you recommend?

recipient of a system's output may be an individual, as in the example of the marketing manager, or it may be a workgroup.

Many systems are used routinely for control purposes in the organization and require limited decision making. The accounts receivable application generally runs with little senior management oversight. It is a highly structured application with rules that can be followed by a clerical staff. A department manager handles exceptions. The output of some systems may be used as a part of a program or strategy. The system itself could be implementing a corporate strategy, such as simplifying the customer order process. A system might help managers make decisions.

Information technology, however, extends far beyond the computational capabilities of computers. Today computers are used extensively for **communications** as well as for their traditional roles of data storage and computation. Many computers are connected together using various kinds of communications lines to form **networks.** There are more than 43 million host computers, for example, on the Internet, and over 100 million computers around the world access it, an estimated 70 million of which are in the U.S. Through a network, individuals and organizations are linked together, and these linkages are changing the way we think about doing business. Boundaries between firms are breaking down from the electronic communications link provided by networks. Firms are willing to provide direct access to their systems for suppliers and customers. If the first era of computing was concerned with computation, the second era is about communications.

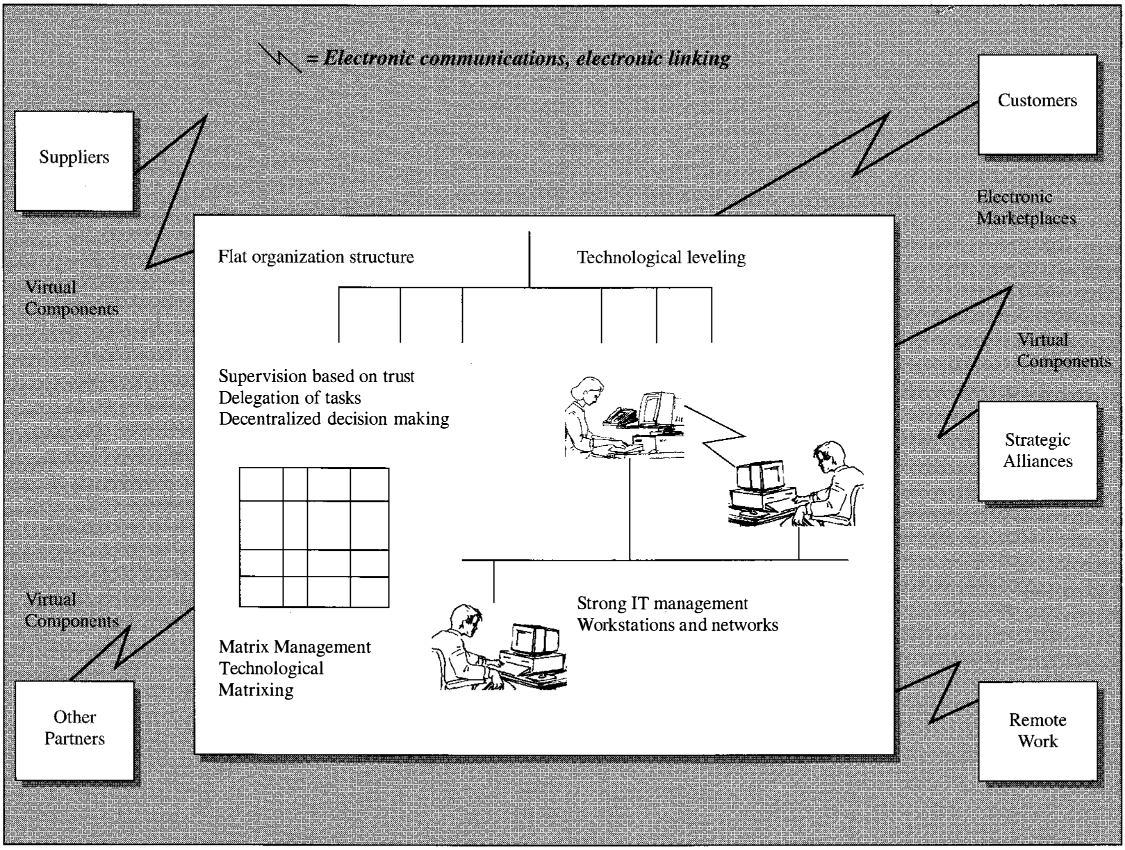


FIGURE 1-1
The T-Form organization.

TRANSFORMING ORGANIZATIONS

How is information technology changing organizations? One impact of IT, discussed in depth in Chapter 4, is its use to develop new organizational structures. The organization that is most likely to result from the use of these variables is the **T-Form** or Technology-Form organization, an organization that uses IT to become highly efficient and effective (Lucas, 1996). Figure 1-1 presents the characteristics of a technology-enabled organization.

The firm has a flat structure made possible by using e-mail and groupware (programs that help coordinate people with a common task to perform) to increase the span of control and reduce managerial hierarchy. Employees coordinate their work with the help of electronic communications and linkages. Supervision of employees is based on trust because there are fewer face-to-face encounters with subordinates and colleagues than in today's organization. Managers delegate tasks

MANAGEMENT PROBLEM 1-2

Assume you have just been appointed to chair the board of a medium-sized manufacturing firm that makes small consumer appliances. The company has experienced stagnant growth over the past five years, and a new board of directors was recently elected by dissident stockholders.

One of your first tasks is to help top management discover why sales are constant and profits have been declining. Currently, the firm is faced with excessive inventory and problems in acquiring raw materials. Prices for these materials have been fluctuating widely in recent months; the previous management seems to have been unable to cope with this problem.

How will you approach this task? What sources of information will you seek to help understand and solve problems in the company?

and **decision making** to lower levels of management, and information systems make data available at the level of management where it is needed to make decisions. In this way, the organization provides a fast response to competitors and customers. Some members of the organization primarily work remotely without having a permanent office assigned.

The company's technological infrastructure features networks of computers. Individual client workstations connect over a network to larger computers that act as servers. The organization has an internal Intranet, and internal client computers are connected to the Internet so members of the firm can link to customers, suppliers, and others with whom they need to interact. They can also access the huge repository of information contained on the Internet and the firm's own Intranet.

Technology-enabled firms feature highly automated production and electronic information handling to minimize the use of paper and rely extensively on images and optical data storage. Technology is used to give workers jobs that are as complete as possible. In the office, companies will convert assembly line operations for processing documents to a series of tasks that one individual or a small group can perform from a workstation. The firm also adopts and uses electronic agents, a kind of software robot, to perform a variety of tasks over networks.

These organizations use communications technology to form temporary task forces focused on a specific project. Technology like e-mail and groupware facilitate the work of these task forces. These temporary workgroups may include employees of customers, suppliers, and/or partner corporations; they form a virtual team that meets electronically to work on a project.

The organization is linked extensively with customers and suppliers. There are numerous electronic customer/supplier relationships. These linkages increase responsiveness, improve accuracy, reduce cycle times, and reduce the amount of overhead when firms do business with each other. Suppliers access customer computers directly to learn of their needs for materials, then deliver raw materials and assemblies to the proper location just as they are needed. Customers pay many suppliers as the customer consumes materials, dispensing with invoices and other documents associated with a purchase transaction.

The close electronic linking of companies doing business together creates virtual components where traditional parts of the organization appear to exist, but in reality exist in a novel or unusual manner. For example, the traditional inventory of raw materials and subassemblies is likely not to be owned or stored by a manufacturing firm. This virtual inventory actually exists at suppliers' locations. Possibly the subassemblies will not exist at all; suppliers will build them just in time to provide them to the customer. From the customer's standpoint, however, it appears that all needed components are in inventory because suppliers are reliable partners in the production process.

This model of a technology-enabled firm shows the extent to which managers can apply IT to transforming the organization. The firms that succeed in the turbulent environment of the twenty-first century will take advantage of information technology to create innovative organizational structures. They will use IT to develop highly competitive products and services, and will be connected in a network with their customers and suppliers. The purpose of this book is to prepare you to manage in this technologically sophisticated environment of the twenty-first century.

INFORMATION TECHNOLOGY AND THE MANAGER

Managers are involved in a wide range of decisions about technology, decisions that are vital to the success of the organization. Some 45 to 50 percent of capital investment in the U.S. is for information, according to the Department of Commerce and other sources; *Business Week* estimates that there are 63 PCs per 100 workers in the U.S. (including machines at home), and others have estimated that one in three U.S. workers uses a computer on the job. A recent survey of 373 senior executives at large U.S. and Japanese companies found that 64 percent of the U.S. managers said they must use computers in their jobs. Other surveys have suggested that as many as 88 percent of managers use computers. One estimate is that in 1996, U.S. firms spent $500 billion on information technology while the IT bill for the world was $1 trillion (*Scientific American,* July 1997). Because this technology is so pervasive, managers at all levels and in all functional areas of the firm are involved with IT. Managers are challenged with decisions about:

- The use of technology to design and structure the organization.
- The creation of alliances and partnerships that include electronic linkages. There is a growing trend for companies to connect with their customers and suppliers, and often with support service providers like law firms.
- The selection of systems to support different kinds of workers. Stockbrokers, traders, and others use sophisticated computer-based workstations in performing their jobs. Choosing a vendor, designing the system, and implementing it are major challenges for management.

- The adoption of groupware or group-decision support systems for workers who share a common task. In many firms, the records of shared materials constitute one type of knowledge base for the corporation.
- Determining a World Wide Web strategy. The Internet and World Wide Web (Chapter 12) offer ways to provide information, communicate, and engage in commerce. A manager must determine if and how the firm can take advantage of the opportunities provided by the Web.
- Routine transactions processing systems. These **applications** handle the basic business transactions, for example, the order cycle from receiving a purchase order through shipping goods, invoicing, and receipt of payment. These routine systems must function for the firm to continue in business. More often today managers are eliminating physical documents in transactions processing and substituting electronic transmission over networks.
- Personal support systems. Managers in a variety of positions use personal computers and networks to support their work.
- Reporting and control. Managers have traditionally been concerned with controlling the organization and reporting results to management, shareholders, and the public. The information needed for reporting and control is contained in one or more databases on an internal computer network. Many reports are filed with the government and can be accessed through the Internet and the World Wide Web, including many 10K filings and other SEC-required corporate reports.
- Automated production processes. One of the keys to competitive manufacturing is increasing efficiency and quality through automation. Similar improvements can be found in the services sector through technologies such as image processing, optical storage, and workflow processing in which paper is replaced by electronic images shared by staff members using networked workstations.
- Embedded products. Increasingly, products contain embedded intelligence. A modern automobile may contain six or more computers on chips, for example, to control the engine and climate, compute statistics, and manage an antilock brake and traction control system. A colleague remarked a few years ago that his washing machine today contained more logic than the first computer he worked on!

THE CHALLENGE OF CHANGE

A major feature of information technology is the changes that IT brings. Those who speak of a revolution from technology are really talking about change. Business and economic conditions change all the time; a revolution is a discontinuity, an abrupt and dramatic series of changes in the natural evolution of economies. In the early days of technology, change was gradual and often not particularly significant. The advent of personal computers accelerated the pace of change, and when the Internet became available for profit-making activities around 1992, change became exponential and revolutionary. To a great extent, your study of information technology is a study of change.

In what way can and does technology change the world around us? The impact of IT is broad and diverse; some of the changes it brings are profound. Information technology has demonstrated an ability to change or create the following:

- Within organizations
  Create new procedures, workflows, workgroups, the knowledge base, products and services, and communications.
- Organizational structure
  Facilitate new reporting relationships, increased spans of control, local decision rights, supervision, the formation of divisions, geographic scope, and "virtual" organizations.
- Interorganizational relations
  Create new customer-supplier relations, partnerships, and alliances.
- The economy
  Alter the nature of markets through electronic commerce, disintermediation, new forms of marketing and advertising, partnerships and alliances, the cost of transactions, and modes of governance in customer-supplier relationships.
- Education

  Enhance "on campus" education through videoconferencing, e-mail, electronic meetings, groupware, and electronic guest lectures.

  Facilitate distance learning through e-mail, groupware, and videoconferencing.

  Provide access to vast amounts of reference material; facilitate collaborative projects independent of time zones and distance.
- National development

  Provide small companies with international presence and facilitate commerce.

  Make large amounts of information available, perhaps to the consternation of certain governments.

  Present opportunities to improve education.

SIX MAJOR TRENDS

In the past few years, six major trends have drastically altered the way organizations use technology. These trends make it imperative that a manager become familiar with both the use of technology and how to control it in the organization. These trends, discussed further in later chapters, are as follows:

1. *The use of technology to transform the organization.* The cumulative effect of what all the technology firms are installing is to transform the organization and allow new types of organizational structures. Sometimes the transformation occurs slowly as one unit in an organization begins to use groupware. In other cases, like Kennametal or Oticon, a Danish firm discussed in Chapter 18, the firm is totally different after the application of technology. This ability of information technology to transform organizations is one of the most powerful tools available to a manager today.

2. *The use of information processing technology as a part of corporate strategy.* Firms like Brun Passot are implementing information systems that give them an edge on the competition. In Chapter 5 we look at this phenomenon and study some examples. Firms that prosper in the coming years will be managed by individuals who are able to develop creative, strategic applications of the technology.
3. *Technology as a pervasive part of the work environment.* From the largest corporations to the smallest business, we find technology is used to reduce labor, improve quality, provide better customer service, or change the way the firm operates. Factories use technology to design parts and control production. The small auto-repair shop uses a packaged personal computer system to prepare work orders and bills for its customers. The body shop uses a computer-controlled machine with lasers to take measurements so it can check the alignment of automobile suspensions, frames, and bodies. In this text we shall see a large number of examples of how technology is applied to change and improve the way we work.
4. *The use of technology to support knowledge workers.* The personal computer has tremendous appeal. It is easy to use and has a variety of powerful software programs available that can dramatically increase the user's productivity. When connected to a network within the organization and to the Internet, it is a tremendous tool for knowledge workers.
5. *The evolution of the computer from a computational device to a medium for communications.* Computers first replaced punched card equipment and were used for purely computational tasks. From the large centralized computers, the technology evolved into desktop, personal computers. When users wanted access to information stored in different locations, companies developed networks to link terminals and computers to other computers. These networks have grown and become a medium for internal and external communications with other organizations. For many workers today, the communications aspects of computers are more important than their computational capabilities.
6. *The growth of the Internet and World Wide Web.* The Internet offers a tremendous amount of information on-line, information that you can search from your computer. See Figure 1-2 which is from the United Nations Development Program site; this site contains a number of statistics on development one can view and download for further analysis. Networks link people and organizations together, greatly speeding up the process of communications. The Internet makes expertise available regardless of time and distance, and provides access to information at any location connected to the Internet. Companies can expand their geographic scope electronically without having to open branch offices. The Internet leads naturally to electronic commerce—creating new ways to market, contract for, and complete transactions.

What does all this mean for the management student? The manager must be a competent user of computers and the Internet, and learn to manage information

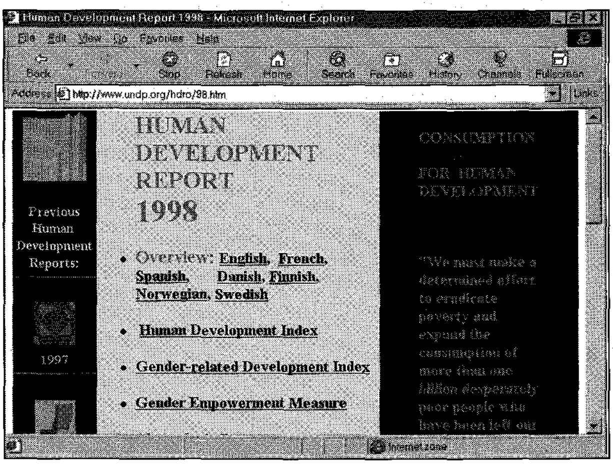


FIGURE 1-2
Part of the United Nations Development Program web site.

technology. The personal computer connected to a network is as commonplace in the office as the telephone has been for the past 75 years. Managers today are expected to make information technology an integral part of their jobs. It is the manager, not the technical staff member, who must come up with the idea for a system, allocate resources, and see that systems are designed well to provide the firm with a competitive edge. You will have to recognize opportunities to apply technology and then manage the implementation of the new technology. The success of information processing in the firm lies more with top and middle management than with the information services department.

A PREVIEW OF THE BOOK

With this introduction to the information systems field, we are prepared to explore the nature of information in greater detail. Table 1-1 lists some important IT management issues and indicates where they are discussed in the book. In Chapter 2 we examine the nature of decision making and managerial activities, and Chapter 3 introduces several frameworks for systems. Part Two deals with the interaction of the organization and information systems. Part Three discusses computer technology. You need a basic understanding of computers to make management decisions about information systems.

In Part Four, we present systems analysis and design techniques, topics of vital importance for a user. We advocate that users form a significant part of the design team and that a user be in charge of the design of a new system. Part Five presents some exciting direction in systems. Finally, Part Six discusses issues of senior management concern: the relationship between user departments and the information services department, and the social impacts of information technology.

TABLE 1-1

EXAMPLES OF *IT* MANAGEMENT ISSUES

Issue	Chapter	Explanation
Using technology to design efficient and effective organizations	1, 4	IT enables new types of organizations and relationships among suppliers and customers.
Developing a plan for information technology in the organization	5, 24	Planning allows you to anticipate problems and prepare for opportunities. Instead of reacting to problems as they arise, a plan prepares you to make decisions that are integrated with corporate strategy.
Using IT as a part of corporate strategy	5	Firms use IT to gain an advantage over the competition and to sustain that advantage.
Taking advantage of interorganizational systems	4, 5	Using IT to design organizations and as a part of strategy often involves developing applications that connect two organizations, such as links between a manufacturer and a supplier for ordering and delivering materials to a factory.
Deciding on and developing new applications of IT	15-17	Organization design, strategy, and planning will all lead to new applications of technology in the organization. You must design and implement these new applications.
Reengineering business processes	18	Reengineering is a major trend in business; you are seeking order of magnitudes improvements in a business process. This kind of radical change has a major impact on the organization and its employees, making success difficult.
Adopting special applications	21, 22	There are a number of IT applications that can have a real payoff for the organization including decision-support systems, expert systems, and groupware.
Changing the organization	19	One of the greatest challenges, and a requirement to obtain real value from technology, is to create meaningful change. When you develop new applications, you change some aspect of the business. When you use IT organization design variables, you are transforming the entire organization.
Managing the IT infrastructure in a time of explosive growth and technological change	13	You must make decisions about:
	13	The migration to client-server computing
	9, 13	Client (desktop) software standards
	11, 12	Networking in general
	12	Presence on and use of the Internet
	12	Electronic commerce
	13	The **integration** of heterogeneous hardware and software across computers and networks
Deciding whether and what to outsource	14, 24	Outsourcing means that you hire some other organization to perform a service. A significant number of firms use outsourcing for some part of their IT function, for example, running a communications network, developing a new application, or even managing the firm's entire IT effort.
Deciding how much to invest in IT	24	All the decisions above add up to the sum total that you are investing in information technology.

CHAPTER SUMMARY

1. Information technology is responsible for a revolution that will equal or exceed the impact of the Industrial Revolution on business.
2. Managers, no matter what their primary functional interest—marketing, finance, production, or human relations—make decisions about technology.
3. Firms that succeed in the twenty-first century will use technology to create their structure, manage themselves, market goods and services, and communicate with a variety of external organizations.
4. You will use the Internet routinely and encounter networks of computers within companies connecting a variety of organizations.
5. Managers are responsible for finding creative, strategic uses of information technology, applications that will give them an edge over the competition.
6. You will face a number of challenges managing the technology and seeing that the firm obtains a return from its investments in IT. In all of these efforts, you will be using technology to bring change to the organization, its employees, customers, suppliers, and marketplace.

IMPLICATIONS FOR MANAGEMENT

Networking has added a variety of new ways to communicate electronically. *Information technology today provides computational and communications capabilities that were inconceivable a decade ago.* A manager has to know enough about technology to take advantage of the power IT offers. We are not talking about building an isolated application—rather the technology exists to affect the fundamental way the organization is structured, its operations, and its relations with other organizations like suppliers and customers. *Companies and managers that succeed in the future will use information technology in all aspects of their business.*

KEY WORDS

Application
Communications
Computer
Data
Decision making
Information
Information technology (IT)
Integration
Internet
Interpretation
Network
Output
Processing
System
T-Form organization
User

RECOMMENDED READING

Applegate, L.; W. McFarlan; and J. McKenney. *Corporate Information Systems Management.* 5th ed. New York: Irwin–McGraw-Hill, 1999. (An excellent discussion of the issues managers face in dealing with the technology.)

Landes, D., *The Wealth and Poverty of Nations: Why Some Are So Rich and Some So Poor.* New York: W. W. Norton, 1998. (The author believes nations that strive for high levels of education and gender equality and that embrace technology create the highest standards of living.)

Mason, R.; and I. Mitroff. "A Program for Research in Management Information Systems," *Management Science,* 19, no. 5 (January 1973), pp. 475–487. (This article describes an information system from the perspective of an individual decision maker. While delving into the philosophical concepts underlying information systems, it presents a very appealing framework for the study of systems.)

Nolan, R.; and D. Croson. *Creative Destruction.* Boston: Harvard Business School Press, 1995. (A book devoted to the need for organizational transformation.)

DISCUSSION QUESTIONS

1. What is responsible for the explosion of information technology that has occurred over the past several decades?
2. What role does the manager play in the management of information technology?
3. Why does the introduction of information technology in an organization result in complications?
4. What are the characteristics of a technologically enabled organization?
5. What is the difference between using technology for computations and for communications?
6. Can you think of definitions of information systems other than the one presented in this chapter? What are the advantages and disadvantages of these definitions compared with the one we adopted?
7. How can there be more than one interpretation of information? Can you think of examples in which the same information is interpreted in different ways by different individuals?
8. What is the value of information? How would you try to assess the value of information to a decision maker?
9. What different types of information exist? Develop categories for describing or classifying information, for example, timeliness and accuracy. Develop an example or two of information that would fall into each category.
10. What kind of management leadership do you suppose was required for Kennametals to turn its business around?
11. How would you define successful change? How would you measure it?
12. Can you think of an example in which the failure of an information system led to a major disaster? What can we learn from such a catastrophe?
13. To what extent do organizations now depend on the success of information technology to stay in business?
14. What is the relationship between information systems and marketing?
15. How have the six trends in information technology discussed in this chapter influenced management?

16. How have computers evolved to take on an important role in communications?
17. What advantages does the Internet provide for a company?
18. What are the most significant aspects of the Brun Passot applications described in this chapter?
19. What factors would you consider if you were placed on a design team developing a new information system? What would be your major concern about the project?
20. What are the pros and cons of not providing workers like the sales force with a physical office, but instead equipping them with information technology for communications purposes, for example, notebook computers and Internet connectivity?

CHAPTER 1 PROJECT

Simon Marshall Associates

Mary Simon and John Marshall were business school students together. They took jobs at different financial firms after graduation. At their five-year class reunion, Mary and John got together to trade notes on their experiences after graduation.

Mary began, "I've had a lot of fun working in the financial business; we've weathered some good and bad times at my company. I had to begin doing financial statement analysis, but in a year I moved into mergers and acquisitions. That's pretty exciting stuff."

John replied, "Sounds like things have been going well for you; there certainly have been a lot of mergers and acquisitions since we left school. I've been into funds management. I manage a pretty big portfolio and also have a chance to come up with new investment products."

"I guess I'm happy, but I sometimes get pretty tired of the bureaucracy of a big company," observed Mary.

"I know what you mean," responded John. "One crazy trader lost $200 million in a week and wiped out our firm's profit for the year and our bonuses along with it. Sometimes I think if I were braver I'd go out on my own."

"Funny you should say that; I've been thinking of doing the same thing. . . ."

That chance meeting at the reunion led to further discussions. A year later, the two classmates formed Simon Marshall Associates. They described themselves as a "boutique" for special services.

Mary observed, "We obviously can't offer the same kind of capital that a big investment bank or brokerage firm can. However, we're very good at personal services. Since John is used to managing money, our strategy has been to attract wealthy investors who trust us to take care of their funds."

John added, "I try to find out what they're interested in—growth, steady income, and so on—and then advise them on what to put in their portfolios. We have tried to get clients who are active in business as well as retired people or clients just living on their capital. If I can make a business owner happy, we may have a shot at helping that person with a merger or acquisition."

Mary said, "I knew the merger activity would take a while to get going, and it has. We've helped one firm buy another one, and a couple of our wealthy investors have decided to get back into business, so I found some opportunities for them."

John observed, "I'm pretty satisfied with where we are now. Both Mary and I are making less money than we were before we started the company, but we're having a lot more fun."

Mary went on: "I agree. One thing we have to do, though, is bring in computers. Of course, we have quote machines, but we've been so busy talking with clients that we haven't had much time to keep up-to-date with the technology."

"The computers at my previous firm were fantastic, at least in cost," John said. "I wouldn't want us to get into that kind of overhead here. I wish we could get something that would be appropriate for our business, not a big system that wouldn't work properly half the time anyway."

Discuss the kind of information you think a firm like Simon Marshall needs. What role do you think technology might have in a firm like this one?

Interpreting and Understanding Information

Outline

Focus on Change

This chapter is about how people use information to make decisions. Technology has provided decision makers with new sources of information and tools for analysis. Consider the phenomenon of the Internet and the vast amount of information available, often at no charge, to people facing a decision. If you plan to buy an automobile, there are at least three Web sites that provide retail sticker prices and dealer invoice car prices. Auto-by-Tel sends your requirements to dealers for a bid, and a new service, Priceline, sends your bid for a specific vehicle to a group of dealers to see if one of them will sell you the car at your price. In organizations, vast databases contain information and knowledge about the firm. The decision maker uses powerful software packages and workstations connected to networks to access data and perform complex analyses. Information technology has had a profound impact on the way we make decisions.

THE NATURE OF INFORMATION

The last chapter described the broad categories of change stimulated by technology. Many of the contributions of IT involve people and their use of information. Individuals seek information for many reasons, for example, to make decisions, evaluate a proposal, answer questions from a customer, and so on. Too many information systems have failed, not because of their underlying technology, but because they did not contribute much to solving user problems. These systems may have provided inappropriate or inaccurate information, addressed the wrong problem, or suffered from other flaws that came about because designers did not understand how managers make decisions and use information. The objective of this chapter is to discuss information and decision making before we delve heavily into the technology used to support it.

What Is Information?

We define information as some tangible or intangible entity that reduces uncertainty about some state or event. As an example, consider a weather forecast predicting clear and sunny skies tomorrow. This information reduces our uncertainty about whether an event such as a baseball game will be held. Information that a bank has just approved a loan for our firm reduces our uncertainty about whether we shall be in a state of solvency or bankruptcy next month. Information derived from processing transactions reduces uncertainty about a firm's order backlog or financial position. Information used primarily for control in the organization reduces uncertainty about whether the firm is performing according to plan and budget.

Another definition of information has been suggested: "Information is data that has been processed into a form that is meaningful to the recipient and is of real perceived value in current or prospective decisions" (Davis and Olson, 1985, p. 6). This definition of information systems stresses that data must be processed in some way to produce information; information is more than raw data. In later chapters, we discuss information systems that process data to produce information. In this chapter, however, we focus on information and its interpretation.

HOW PEOPLE INTERPRET INFORMATION

A classic article on information systems suggested in part that an information system serves an individual with a certain **cognitive style** faced with a particular decision problem in some organizational setting (Mason and Mitroff 1973). In

MANAGEMENT PROBLEM 2-1

Sue Johnson has taken a new position as the president of a medium-sized electronics firm. The company has been experiencing declining market share and prices. Her first problem is to identify what is going wrong, and so she is working on developing a list of sources of information and the kind of information she would like to gather for this analysis.

Clearly she needs to talk with members of her own staff and with selected customers. She also thinks it might be helpful to talk to financial analysts that follow her industry. Sue has asked your help in creating a list of sources, and even more important, the kind of information you feel she should request. What are the possible reasons for a decline in market share? What information does Sue need to test various hypotheses about what is happening? Assuming that she is successful in reaching a conclusion about the source of her problems, what options does she have for improving the situation?

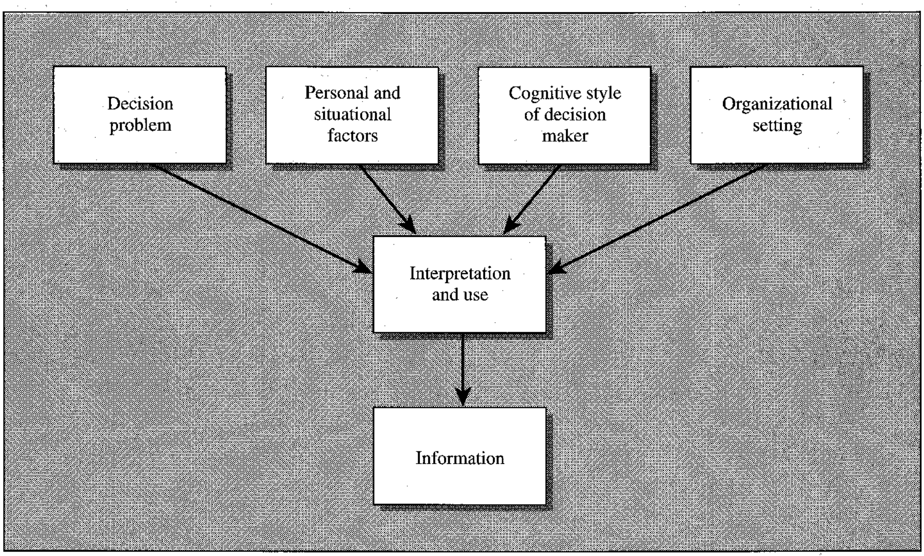


FIGURE 2-1
Influences on the interpretation and use of information.

addition to these variables, we suggest the importance of personal and situational factors in the interpretation of information. We shall examine each of these factors to see how they influence the interpretation process. (See Figure 2-1.)

Clearly, the nature of the problem influences the way we interpret information. How serious is the decision? What are the consequences of an incorrect decision, and how do they compare with the benefits of a correct one? An important decision may require more care in analyzing data than would a minor decision. For example, a bank's decision to merge with a stock brokerage firm is more important than its decision to lease additional office space. In such a strategic decision as whether to merge, the consequences and costs involved, plus the impact on the organization, require that information be scrutinized much more closely.

The organization itself affects the interpretation of information. Studies have shown that the individual becomes socialized by the organization. Over time we are influenced by our organizations in the way we approach problems. Thus, in most instances, the attitudes of a new employee will differ substantially from those of the chairman of the board. As the new employee associates over the years with other employees of the firm, he or she is influenced by their attitudes and by the environment of the workplace. Gradually, new employees begin to change their attitudes to be more consistent with those of their associates.

People who have different ideas interpret information differently. Again, many of a person's ideas are influenced by peers and by the socialization process in the particular organization where the individual works. Several individuals trying to influence the government to regulate prices in an industry may use the same information. However, the head of a corporation in the industry, the leader of a consumer group, and a government decision maker in a regulatory agency will probably interpret the same information differently.

Personal and situational factors also influence the interpretation of information. One study done many years ago showed that given comparable information, decision makers interpreted a problem differently depending on their position. In this exercise, finance executives saw financial problems, sales executives recognized sales problems, and so forth. In all the given scenarios, the information was the same—it was just interpreted differently (Dearborn and Simon, 1958). (A more recent study found managers are getting less parochial, though personal experience suggests that many managers are heavily influenced in problem diagnosis by their backgrounds and position.)

Psychologists studying the thought patterns of individuals have developed the concept of cognitive style. Although there is no agreement on exactly how to describe or measure different cognitive styles, the concept is appealing since people do seem to have different ways of approaching problems. One of the simplest distinctions is between analytic and heuristic decision makers. The **analytic** decision maker looks at quantitative information. Engineering is a profession attractive to an analytic decision maker. The **heuristic** decision maker, on the other hand, is interested in broader concepts and is more intuitive. Most researchers believe that we are not analytic or heuristic in every problem but that we do have preferences and tend to approach the same type of problem with a consistent cognitive style.

A Model for Interpreting Information

We have suggested a number of factors that influence the interpretation of information. How are all these factors combined? What is their net impact on the

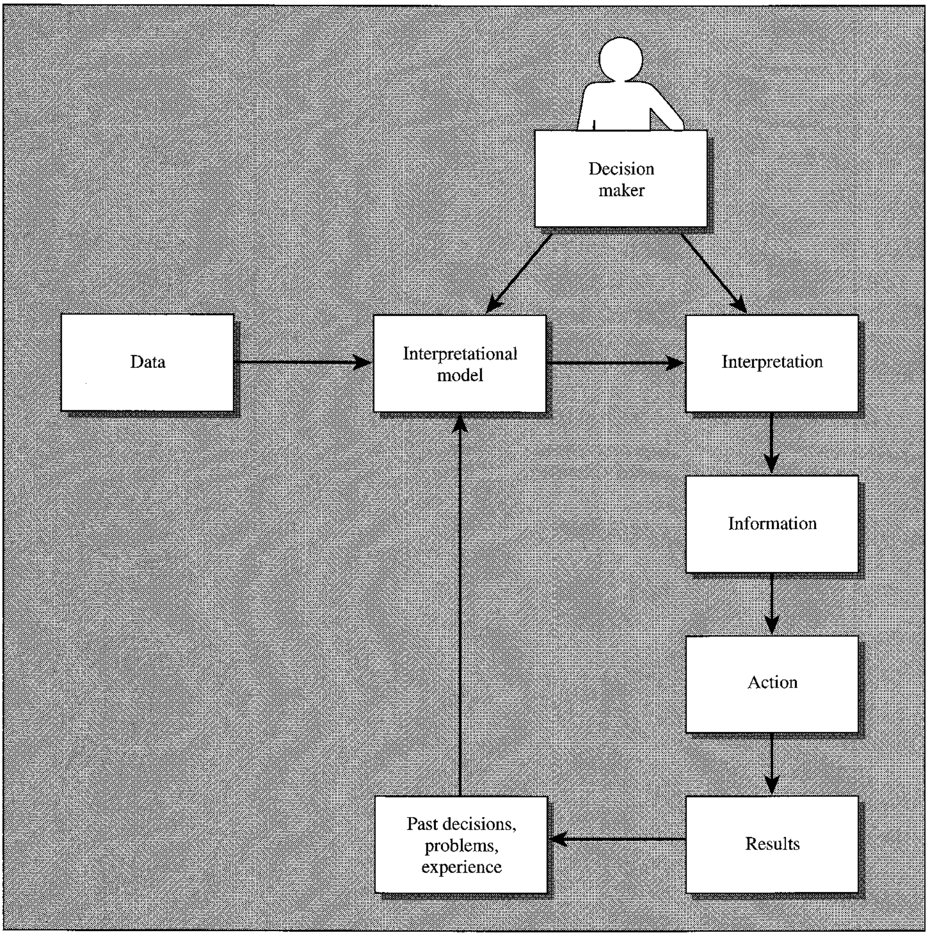


FIGURE 2-2
Model for interpreting information.

interpretation of information? Figure 2-2 summarizes all the variables described above. The figure portrays one representation of how a user of information systems develops a model to interpret information and how he or she would constantly execute and revise the model.

In the model, to interpret data a decision maker draws on current data and a history of past decisions and their results. The interpretation turns data into information, and the decision maker takes some action. He or she observes the results and stores them for future reference.

We expect the model to be formed **inductively** by the decision maker and to be heavily influenced by beliefs. For example, a decision maker may observe data on sales and production over time and find that these data seem to predict customers' reactions to a product. The decision maker is building an interpretational model based on his or her beliefs and analysis of historical data and observations.

After testing the interpretational model and developing confidence in it, the decision maker uses the model **deductively.** He or she observes data and uses the model to interpret them. Now, the decision maker perceives data on sales and production as constituting information on product acceptance; he or she may even ignore other information conveyed by these data.

After an interpretational model has been formed, further experiences are fed back to modify the model. Past decisions, problems, and experiences all influence the future interpretation of information. These experiences are based on actions taken on the basis of information and the results of those actions. If changes in a new product based on sales and production data increase sales, the interpretational model described above will be reinforced.

Characteristics of Information

Information can be characterized in a number of ways; some kinds of information are more suitable for decision making than others. The time frame for information can be historical or predictive. **Historical** information can be used to design alternative solutions and to monitor performance. Information may be expected or it may be unanticipated. Some information systems experts feel that information is worthless unless it is a surprise to the recipient. However, information that confirms something also reduces uncertainty. **Surprise** information often alerts us to the existence of a problem; it is also important in developing and evaluating different alternatives. Information may come from sources **internal** to the organization or from **external** sources, such as government agencies.

Information may be presented in summary form or in **detail** and vary in **accuracy. Summary** information is often sufficient for problem finding, but summary and detailed information may be needed for other uses. Information can be frequently updated, relatively old, loosely organized, or highly **structured.** An example of highly structured information is a report with clear categories to classify all the information it contains. Loosely organized information might be a report composed of different forms of information from multiple sources.

In general, different types of decisions require different kinds of information and providing inappropriate information is one common failing of information systems. (See Table 2-1.) Operational control decisions are characterized by historical information. Usually the results are expected and the source of the information is the internal operations of the organization. The data—for example, production control data, inventory status, or accounts receivable balances—must be detailed. Because operational control decisions involve day-to-day operations of the firm, information often must correspond closely to **real time.** This information is often highly structured and precise.

Information for strategic decisions, on the other hand, is more predictive and long range in nature. Strategic planning may uncover many surprises. Often, external data on the economy, the competition, and so forth are involved in strategic decision making. Summary information on a periodic basis is adequate; there is

TABLE 2-1

INFORMATION CHARACTERISTICS VERSUS DECISION TYPES

	Decision type		
Characteristics	**Operational control**	**Managerial control**	**Strategic planning**
Time frame	Historical	⟶	Predictive
Expectation	Anticipated	⟶	Surprise
Source	Largely internal	⟶	Largely external
Scope	Detailed	⟶	Summary
Frequency	Real time	⟶	Periodic
Organization	Highly structured	⟶	Loosely structured
Precision	Highly precise	⟶	Not overly precise

usually no need for highly detailed or extremely precise information. Strategic-planning decisions are usually characterized by loosely structured information. The requirements for managerial control decisions fall between operational control and strategic planning.

Obviously, there are many ways to classify information, and this complicates the decision maker's problem in expressing what output is desired from an information system. The most important thing for the user of an information system to be aware of is the intended use of the information and the type of decision he or she is facing. Then the user should try to decide on the general characteristics of the information needed, using categories such as these as guidelines to develop more detailed information requirements. Consideration of similar characteristics should enable the user to avoid requesting grossly inappropriate information from an information system.

FROM INFORMATION TO KNOWLEDGE

Knowledge is a strategic resource for many organizations. We can define knowledge as "information plus know-how" (Kogut and Zander, 1992). Information alone is not enough to produce knowledge; we must also understand the best way to use information to solve a problem, contribute to a product or service, or make a similar contribution to the organization. Knowledge builds over time in the heads of employees in the form of past decisions, processes in the organization, characteristics of products, interests of customers, and similar experiences.

A colleague of mine likes to tell the story of a New England company that decided to move to the South. It offered all current employees jobs but would pay the moving expenses only of employees above a certain management level. When the company left for its new location, most of the staff stayed behind. Within a year, the company was bankrupt. It had lost the knowledge that the staff possessed on how to run the business. Customers did not like dealing with new order processing and customer service staff members who did not know their business and needs. These customers began to place their orders with competitors, and the firm could not survive its loss of knowledge from the staff it left behind.

High-Tech Mortgages

Information technologies have the potential to replace the functions performed by mortgage bankers, according to the president of Freddie Mac. Internet mortgage sites are encroaching on the traditional banker as a source of information; some of them allow the home buyer to close on a mortgage on-line.

Before the closing, of course, an approval is required. A banker checks the credit of a mortgage applicant and determines the likelihood that he or she will be able to repay the loan. Computerized underwriting systems are reducing the time and effort required to check on credit, with the time from application to closing dropping from weeks to days. Anyone who wishes to be in the mortgage business can evaluate a borrower's credit with a computerized system; an experienced mortgage banker is no longer needed for this task.

The president of Freddie Mac thinks that technology will force a consolidation of the industry and that a number of traditional firms will no longer be in business in the future. Freddie Mac and Fannie Mae dominate the purchase of mortgages for resale as securities to investors. Freddie Mac offers an automated underwriting system that is being used by 700 lenders to compute a "score" for 1000 mortgages a week. The system cuts closing costs by $300 to $650 for the borrower. About 1000 mortgage originators use Fannie Mae's underwriting system for 10,000 transactions per month.

The Freddie Mac Loan Prospector system evaluates whether the loan will be acceptable for immediate sale to the agency. The system uses statistical methods to forecast the creditworthiness of the borrower consistently and accurately; the agency claims the program outperforms human mortgage bankers. Freddie Mac estimates that systems like this could save borrowers $2 billion a year in closing costs. Some applicants will be moved out of subprime categories into conventional mortgages at a savings to them of up to $100 million a year in interest payments.

Fannie Mae has experienced a 14 percent rise in productivity as measured by its annual mortgage origination volume divided by employees in mortgage banking. The

(continued)

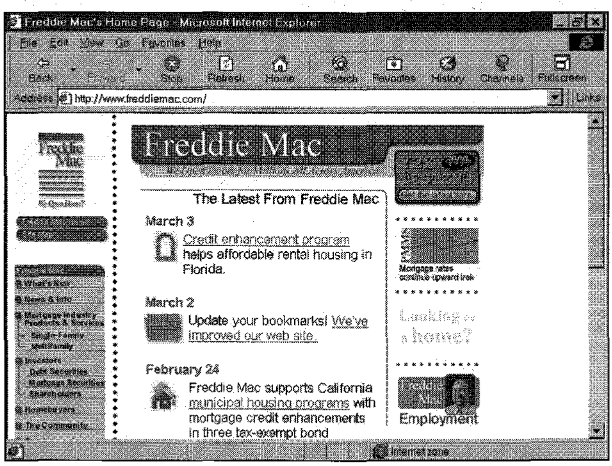
Highly developed countries are in a "post-industrial" age; they have far more employees in the services industry than in manufacturing. Most of these people work with information and rely on their knowledge to earn income; employees in this sector are often called "knowledge workers." For such organizations, knowledge is a strategic resource; it is valuable and hard to imitate. Imagine a company like Andersen Consulting with over 45,000 employees worldwide. When a new client approaches Andersen Consulting with a problem, there is probably someone at the consulting firm that has relevant knowledge to help solve the problem. Andersen's consultants represent a huge investment in knowledge; the firm's challenge is to capture that knowledge and make it available throughout the world. Andersen Consulting uses information technology, including groupware and an Intranet, to help meet this challenge.

It is instructive to look at different types of knowledge; Nonaka (1994) distinguishes between **explicit** and **tacit** knowledge. Explicit knowledge is represented

High-Tech Mortgages—Continued

technology has also reduced paper, substituting electronic applications, which the agencies return in four minutes. An Electronic Mortgage Registration System completes the process; there will be no more paper mortgages to burn when the borrower makes the final payment. Freddie Mac and Fannie Mae are working with lenders, title companies, real-estate agents, and information providers to make loan tracking electronic, further reducing paper.

The mortgage loan application process involves customers, information, statistical analysis, decision makers and a variety of organizations. It is a vivid example of how to apply different kinds of technology to support a complex task.



by facts. Our formal education provides a great deal of explicit knowledge. This text is an example of an attempt to present explicit knowledge to you, knowledge about information technology and how to manage it in an organization. Tacit knowledge is something we understand but have difficulty explaining. A good example of tacit knowledge is the ability to ride a bicycle. Many people can ride a bicycle, but it is very hard to explain in words to someone how to master this skill; our knowledge about bike riding is tacit. By internalizing explicit knowledge, we turn it into tacit knowledge. If you are able to articulate tacit knowledge, you may be able to convert it to explicit knowledge for others to use.

How do companies acquire knowledge? The most obvious way is through experience, working with products, services, customers and suppliers. Knowledge often comes from beginning to understand cause and effect relationships. Almost everything that one does in an organization presents a learning opportunity. Research and Development departments, new product groups, engineers, and similar groups are formal efforts of the firm to create and acquire knowledge. One important job for a manager is to foster the development of organizational knowledge and to create an organization that learns as it operates.

The Decision-Making Process

We have suggested that one important role of information systems is to support decision making. How do people make decisions?

Problem Finding and Solving

We must be aware of a problem before we can make a decision. A problem exists when the decision maker's ideal situation differs from reality, for example, when sales are below expectations. This example corresponds to something we call **disturbance handling**; the manager discovers a discrepancy between the ideal model and reality, and attempts to find some way to eliminate the discrepancy.

After noting the existence of a problem, the decision maker must decide what caused it. Are inventories up? Is the advertising budget too low? After determining the cause or causes, the decision maker tries to solve the problem by developing some program to remedy the situation. There is also another type of problem-finding activity undertaken by the manager who is looking for improvement projects. In this sense, the problem can be defined by asking, "What else could we be doing at the present time?" The manager is trying to anticipate problems and plan for them.

The tremendous amount of information available in corporate databanks or **data warehouses** combined with the vast information resources of the World Wide Web on the Internet make problem finding an extremely important managerial activity. You must learn how to discover that a problem exists and then use the variety of resources available through computers and networks to locate data. You will use the data to both understand the problem and develop a solution for it.

Types of Decisions

Not all decisions are alike; some involve different levels of the organization and some are more important than others. Anthony (1965) suggests that there are three broad categories of decisions made in organizations, a model still widely used today.

Strategic Planning In **strategic planning** the decision maker develops objectives and allocates resources to obtain them. Decisions in this category are characterized by long time periods and usually involve a substantial investment and effort. The development and introduction of a new product is an example of a strategic decision.

Managerial Control Decisions involving **managerial control** concern the use of resources in the organization and often include personnel or financial problems. For example, an accountant may try to determine the reason for a difference between actual and budgeted costs.

Operational Control An **operational control** decision covers the day-to-day problems that affect the operation of the firm: What should be produced today in the factory? What items should be ordered for inventory?

Who makes the preponderance of each of the three types of decisions? Anthony does not specify who handles each type of decision. However, from the nature of the problems, we suspect that top managers in the organization would spend more time on strategic decision making than supervisors, and supervisors would be more concerned with operational decisions.

HOW DO INDIVIDUALS MAKE DECISIONS?

Stages in the Decision-Making Process

In finding and solving a problem, the decision maker faces myriad decision cycles. What is the problem, what is its cause, what additional data are needed, and how should the solution be implemented? Each of these major steps in solving a problem involves the solution of subproblems.

The Nobel laureate, Herbert Simon (1965), suggests a series of descriptive stages for decision making to help understand the decision process. The first stage is defined as **intelligence,** which determines that a problem exists. The decision maker must become aware of a problem and gather data about it. We have described this stage as **problem finding** or identification.

During the **design** stage, the problem solver tries to develop a set of alternative solutions. The problem solver asks what approaches are available to solve the problem and evaluates each one. In the **choice** stage, the decision maker selects one of the solutions. If all the alternatives are evaluated well, the choice stage is usually the simplest one to execute. We should also add a stage to Simon's model called **implementation** in which we ensure that the solution is carried out.

A more elaborate model of the decision-making process is found in Figure 2-3 (Slade 1992). First, a decision maker must recognize that a decision needs to be made. Although this observation probably sounds obvious, there have been many examples of individuals who ignored the need for decisions. Several U.S. presidents have been criticized for a failure to address key problems. It is likely that one of them lost his reelection bid because he failed to recognize that decisions were needed on domestic policies as well as on foreign affairs.

Next the decision maker must identify alternatives, a process similar to the design stage in Simon's model of decision making. For routine or repetitive decisions, the decision maker may be able to simply choose the usual action. When sales of a particular product are up, there may be a standard rule that says to reorder a certain quantity of new products for every increase of one hundred units in sales. Most of the time, however, the decision maker will have to evaluate the alternatives identified in the previous step.

Somehow the decision maker must rate the alternatives on some basis; he or she then chooses the most attractive (or in some cases the least unattractive) alternative.

Rental Cars: Competing with Technology

Hertz and Avis are arch rivals in the car rental business. Both companies have introduced handheld computer terminals so that a service representative can check in a returning car before the customer has had a chance to get out of the vehicle. Each company has taken a slightly different approach to providing this additional customer service.

When a rental return comes into the Avis lot, the service representative approaches the car and enters the Avis registration number, found on the rear window, into a portable terminal that he or she carries on a shoulder strap. The terminal is linked locally to the Avis Wizard mainframe reservation system through the FM radio band. The Wizard system currently handles more than 8000 terminals around the world. The mainframe system retrieves the information on the rental and displays the customer's name. The service representative obtains the odometer reading and gas tank level, and enters the data into the portable terminal. Then the mainframe computes the bill, and the terminal prints it for the customer. The entire operation takes one to two minutes.

The Hertz system offers the same service, but the portable terminal is entirely self-contained; it is not linked to the central computer. The lack of a mainframe link means that the service representative must perform a number of calculations before printing a receipt. He or she must enter information that is already stored on the mainframe. Later, the data must be manually reentered into the main Hertz computer network.

Has either firm gained a competitive advantage with these systems? The answer may be "yes, temporarily." It was relatively easy for other rental car firms to copy the technology since this innovation could not be protected legally. Certainly the customer benefits with extremely rapid rental-car returns. Hertz has extended the technology to let members of its special club pick up a car without stopping at a counter (given a prior reservation). In this highly competitive industry, firms may gain a temporary advantage until others catch up, but it is generally easy for the largest companies to copy each other's innovations. In the end, it is likely to be the customer who wins while the rental-car companies continue to seek an elusive competitive edge.

This stage in the Slade model corresponds to Simon's choice stage. As Figure 2-3 suggests, the highest-ranked alternative may still be unacceptable. The decision maker must try to generate new alternatives. If the situation is hopeless, the decision maker may abandon the problem. In most organizational settings, this last course of action is not acceptable or is certainly not encouraged.

Once the decision maker has made a choice, it is necessary to implement it, that is, to effect the choice. Many managers and leaders have been faulted, not because they made bad decisions, but because they failed to take the action necessary to implement them. Implementation is often difficult for managers because they have to act through others. The individuals charged with implementation may not be committed to the decision or may have reasons to subvert it.

The discussion so far makes it appear that people are confronted with a clear decision problem and take action within a short period of time. Our recent research suggests that many decisions may actually be made over a long period of

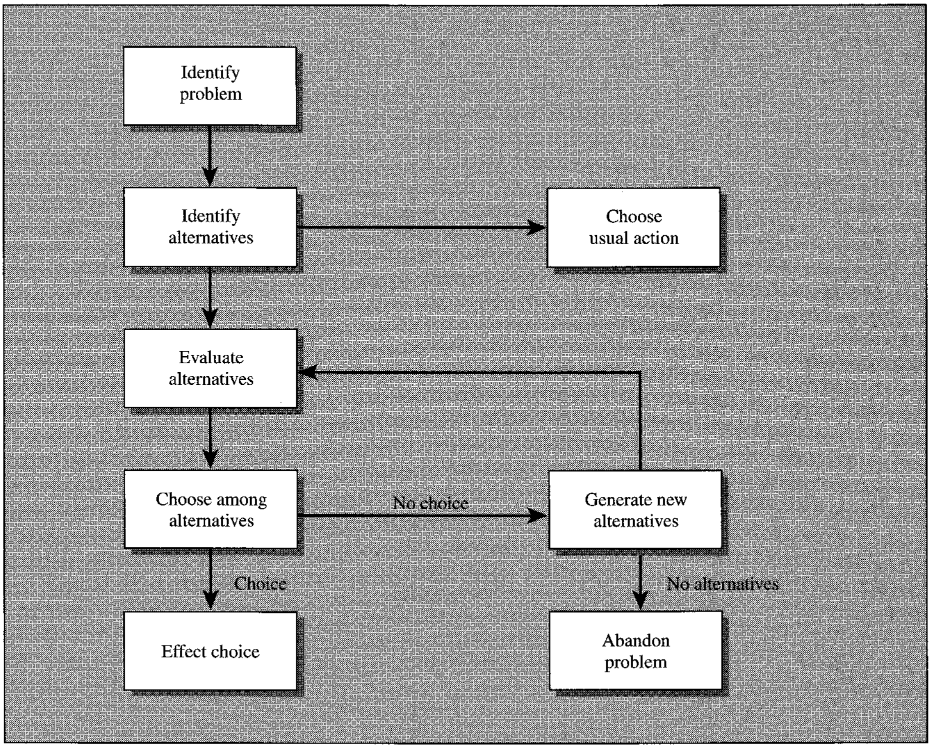


FIGURE 2-3
Slade's model of the decision-making process.

time. In one company we studied, the decision to develop a new use of technology took over six months as a group of managers discussed different options. The process of identifying a new option occurred when the managers rejected an earlier option. At least in this instance, the decision makers did not identify all alternatives and then select one at a single point in time. Rather the decision turned into a series of explorations of options and a growing consensus on the best alternative to choose.

Making a decision can be a complex undertaking; however, decisions are what determine the direction of our lives and our organizations. Information systems, among other roles, help provide information for decision making. A good example of the use of technology to support decision making comes from Frito-Lay. At Frito-Lay, the large manufacturer of snack foods, district managers are able to use technology to study sales of individual products at specific stores. The manager can see exactly what products sold in what package sizes at a specific 7-11 in, say, Dallas, Texas! The company built analysis tools to sift through tremendously detailed transactions data that it collects as a routine part of sales to grocery stores and other snack food vendors. The manager reviews competitors' sales and

Expanding Your Charter

Delivery firms started in business to transport goods. However, as more firms outsource, these firms are expanding their original charters; they no longer provide transportation, they provide services. Federal Express takes computer orders over the phone for a computer manufacturer and then delivers the computers. Ryder Systems carries tractor repair kits for farmers and assembles the parts in each kit. These logistics firms can become the entire operating division of a company. As one commentator said, "All you need to own is the label and they will do everything else." This little-known business is one of the fastest growing; it has over $30 billion a year in revenue.

The big operators with estimates of their outsourcing business include Menlo Logistics ($456 million), Schneider National ($800 million), and UPS ($600 million). Some examples indicate how important logistics firms are to their customers. Xerox lets Ryder put some parts on copy machines. Ryder employees deliver the copiers, set them up, and explain how they work. Menlo workers pump up Nike's basketballs, soccer balls, and footballs since they ship better partially inflated. For some customers, Ryder puts the balls in packages and attaches the price tags.

Communications technologies help these logistics companies provide the kind of service necessary to satisfy the companies who outsource to them and their customers. If you understand your supply chain and can describe the decisions and processes involved, then an outsourcer may be able to provide superior service at a lower cost than the "do-it-yourself" option.

promotions, and makes decisions on advertising and production. Production managers make further decisions on the purchase of raw materials and factory schedules. Frito-Lay has a sophisticated person–machine system to support operational decision making and planning.

THE INFLUENCE OF THE ORGANIZATION

We have been discussing how individuals make decisions. In most organizations, groups of individuals are involved in making decisions. How does this group finally reach a consensus and make a decision that commits the entire firm?

We all have observed different organizations in action and wondered how decisions are made. There are a number of ways to classify organizations. Probably the best known form is the **bureaucracy.** Most universities, government agencies, and many large organizations fall into this category. Bureaucracies are characterized by a large number of management layers. There are many rules and procedures to protect individuals; if you follow the procedures, how can you be wrong? Bureaucracies try to survive and to minimize uncertainty; members of these organizations stress job security. We would expect decisions in bureaucracies to be conservative and require modest changes to existing procedures.

The **charismatic** organization is dominated by a strong leader. This individual sets the goals of the firm and tends to make all decisions. His or her decisions are hard to predict because this kind of leader often does not reveal plans to the rest of the organization. It is safe to say that the leader is likely to make the decision that subordinates then execute.

The **adaptive** organization tries to respond quickly to its environment. The organization stresses rapid response times and does not have a large number of layers of management. A small group of decision makers analyze data and come to decisions quickly.

Although there are many other types of organizations, our main point is that individuals usually make decisions in the context of some organization. It is clear that most decisions are not entirely *rational* as advocated by an economist. People are not always able to examine all alternatives and choose a course that maximizes the value of some outcome. The nature of the organization will influence the decision and the kind of information that people making the decision require.

A SCENARIO FOR THE NOT-TOO-DISTANT FUTURE

How will managers in the future solve problems and make decisions? What will the impact of technology be on you as an individual? A scenario, adapted from Jarvenpaa and Ives (1994), suggests how you are likely to work in the future.

The landing gear of the 787 came up as Tara Rodgers in seat 6B linked her personal assistant to an onboard computer built into the armrest of her seat. The display screen on the back of the seat in front of her was larger and had a higher resolution than the screen on Tara's personal assistant. It also provided access to the airline's electronic amenities. Tara tuned into the airline's audio system, which gave her capabilities similar to those of her personal assistant including connection to inflight entertainment, the ability to listen to ground control conversations, and special circuitry to eliminate the plane's background noise.

Tara touched an icon on the screen in front of her to view the in-flight service menu. She canceled dinner and eliminated nonessential messages from flight personnel. (Tara had taken the flight many times before and did not want the captain's sightseeing instructions.) She asked for a glass of port to be delivered in two hours. She did not expect her electronic documents to attract the attention of the EUC's customs and immigration systems, but she authorized the system to wake her if an onboard interview with immigration officials was requested. By speaking softly into a microphone plugged into the arm rest, Tara completed her customs declaration. The airline's computers had already entered the flight number, date, and other details of the trip.

Tara barely noticed the soft, classical music that she had chosen as background for her audio system. Her personal profile, stored in her assistant, or possibly the airline's frequent flyer database, had chosen her type of music and preset the volume based on her personal preferences. This profile would also suggest that her morning coffee be served with cream and no sugar.

Tara touched another icon to make arrangements for her brief stay in Oxford. Her trip from New York was sudden, and she had not made hotel reservations. The electronic reservation agent her firm subscribed to had booked her into a charming guest house she had liked during her last visit to Oxford. Using the travel agents' virtual reality simulator, she wandered into the rooms with open doors (available this evening) and selected the one with the best view of the college. She also could have looked at a short video segment showing where to meet the car that would take her from Heathrow to Oxford, after booking the car electronically. Had she been closer to London, she could have looked at a prerecorded introduction to her driver.

The airline's computer predicted an on-time arrival with 95 percent certainty, and Tara began the work she wanted to complete before trying to get some sleep. First she called her husband and watched her children at play in their family room.

Back at work, Tara touched a key to activate her electronic messaging system and listened again to the message from the senior partner of Worldwide who had sent her off on this sudden trip. "Tara, this morning I received a message from London from Professor Locke at Templeton College, Oxford. Locke has worked closely with our U.K. and European offices on a number of projects; London believes he has the inside track on a promising opportunity, but we have to move quickly.

"The prospective customer is Empire Software, a company that specializes in the production of integrated software systems for the international freight business. Sir Phillip Knight, CEO of Empire, is in residence at Templeton College for a three-day forum. Over coffee, Knight expressed a concern to Locke that his firm is not taking advantage of the advances in software engineering and that his management team is poorly prepared to respond to competitive threats. Knight was very interested in some kind of customized educational program for the firm's top 100 employees. Locke has set up a meeting with Knight for tomorrow afternoon at

MANAGEMENT PROBLEM 2-2

The governor of a state is confronted with a series of conflicting recommendations from his staff. Recently welfare costs have been dropping, and he is concerned that they will start to rise again.

The director of the state welfare department suggested in her report that the new reduced payments schedule passed by the legislature has reduced overall expenditures and so the downward trend will continue. The governor's advisor for economic affairs indicated that the recent improvement in the state's economy had resulted in large increases in employment. These new jobs are attracting people and taking them off the welfare roles. A state senate leader, however, felt that most of the change resulted from enforcing requirements for welfare, limits on how long one can collect payments, and requirements to work.

Who is right? What is responsible for so many different positions? How can the governor reconcile these conflicting viewpoints and arrive at the true cause of the problem?

Templeton to talk more. Locke thinks that if we move quickly, we might be able to land this job without Empire going through a competitive bidding process. Locke would like our help in putting together the educational program.

"Tara, you worked with Knight five years ago on a project when he ran development at Dover Software and you were with that awful competitor of ours. When the UK office ran a search, the identifier system came up with your name because of that job and your knowledge of the software industry.

"Empire is a high-growth company that has been very profitable. Locke thinks there will be follow-up business if we get the job. Knight feels Empire is in a bad position to operate globally; he thinks software engineering will help Empire compete as well as relying on Eastern European software houses for assistance. Knight likes the kind of wholesale organizational change program Locke has been talking about in the Templeton seminar. I've checked our customer database and I find that we have not done much with Empire, though we have a couple of engagements with them in Asia and Europe. We have no U.S. projects with them.

"I checked your availability for the next two days and have started to reassign your responsibilities to other associates. Jerry Wright is your contact from the London office; he has worked with Locke in the past, but doesn't know Empire or Knight. I contacted Mary Ellen Smith, who is a doctoral student at UC Irvine, to be your special research assistant. She will be at your disposal for the next 48 hours working out of her home. You can ask her to look through our files and external databases to pull together a brief on Empire, their competitors, the industry, and so on."

Tara listened to a forwarded message from Professor Locke and Jerry Wright. She checked corporate records for a profile on Wright; his specialty was working on projects that required pulling together diverse resources from the Worldwide Group. He was highly motivated and would perform, though he might be occasionally a bit brusque and overly task-oriented.

Wright had spoken to Locke and forwarded his notes to Tara. Wright had provided the names of several Empire people in the U.S. and Europe that Worldwide was working with. Tara saw that one of these projects pertained to software development productivity. She linked to Worldwide's central databank to review reports on that project. Tara found a presentation prepared and delivered to a technical directions steering committee in Tokyo three months earlier. The findings were similar to Knight's concerns about productivity and global reach. One recommendation was a call for a management education program and an examination of locating a development group in the Pacific Rim.

Tara sent an urgent message to the Tokyo partner who had worked with Empire on this project. He was vacationing on a cruise ship in the Caribbean, but the messaging system located him and forwarded the message in English and Japanese. Tara attached the correspondence relating to her current project and asked for a quick update and one-minute summary of the original findings that she could use the next day. Then she downloaded the complete text of the Tokyo presentation to her personal assistant and highlighted the key sections she would use tomorrow if she did not find better information. Finally, she forwarded the results of her work to Wright in London.

By this time, Mary Ellen Smith had forwarded Tara a dossier on Empire. Smith had produced a rich assortment of documents on Empire as well as a strong overview report. Using a global paging service, Tara set up a conference call with Smith and an executive education specialist in Boston. Tara wanted a list of names from the firm, from colleges, and from independent consultants of people qualified to participate in a program of this type. She needed data on fees, availability, areas of specialty, and participant evaluations from their past programs. She also wanted to see video clips of each candidate performing in front of an executive audience.

Smith said she would use her electronic agent to search through faculty expertise files in the top tier business schools around the world. Tara asked Smith to identify five to ten top candidates and the education specialist to look for several possible venues for the program. Several of the experts would probably remain at their home base and provide instruction through audio, video, and computer links to the conference site. Checking through uploaded files from other Worldwide personal assistants, she found that Knight had a summer home in Bermuda and suggested that as one possible seminar location.

Before signing off, the education consultant downloaded a multimedia presentation to Tara's personal assistant. Worldwide had recently used this presentation to sell a similar educational project to another client; she could save time by using this "boilerplate" for tomorrow's meeting.

Tara asked the assistant to identify an initial list of individuals who could contribute to the program. Using her firm's database, she checked on their availability over the next six months and watched video clips of several instructors working with executive audiences. She called one presenter in Oregon to ask if she could use his video clip in her presentation tomorrow.

Tara contacted Kolormagic, a firm that provided worldwide graphics work for its clients. Headquartered in Singapore, the company maintained a group of graphics artists around the world who could provide consistent, high-quality multimedia presentations for clients. Singapore offered inducements for the company to locate there, including its superior technology infrastructure.

Kolormagic arranged for an artist on Maui to work with Tara. She checked previous work from this artist in the Worldwide database and was satisfied with his work. She forwarded to the artist logos from Worldwide and Empire, names, titles, pictures, and links to the previous multimedia demonstration she had reviewed. She spent the next hour discussing the presentation with the artist. The artist promised a rough presentation by the time Tara reached Oxford. Locke, Wright, and the Japanese partner in the Caribbean would all be able to review the presentation before it was delivered.

Tara completed a summary of her activities and forwarded it to Wright and the Worldwide database. She set a wakeup call for 45 minutes before landing. As the flight attendant arrived with the glass of port, she checked Knight's personal profile from her one previous contact with him; she retrieved the name of his favorite wine, and forwarded it to Wright in London. Now it was time for some sleep.

Is this scenario realistic? Much of the technology described here exists today. The advances that are necessary to make the scenario feasible will come from lowering communications costs and increasing capacities for transferring information.

Given growing competition in the communications industry, it is likely that you will enjoy the use of the technology described above during your career.

CHAPTER SUMMARY

1. A major role for IT is providing information, and frequently this information is used for making decisions in an organization.
2. It is important to understand how individuals interpret information and make decisions using it, as well as how organizations influence each individual's interpretation of information.
3. Different individuals are likely to have differing interpretations of the same data; they may both begin with the same data but come to entirely different conclusions on its meaning and on the appropriate action to take.
4. A variety of interpretations of data raise a major challenge for management in the organization and for those who design information systems.
5. Information has a number of characteristics. The type of information needed for different kinds of decisions differs; for example, strategic planning uses different information than operational control or managerial control.
6. Schools frequently focus on teaching students techniques for solving well-defined problems; it is important to learn how to find problems and understand their cause.
7. Knowledge is information plus know-how. Knowledge is an important, strategic resource for the firm, and managers need to see that the firm learns from its experiences. Information technology can help support the acquisition and sharing of knowledge worldwide.

IMPLICATIONS FOR MANAGEMENT

Information is a tricky substance. You can give it away and still keep it for yourself. If someone already knows the information, giving it to them again does not provide any benefits. The same information can have widely differing impacts on different people. Countries with advanced economies more and more use information to add value to products and services. As a manager you will work in an information-rich environment and you will use and communicate information in a variety of ways. Try to keep in mind the unusual characteristics of information, especially the factors that influence how different people come up with radically different interpretations of the same information. If you can turn information into knowledge, you should be able to use the knowledge as a strategic resource for competitive purposes.

KEY WORDS

Accuracy
Adaptive
Analytic
Bureaucracy
Charismatic

Choice
Cognitive style
Data warehouse
Deductively
Design
Detail
Disturbance handling
Explicit
External
Heuristic
Historical
Implementation
Inductively
Intelligence
Internal
Knowledge
Managerial control
Operational control
Problem finding
Real time
Strategic planning
Structured
Summary
Surprise
Tacit

RECOMMENDED READING

Banker, R.; R. Kauffman; and M. Mahmood. *Strategic Information Technology Management*. Harrisburg, PA: Idea Group Publishing, 1993. (An interesting and stimulating collection of articles about the strategic use of technology.)

Denning, P.; and R. Metcalfe. *Beyond Calculation: The Next Fifty Years of Computing*. New York: Copernicus Springer-Verlag, 1997. (A collection of articles by noted experts in technology on what the future holds.)

Nonaka, I. "A Dynamic Theory of Organizational Knowledge Creation," *Organization Science,* 5, No. 1 (1994), pp. 14–37. (A somewhat complex article that defines knowledge and its importance to the firm.)

Parker, M. M. *Strategic Transformation and Information Technology*. Englewood Cliffs, NJ: Prentice Hall, 1996. (An up-to-date look at the way technology changes organizations and the opportunities it provides managers.)

DISCUSSION QUESTIONS

1. What alternative definitions for information can you propose?
2. What do you think selective perception is? How does it affect the design and use of information systems?

3. Why is information more than just data?
4. How would you measure cognitive style? How does this concept help in the interpretation of information and the design of information systems?
5. Can an organization skew the information it develops and uses?
6. How can different interpretations of information lead to conflict? How can this conflict be resolved?
7. Develop procedures to elicit and define information needs for making a decision. How could you implement your plan? What are the problems?
8. How does the importance of a decision reflect itself in the user's interpretation of information?
9. Would you expect an analytical decision maker to be more favorably disposed toward a spreadsheet model than a heuristic one? Why or why not?
10. Pounds, a former dean of MIT's Sloan School, suggests that a problem exists when the decision maker's normative model of what should be conflicts with reality. How does this normative model relate to our information interpretation model? Are the two models completely independent?
11. Can the same information system be used by more than one decision maker?
12. How can we custom tailor information systems to suit different decision makers at a reasonable cost?
13. Examine for bias one particular indicator with which you are familiar. For example, how valid an indicator of reliability is a grade point average?
14. What differentiates knowledge from information?
15. Are there information systems that deal with decisions or processes outside Anthony's categories? What types of systems are these?
16. What are the most frequent indicators for evaluating the performance of lower, middle, and top managers?
17. How does an organization acquire and disseminate knowledge?
18. How can knowledge become a competitive resource for the firm?

CHAPTER 2 PROJECT

The Admissions Decision

One of the most feared decision processes, at least by students, is the *admissions decision* that colleges and universities make. This decision determines whether a student will be accepted and often involves a second decision on the possible award of financial aid. Drawing on your experiences applying to schools, describe the information that is used in making the decision. What data were you asked to supply? What information came from external sources? What are the characteristics of the information?

Use one of the decision-making models in the text, for example, Figure 2-3, to describe how the admissions committee processes information and makes a decision. How should this committee interpret information? Should the interpretation be the same for each student, or are there situations in which some information should weigh more heavily for a candidate?

CHAPTER 3

Information Technology in Perspective

Outline

Focus on Change

The frameworks in this chapter are concerned with the way individuals and organizations apply information technology. They help us understand how technology contributes to individuals and to their workplaces. We also seek to answer the question of where to find value from an investment in IT. We observe a large number of changes from technology, as evidenced in the discussion of Chrysler Corporation. Information technology enabled Chrysler to implement two programs: lean production and just-in-time inventory. The results of all these changes have been to complete Chrysler's rescue and return it to profitability. The company's success has been such that in 1998–1999, it merged with Mercedes Benz to form a powerful, worldwide automotive giant.

A **framework** is a conceptual model that helps us understand and communicate about information systems. Information technology covers a vast array of topics; you need a way of thinking about issues in the field to manage IT successfully. A large number of systems have failed to produce benefits because designers did not understand the role of technology in the organization nor the requirements of system users. The frameworks discussed in this chapter should help shape the way you think about this broad field called information technology.

FRAMEWORKS FOR INFORMATION TECHNOLOGY

A framework provides you with a way to organize your thoughts and analyze a problem. There is no one theory of information systems and technology, though a user or designer of a system needs some conceptual model of an information system. In this text we present several different approaches to frameworks and adopt one for purposes of discussion. It is not essential that everyone adopt the framework we use here. It is important, however, for you to have some conceptual model when making decisions pertaining to these systems.

Decision-Oriented Frameworks

In the previous chapter we discussed the decision-making stages of intelligence, design, and choice proposed by Simon (1965). Anthony (1965) is concerned with the purpose of decision-making activities, whereas Simon stresses methods and techniques. In addition to the stages in Chapter 2, Simon proposes that there are two types of decisions: programmed and nonprogrammed. Programmed decisions are routine and repetitive and require little time spent in the design stage. Entering data into a spreadsheet program is an example of a programmed activity. Nonprogrammed decisions are novel and unstructured, for example, deciding on the marketing mix for a set of products. There is no one solution, and much time is spent in design since the problem has probably not appeared before. Clearly, few decisions are at one polar extreme or the other; most fall along a continuum between programmed and nonprogrammed.

Different types of decision-making technology are suitable for attacking each type of problem. Programmed decisions have traditionally been made by habit, by clerical procedures, or with other accepted tools. More modern techniques for solving programmed decisions involve operations research, mathematical analysis, modeling, and simulation.

Nonprogrammed decisions tend to be solved through judgment, intuition, and rules of thumb. Over time, we expect to see new technology providing more programming for nonprogrammed decisions; that is, decisions will tend to move toward the more programmed pole of the continuum.

A Synthesized Framework

A framework synthesizing the work of Anthony and Simon (see Chapter 2) is very appealing because it helps us classify a variety of systems (Gorry and Scott Morton, 1971). Table 3-1 classifies Anthony's decision types from operational control to strategic planning on a scale of structured to unstructured. (Gorry and Scott Morton feel that *structured* and *unstructured* are more appropriate terms than *programmed* and *nonprogrammed.*)

In a structured decision, the three phases—intelligence, design, and choice—are fully structured. In an unstructured decision, all three phases are unstructured. Any decision in between the two extremes is semistructured. As in Simon's framework, the line between structured and unstructured decisions shifts over time as new decision techniques are developed and applied to unstructured problems.

From Table 3-1, it appears that many information systems have attacked problems in the structured, operational control cell. These problems are similar in many organizations and are among the most easily understood. It is easier to mechanize these decisions and to predict and achieve cost savings for them than less structured decisions or strategic-planning decisions. Since operational systems are important to the daily functioning of the firm, they are high-priority applications.

Many individuals in the information systems field believe that unstructured decisions have the greatest payoff for the organization. The development of systems for unstructured problems is a major challenge and is undoubtedly more risky than

TABLE 3-1

THE GORRY-SCOTT MORTON FRAMEWORK

Classification	Operational control	Management control	Strategic planning
Structured	Order processing, accounts payable	Budgets, personnel reports	Warehouse location, transportation mode mix
Semistructured	Inventory control, production planning	Analysis of variance	Introduction of new product
Unstructured	Cash management	Management of personnel	Planning for R&D

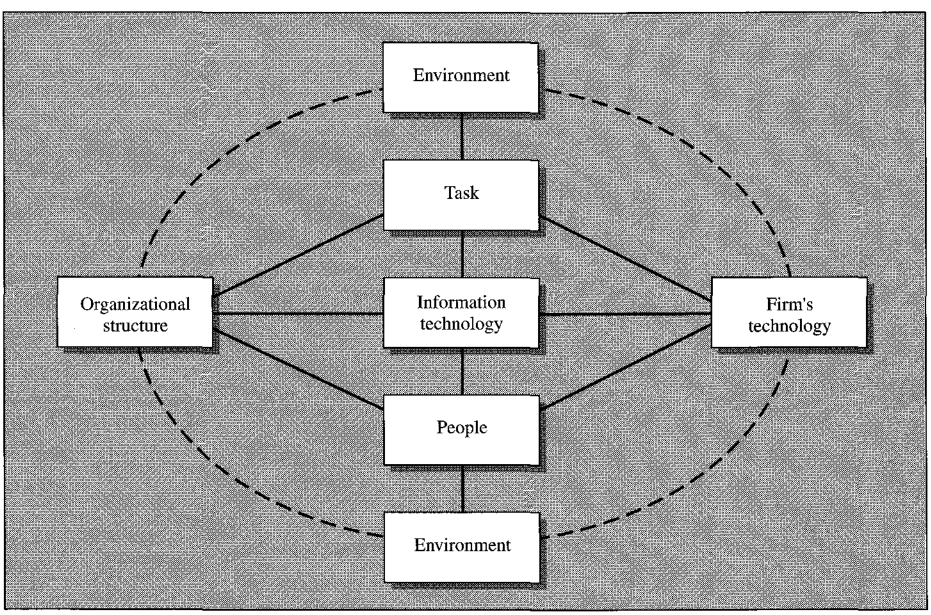
the development of comparable systems for structured problems. The goals and design techniques for unstructured decisions differ from those for structured ones. In the structured case, the goal of an information system is usually to improve the processing of information. In an unstructured situation, the goal of the information system is more likely to improve the organization and presentation of information inputs to the decision maker.

We include a large number of technology applications in this text. Organizations and individuals have been extremely creative in developing new uses for IT. Huge computer complexes support airline reservation systems, for example, while managers in a variety of fields use **personal computers** for decision support and analysis. A framework such as the Gorry-Scott Morton model can aid our thinking in studying different kinds of systems. What kind of management support does the system provide? What is the nature of the problem?

Adding Organizations and Decisions to a Framework

An expanded framework in light of new IT applications based on the work of Harold Leavitt provides additional insights (Stohr and Konsynski, 1992). Figure 3-1 shows that an organization develops some internal structure so the people who work in the organization can perform their tasks. People undertake these tasks so the firm can accomplish its mission or purpose, such as manufacturing and selling a product or providing a service. This framework separates information technology from the

FIGURE 3-1
Modified Leavitt model.



other technology in the firm because Stohr and Konsynski believe IT has become central in linking all parts of the organization and helping it accomplish its tasks.

A significant feature of the framework is the idea that a change in one component is likely to cause changes in others. Chapter 4 explores the use of IT to design new kinds of organizations. A change in the environment may force the company to restructure itself—change its tasks and even the number of people who are associated with it. Many firms were "restructured" and "downsized" or reduced their numbers of employees to improve profits in the 1990s. Changes in world politics are causing the U.S. government to reallocate defense expenditures. This change in the environment is having a dramatic effect on the defense industry.

Table 3-2 provides more detail on the factors in each component of the framework. For example, there are many ways to structure an organization and there are

TABLE 3-2

ELABORATION OF THE FRAMEWORK

Organizational structure
1. Formal organizational structure (hierarchy, teams)
2. Corporate roles, responsibilities
3. Corporate goals, strategy, policies
4. Informal communication structure, culture
5. Formal and informal decision processing mechanisms

People
1. Intrinsic factors: age, education, knowledge, technical skills, managerial skills, leadership skills, personality types, cognitive styles
2. Motivational factors: personal objectives, utilities
3. Interpersonal factors: corporate political affiliations, friends, alliances, influence
4. Extrinsic factors: roles, responsibilities, position in organization

Tasks
1. Management categories: scanning, organizing, motivating, monitoring, controlling
2. Repetitive activities, nonrepetitive activities
3. Individual level: learning, communicating, deciding, performing

Technology
1. Physical asset structure: land, buildings, plant, equipment
2. Financial asset structure
3. Geographic distribution of resources

Information technology
1. Databases, storage devices
2. Computational capabilities, software
3. Communication capabilities, networks
4. Knowledge bases
5. Information architecture
6. Environment
7. National and global economy
8. Customers, suppliers, competitors
9. Products, substitutes
10. Technological innovation

a large number of influences on people. These factors are important to the decision processes in the organization. They affect the way we can use information technology to help the organization achieve its objectives.

A FRAMEWORK BASED ON *IT*

Changing Technology and Applications

The purpose of employing any technology is to obtain an advantage over old ways of doing business. The frameworks above were developed around early information systems that made use first of computer and then communications technology. These early frameworks can be improved by taking into account the explosion of worldwide computer networking. Individuals and organizations have shown tremendous initiative in finding ways to apply information technology to improve their operations, gain a competitive advantage, provide personal productivity tools for employees, and even change the very structure of the organization. IT today is a vehicle for making substantial changes in organizations, markets, and the economy.

Processing Transactions

Today most transactions processing systems operate on-line, and a number of computer vendors compete for the business of providing hardware and software for **on-line transactions processing (OLTP)** systems. Whenever a customer in a store uses a credit card for a purchase above a certain amount, the merchant places the card in a reader that sends data recorded on the magnetic strip on the back of

Vanity Fair's Technology

Vanity Fair manufactures a variety of clothing products, from Lee and Wrangler jeans to women's undergarments. The company is a leader in computerized market-response systems, systems that restock a retailer's shelves as quickly as possible. Vanity Fair often restocks within three days of an order while Levi's can take a month to supply new product. The company began by connecting its computers to those of retailers like Wal-Mart and J.C. Penney. VF provides hundreds of styles to thousands of outlets; its communications center has some 40 floor-to-ceiling terminals that technicians use to control the network.

Every night Wal-Mart sends data collected on register scanners in 2100 outlets to Vanity Fair. VF then restocks the stores automatically based on what was sold that day. If VF has the product in stock, it is shipped the next day so that within three days the new jeans are on the shelf. If the item is not in stock, the VF computer orders a replacement that is manufactured and shipped within a week. Another advantage of this system is that the retailer only replenishes products that are selling. Since the items in stock are what the customer wants, there are fewer clearance sales. The chairman of VF credits the system, which handles half of its jeans orders, with giving the company the largest market share in the jeans business.

the credit card to a central transactions processing computer. The merchant enters the amount of the purchase, and the computer looks up the customer's record to determine if a purchase of that amount is authorized. If so, the computer sends back an authorization number to the merchant. No matter what happens between the credit card company and the customer, the merchant is assured of receiving payment from the credit card company after following the authorization process. Modern systems initiate a transfer from the credit card company account to the merchant's account based on the authorization, so the merchant receives payment very quickly.

Transactions processing systems handle vast amounts of data, much of which convey little interesting information to a manager. However, summaries of transactions data are often useful. For example, a summary of sales by product and territory from a sales database could be very valuable for a marketing executive or brand manager. Today companies are creating "data warehouses" that contain huge amounts of operational data; they try to discover useful information by sifting or "mining" these data. Transactions systems are the backbone of many information systems in firms.

Decision Support, Executive IS, and Expert Systems

Information technology can be used to support decision making in the organization as well as process transactions. Managers running spreadsheet programs on their personal computers to decide whether to launch a new product or make a particular investment are using the computer for decision support. There are also special cases of decision-support systems (DSS) known as group DSS and executive information systems (EIS), which are DSS designed specifically to support top management. Expert systems provide support in another fashion: They capture the knowledge of an expert and encode it in a computer program so the knowledge can be more widely shared. We discuss decision support systems in Chapter 21 and expert systems in Chapter 22.

Knowledge Worker Support

Large mainframe computers rarely feature applications that enhance the productivity of the typical manager. One of the great appeals of personal computers is the software available for personal productivity. Office software such as spreadsheets, word processors, database packages, presentation graphics programs, and organizers turn a PC into a manager's workstation. Many of these same functions are portable through very small notebook computers and personal digital assistants like the Palm Pilot, devices which are capable of exchanging data with a larger personal computer.

Supporting Groups and Cooperative Work-Groupware

One of the most exciting uses of technology is the support of group and cooperative work. When individuals in different locations need to communicate with each other to share information, a distributed network of personal computers with appropriate software can provide the coordination mechanism. Consider a group of customer service staff members who answer questions about how a software package works. A network with groupware makes it possible to record different problems and solutions and store them in a textual database so that other representatives can search the database to find your solution when they encounter a similar problem. Groupware programs such as Lotus Notes perform this function. It provides **electronic mail** and communications and automatically updates local databases with documents that need to be shared. A development tool lets end users create new applications within Notes.

Interorganizational Systems

Applications that tie two organizations together are known as **interorganizational systems** (IOSs). Partnerships and strategic alliances are created and enhanced with interorganizational systems. Such systems may be nothing more than e-mail connections, or they can represent full computer-to-computer connections between customers and suppliers as one example. Interorganizational systems make possible **virtual components** in which a partner substitutes for some component of your company, such as using Federal Express to deliver your products instead of your own fleet of trucks.

Key Technologies: Communications, Networking, and Database

The kinds of applications and systems described above rely heavily on three key technologies: communications, networks, and database. These technologies have developed rapidly during the last decade and are responsible for what you can accomplish with IT. Much of the information and knowledge of organizations is now stored in machine-readable **databases,** huge repositories of all types of corporate information. Networks tie together thousands of computers; an Internet connection makes it possible to communicate with millions of people who are connected to the World Wide Web.

A More Contemporary Framework

The Gorry-Scott Morton framework has been a unifying paradigm for the information systems field for three decades. But we are now confronted with many more types of systems and new technology than when this original framework was developed. The systems we have just discussed may be used by an individual, a workgroup, or the entire organization, or they may be interorganizational systems that connect one or more organizations. A useful framework for information technology for this text appears in Figure 3-2.

As the figure illustrates, information technology supports individuals, workgroups, organizations, and linkages among organizations. Individuals use this technology to help execute managerial tasks such as designing the organization, formulating corporate strategy, making decisions, and so on. The changing technology we described in the section above enables the organization to

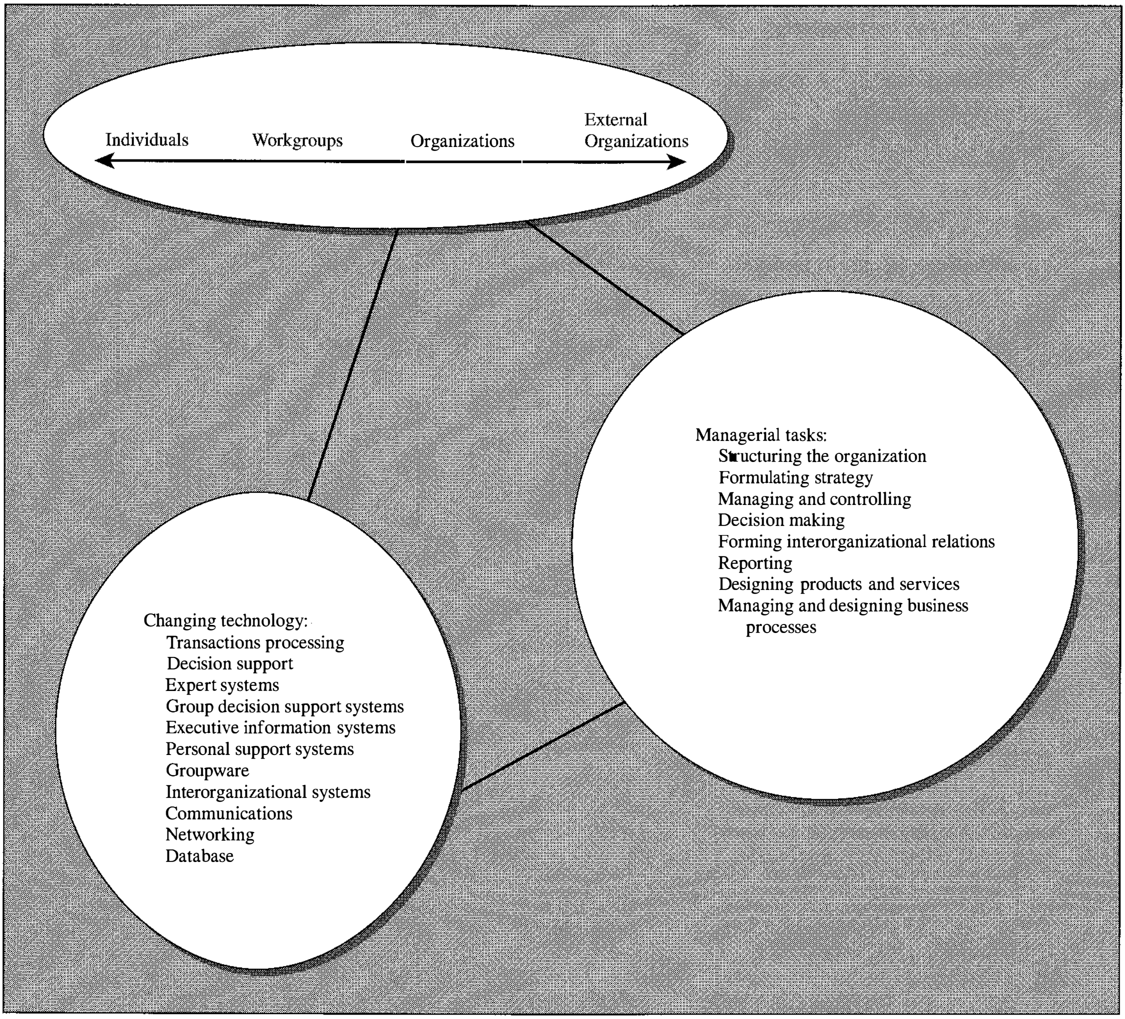


FIGURE 3-2
A framework for IT.

develop applications to support all the tasks involved in managing the firm. The key parts of this framework are:

- A focus on the organization as the most important component of the study of information technology.
- The role of technology in supporting managerial tasks.
- The pervasive nature of technology in the organization.

You should keep this framework in mind as we learn about its various components in the rest of the text.

THE BASICS OF INFORMATION SYSTEMS

Some Generic Types of Systems

Figure 3-3 illustrates three different kinds of information systems. A transactions processing system, shown in Figure 3-3(a), processes input provided by a user, such as the fact that a client purchased a certain number of shares of AT&T. The input is first edited for errors and corrected, if necessary. For example, if the person doing the input typed *ATR* and there is no such stock, the system would ask for the data to be typed again. The input then becomes immediate output (a purchase confirmation for the customer) and is used to modify the database of stock records in the system. Input can also be used to request the retrieval of information stored in the system, such as the customer's entire stock portfolio.

Files containing data are a major component of the information system. The files correspond to the information kept in folders, file cabinets, or notebooks in a manual information system. Files are a part of the organization's database. Information may be retrieved from a file, or the file contents may be altered by modifying, adding, or deleting data in the file. We are also interested in some type of output from a system, which may be a short response to a request for information from a file or the result of elaborate computations. Output is produced in any of a number of different formats and modes of presentation, such as a printed report, a display on a screen, or a verbal response.

Figure 3-3(b) portrays a decision-oriented system. The decision maker uses a workstation to run a decision-support system. The DSS software allows the user to retrieve data from the database. The same software might contain a model management subsystem allowing the user to apply different kinds of **models** for analyzing the data. The system also provides different modes for presenting the results of analyses to the decision maker.

Figure 3-3(c) illustrates a communications-oriented system. Here there are two users who communicate through a central computer, possibly one that is owned and operated by a common carrier that provides electronic mail services. Each user operates a workstation and sends messages to a file that contains electronic mailboxes for all subscribers on the system. When user 2 connects with the central computer from his or her workstation, there is a message notifying user 2 that there is new e-mail waiting to be read. User 2 can read the mail, forward it to someone else, and/or send a reply to user 1.

Using Different Types of Technology

It is helpful to distinguish among the types of information systems according to the technology employed. In a **batch** system, all input is processed at one time to produce the desired output. The input data are collected and used to update the files periodically—daily, weekly, or monthly. The data are frequently out of date in this type of system because updating is periodic, but batch processing is very economical. A payroll system is an example of an application that is often operated in batch mode because paychecks are issued periodically. The ratio of batch

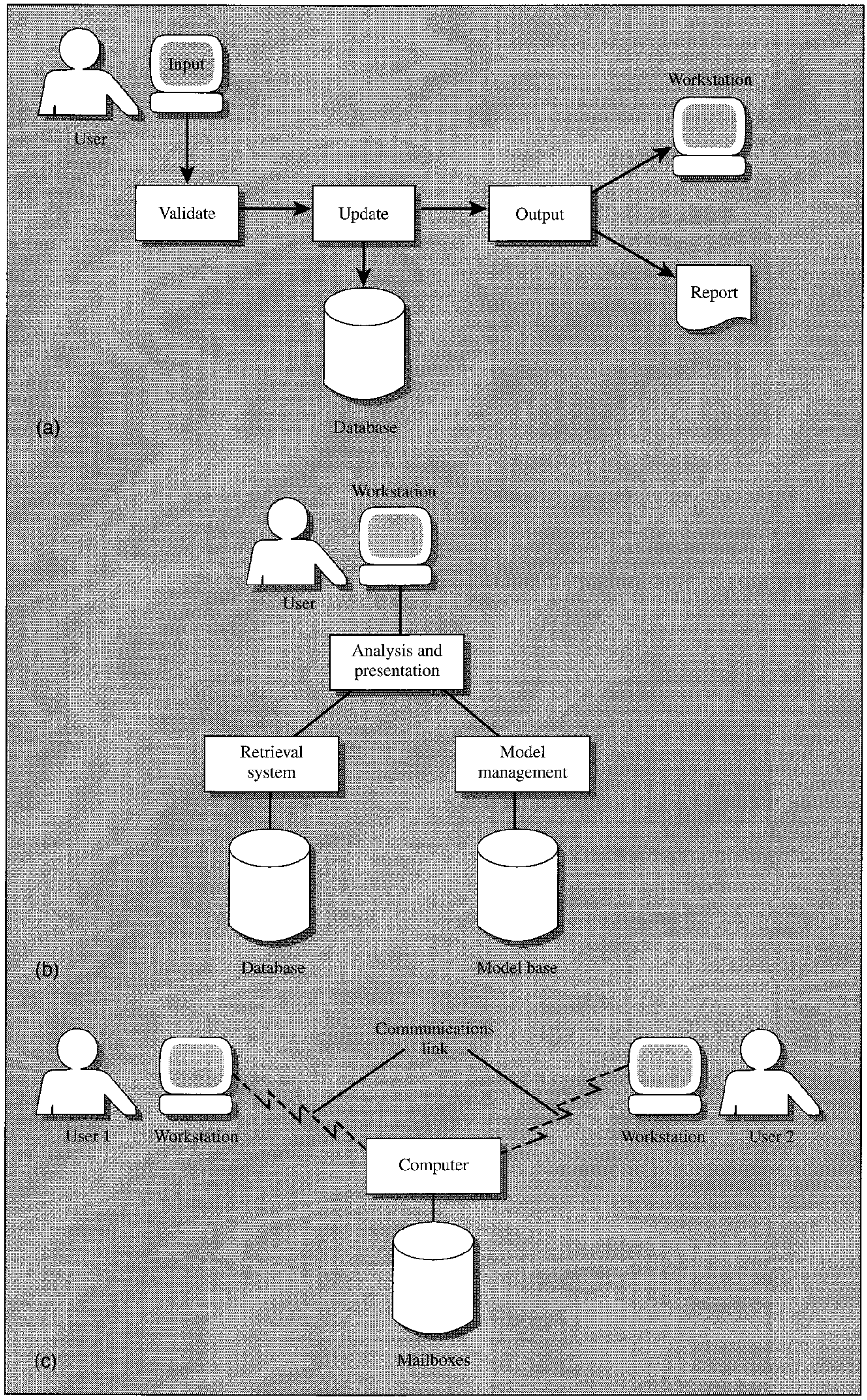


FIGURE 3-3
Three types of information systems: (a) transactions system, (b) decision system, (c) communications system.

processing to interactive processing is declining. Almost all new applications today involve interactive processing, even if they have some batch components. All applications in which a user works directly with a computer, that is, virtually everything other than batch processing, are considered to be **interactive.**

An inquiry system can be used to process retrieval requests for information on-line. Often inquiry systems accept and **edit** input on-line for later updating in batch mode. This input is saved in a file and is used to update the system later. A production control system could be operated in this manner to accept input from terminals on the factory floor during the day. Then, in the evening, when the computer schedule is less heavy, the files could be updated in a batch processing run.

A fully on-line system actually modifies files as the information is entered from terminals. An example of an on-line system is American Airlines' SABRE reservations system, which supports tens of thousands of terminals throughout the world.

A **command and control** system or real-time system is one in which information has to be fed back instantaneously to control an operation. For example, the air traffic control system operates in real-time so the controller can see exactly where aircraft are located at any time.

An Internet/Intranet application uses Internet standards to link host computers with user machines in a **client-server** architecture. The Internet can be used to access external information and send electronic mail, or it can be connected with a firm's transactions processing systems to provide information to customers or to enter into electronic commerce.

The most popular **architecture** today is client-server throughout the organization. In this architecture, a user's client workstation requests data and programs from a server, a larger computer with a great deal of storage capacity. The World Wide Web developed on the Internet because client computers could run a browser program like Netscape or Internet Explorer to access an Internet host computer. For most organizations, it has been difficult to make the transition from mainframe computers to the client-server model.

Table 3-3 summarizes the types of systems and their characteristics, and provides an example of a typical application employing each type of technology. Note that these types of systems may be designed around a number of different kinds of hardware and software. In later chapters we shall discuss different types of architectures ranging from personal computers to massively parallel machines.

IS THERE VALUE IN *IT*?

Managers will generally tell you that they invest carefully and expect a return from their investment. In deciding whether to make an investment, companies frequently compute the **net present value** (NPV) of a proposal, using an interest rate that represents a minimum acceptable return for the firm. Various observers

TABLE 3-3

CHARACTERISTICS AND APPLICATIONS OF DIFFERENT TECHNOLOGIES

Type of system	Characteristics	Example
Simple batch system	Updating at one point in time	Payroll
Inquiry	Update in batch, retrieve on-line, enter and edit data on-line	Production control with factory-floor input
Fully on-line	All input, output, and updating done on-line through terminals	Reservation system
Command and control	Fully on-line and instantaneous feedback to control some process	Air Traffic Control system
Internet/Intranet	Uses Internet standards, hosts, clients, and browsers to make information available, conduct business	Federal Express Web site that lets customers check on the status of shipments themselves
Client-server	Client workstations access corporate data and applications on a server	Analyzing sales data

have criticized information technology for not providing a satisfactory return on investment. How valid is this criticism?

Investment Opportunities Matrix

Table 3-4 presents the Investment Opportunities Matrix, which shows some of the different types of IT investments. The first column of the table describes the kind of investment in technology that one can undertake. The second column provides an example, and the third offers comments on this investment type. The fourth column, "upside," discusses the possibility that you will obtain much *larger return than predicted*. An extraordinary return might result because an investment worked much better than expected, or a product with IT as a component became extremely popular like the Merrill Lynch Cash Management Account in the 1980s or the more recent MCI Friends and Family Program.

The last column in Table 3-4 provides an estimate of the probability that there will be a return from the investment in this type of system. If the estimated probability here is .5, that means there is a 50 percent chance that you will get a return from this type of investment. The column presents ranges because the return depends on the specific IT investment you are planning to make. The second number in the column is my estimate for what you can expect in general for an investment in this type of IT.

The probabilities are subjective; they are estimated from seeing a large number of applications and descriptions of IT investments. Providing numbers like this is controversial; the objective is not to convince you that a particular probability estimate is the correct number. *The point is that there is not the same likelihood of a return from each IT investment.*

TABLE 3-4

***IT* INVESTMENT OPPORTUNITIES MATRIX**

Type of investment	Example	Comments	Upside	Probability of return
Infrastructure	Wide Area Network	Support current business—may allow for future investments	Little itself, but allows new programs	.2 to 1.0 (.5)
Required: no return Managerial control	OSHA reporting system, budgets	A cost of doing business	Almost none	0 to .5 (.2)
No other way to do the job	Computerized reservations system, Air Traffic Control	Enable new task or process, provide better customer service, new products	Could gain more than forecast	.5 to 1.0 (.75)
Direct return from IT	Merrill Lynch, Chrysler	Structured, cost/ benefit and NPV appropriate	A little if you can build on the investment	.7 to 1.0 (.9)
Indirect returns	CRS in travel agencies	Potential for considerable return, but indirect benefits hard to estimate	Could be substantial future benefits	0 to 1.0 (.5)
Competitive necessity	Bank ATMs, much EDI Electronic commerce	Need the system to compete in the business; what is the cost of not investing in technology?	Very little if you are following the industry	0 to 1.0 (.2)
Strategic application	Baxter, Merrill Lynch CMA	High risk–high potential; may be able to estimate return only after implementation	A high potential	0 to 1.0 (.5)
Transformational IT	Virtual organizations, Oticon	Must be combined with changes in management philosophy; good for fast-response organization—risky to change structure, but high potential rewards	A high potential	0 to 1.0 (.5)

Source: H. C. Lucas, Jr., *Information Technology and the Productivity Paradox: Assessing the Value of Investing in IT.* New York: Oxford University Press, 1999.

Infrastructure. Our transportation **infrastructure** consists of roads, interstate highways, rail lines, and airports, to name a few components. Infrastructure tends to be expensive and not terribly exciting, but extremely important. Transportation infrastructure lets the economy function by moving goods from where they are produced to where they are consumed. Technology today requires an underlying infrastructure, but experts differ as to what belongs in infrastructure. Most of us would include computers, communications networks, and some general purpose software such as database management systems. Given the rapid advance of technology, we would expect an organization to have a large number of desktop workstations (NationsBank has more computers than employees according to its chairman), computers that are dedicated as file servers, computers that process transactions, and networks that link computers in the organization together. There should also be connections to the Internet. Increasingly, things like a home page on the Web and corporate information posted to Web pages constitute a minimal infrastructure. Groupware such as Lotus Notes might also be considered a part of infrastructure.

What do you gain from investments in infrastructure? For many firms, information technology is vital to running the business. Banks, brokerage firms, and others that deal in services and transactions have long used technology as part of their production effort. Universities have a tremendous investment in infrastructure to provide technology for students and faculty. Infrastructure, then, is almost a requirement for many organizations to be in business today.

MANAGEMENT PROBLEM 3-1

Dave Masters is vice president of manufacturing for Siliconix, an electronic components manufacturer. Siliconix runs most of its production control and factory systems on an IBM mainframe computer. The firm has just purchased another company that makes similar components, but the newly purchased division runs its applications using a package called SAP R/3 on a client-server computer configuration.

Masters has to decide what to do about the different computer applications. The staff of the corporate management department wants to make the new division feel welcome and does not want to upset its employees. Staff members argue that SAP is probably better than their old custom-programmed system on the mainframe. However, the implementation of SAP is a major task, and they do not recommend undertaking it right now. They are content to run the two systems separately.

Masters is concerned because he feels the entire company would be better off with a single production control system. However, he recognizes that the merger will cause some disruptions, and he questions the wisdom of undertaking a major systems conversion at the same time.

What do you recommend? How should Masters go about making his decision?

On the upside, infrastructure may also enable you to take advantage of some opportunity that arises. The firm that develops the capability to set up a Web page and post information to it is in a good position to create an Intranet within the company. It is also better prepared for electronic commerce since it already has a presence on the Web. It can be argued that infrastructure investment is done as much for the opportunities it opens up as for the immediate needs it satisfies.

My estimate is that there is about a 50 percent chance of getting a payoff that you can measure from infrastructure investments. However, like highways, railroads, and the air travel system, these kinds of investments are crucial to enabling you to do business. You may choose to make more than the minimum investment here, but that decision will be justified more on faith than hard numbers.

Required. How can a system be required? One source of many requirements is the government. Companies have developed applications to satisfy federal or state requirements, particularly for organizations like the Occupational Safety and Health Administration (OSHA). It is hard to see a return on this kind of investment, except possibly *cost avoidance* since there may be a fine associated with noncompliance.

When the automakers first began to insist that their suppliers be able to accept orders electronically, there was little choice for vendors if they wanted to do business with Detroit. If you demanded an economic justification, you could determine the value of sales to the auto companies and compare that with the cost of EDI. However, most managers would probably not consider noncompliance unless they sold very little to Detroit. *Investing in this technology was a cost of doing business.*

Other kinds of required systems include managerial control and applications like budgeting and accounting. IT used for these purposes is important in running the company, but it is very hard to find a great deal of value, either in cost savings or revenue generation, from investing in managerial control technology.

If you insist on economic justification, then the relevant numbers are likely to be opportunity costs. What is the cost of not making the investment rather than what do we save or gain from this application? The upside here is almost none since you will probably invest in this technology and move on.

No Other Way. We have mentioned computerized reservations systems, but there are many more applications of technology that would not be feasible manually. Once you are on the plane, the Air Traffic Control (ATC) system takes over. Unfortunately, while we all depend on this system, severe management and under-investment problems have allowed the ATC system to become seriously outdated. But even with obsolete equipment, it is hard to imagine a manual replacement for it.

Think of the stock exchanges where hundreds of millions of shares trade hands every day. In the 1960s, the NYSE had to close one day a week to clear trades with a volume that is a fraction of today's. In October of 1998, the NYSE traded 1.2 billion shares in a single day!

The New York–New Jersey area has been implementing electronic toll collection at bridges and tunnels; it is to be extended to all area toll roads as well. Eventually, the same system should be in place on much of the East Coast. We know the manual, non-IT option; it is in place today with human toll takers and collection booths that do little to speed traffic flow. Getting motorists through the toll plazas faster would reduce their travel times and increase the capacity and utilization of the bridge, tunnel, or roadway.

The new system, called EZ Pass, requires the motorist to attach a transponder to the windshield. When a car so equipped approaches a toll gate, a device at the gate reads the account number from the transponder, charges the toll, and gives the motorist a green light to proceed. A driver may have an automatic account in which his or her credit card is charged when the toll balance reaches $10, or a manual account in which one sends a check. In the case of the latter account, a sign lights at the toll plaza when it is time to add funds. Drivers receive an itemized monthly statement showing the date, time, and facility for which they were charged toll. The manual system of toll takers has reached capacity; it is very difficult to add more toll booths in most locations. The only feasible way to expand capacity is through an investment in information technology.

If the task for which you are investing has to be done and there is no other way but with information technology, then you probably have little choice in the matter. Some of the high-profile applications have produced substantial benefits for the companies who innovated with technology. There is considerable upside potential if you are the first organization to develop this innovation. Certainly if you are the first mover, then there is a high probability of obtaining a return from investments here; a typical number might be a 75 percent probability of obtaining returns.

A Direct Return. Applications of IT in this category are the textbook case. You can measure an expected return, evaluate the costs, and use a number of capital budgeting techniques to decide whether to invest. Direct applications are well-structured, and estimating costs and benefits is relatively easy compared to other categories in the matrix. There is a very high probability of obtaining a return from investments in systems from which you see a direct benefit from the start. However, because you have identified the returns to start with, the upside potential here is probably not too great unless you can build on the system with some innovation.

An exception to these observations on the upside comes when there is the potential to affect a large portion of an industry. We will see an example of electronic data interchange in the automobile industry; this technology has also had a major impact on grocery and clothing retailers. Health care is another field in which there is great opportunity for major cost savings with technology.

Indirect Returns. This is a relatively new category that we have identified in some recent research on airline computerized reservations systems (CRS) in travel agencies. A simple example may help. Federal Express has a site on the Web where you can check on the location of packages. Before this service, the only way to check was to call a toll-free number and speak with an operator. Federal Express expects direct returns from this system through reductions in the use of its toll-free number and the ability to handle more inquiries with the same or smaller staff. *Indirect benefits* accrue from this technology if customers develop more loyalty to FedEx because it is easy to check on their package using the Internet. In a discussion of this example, a student mentioned that she had been on hold for 30 minutes the last time she called, so the time the system saves the customer is an added indirect benefit.

This example shows how difficult it can be to measure indirect benefits. In the airline CRS case, it was years after the development of these systems before the airlines placed terminals in travel agencies. For FedEx, how do you measure increased customer satisfaction and loyalty and relate it to revenues and profits? The potential upside is great from investments in this category, but very few applications result in significant indirect benefits. Given the difficulty of identifying indirect returns, and even of thinking what they might be, you probably are looking at a 50 percent or lower probability of obtaining indirect benefits from an investment in technology.

Competitive Necessity. While sometimes ideas for new technology innovations do not obtain an enthusiastic response from senior management, one argument that attracts notice is to say that "our competitors are developing a similar application," or worse, "our competitors have already implemented this system and are capturing market share."

One of the best examples of technology that is a competitive necessity is the bank automatic teller machine or ATM. Several researchers have studied ATMs to see if banks have reduced costs or increased revenues at the expense of competitors; one

Physical or Electronic Banks?

Chase Manhattan Bank makes a concerted effort to attract customers outside of its core New York metropolitan and Texas locations, which it serves through more than 600 branches. It targets over 30 million customers in almost every state for its banking services. The mechanism for this effort is technology, telephones, computers, and mail. Some 28 percent of net income at Chase is from consumer banking.

Chase is building a computer network and a database marketing capability to search customer data for sales possibilities. The database contains information about Chase customers who use its credit cards and/or regional banks. Chase used its databases to send out 300 million pieces of mail and as the basis for 140 million sales calls last year. Chase has to face the fact that 60 percent of Americans say they like to have branch banks available to them. Big banks like the merged NationsBanc and Bank of America are seeking the same customers through 4900 branches in the U.S.

In addition to its database, Chase develops custom applications for groups of customers. It has 7000 auto dealers using a system that provides approvals for a customer's loan application in about three minutes.

Chase has embraced the idea of a virtual bank; the question is whether consumers will be eager to use its electronic services. Given the increasing number of people connected to the Internet at work and home, it appears that the question is not if, but when, virtual banking will become the preferred way of handling financial decisions and transactions.

conclusion is that ATMs are simply a competitive necessity. There is evidence of a slight advantage to the first banks that installed ATMs, but all of that advantage has disappeared with banks forming networks of ATMs to meet customer demand for widespread ease of access. It is hard to imagine a bank today that does not offer ATMs.

At least at the time ATMs were first installed, there seemed to be few direct benefits. However, as technology matures, it is possible that an investment in this technology will have a payoff. As mentioned earlier in Chapter 1, the chairman of NationsBank indicated that the bank had closed about 150 branches in 1996 while installing between 600 and 1000 new ATMs. If customers are ready to accept fewer branch locations, ATM technology, which first was a competitive necessity, may become a way to substantially reduce costs.

What is the upside in investments in this category? Probably little if you are following others in the industry. Unless you can come up with an innovation, you are simply replicating your competitors. Any advantage you might gain from the system has already been competed away; my estimate is that there is a 20 percent chance of obtaining a return from your investment in systems that are a competitive necessity.

Strategic Application. Beginning in the 1980s there was a great deal written about the strategic use of IT. American Hospital Supply, which merged with Baxter International, only to be spun off again as Allegiance, provides a 30-year history of integrating technology with strategy. Since the publicity about Baxter and a few other companies, looking for strategic applications has become very popular. Several companies like Baxter, Merrill Lynch with its cash management account, and Brun Passot discussed in Chapter 1, have all provided success stories. Unfortunately, these stories have very little evidence; one has to make a lot of assumptions about the impact of the technology to be convinced that IT is responsible for the firms' successes.

A few of the strategic applications only became strategic after someone recognized that a rather ordinary system could be used for another purpose. For both Baxter and Brun Passot, technology made it easier for customers to place orders with the company. Each firm took advantage of this ability to provide better service and get closer to customers by devising new strategies based on technology. It is unlikely that they recognized their order processing systems as strategic applications when they were first implemented.

In cases where the strategic nature of a system becomes obvious only after it has been installed, it will be difficult to include strategic considerations in justifying the investment. Strategic advantage is often stated in terms of increased market share, something very hard to predict because of the response of both the market and competitors. If you can identify a system as strategic in advance, my estimate is that you have a 50 percent chance of seeing the kind of returns in market share you hope to obtain from your investment. We discuss IT and strategy further in Chapter 5.

Transformational IT. This type of investment is my favorite, and, of course, it is very difficult to implement. Here you use a combination of management and technology to change the basic structure of the organization. This kind of change,

MANAGEMENT PROBLEM 3-2

Block and Thomas, a regional stockbrokerage firm, hired a chief information officer (CIO), a senior manager who is responsible for all technology in the firm. The brokerage firm uses technology heavily as is typical in the industry. Block and Thomas has a number of systems to process stock trades and support its brokers. It also subscribes to a broker workstation system provided by a market data vendor. Each broker has a personal computer that provides a great deal of data and analytic capabilities in different windows on the screen.

The new CIO surveyed users and potential users at Block and Thomas. He concluded that in the past, users had very negative attitudes toward systems. However, the interviews he conducted convinced him that users' attitudes were now different. The users described problems but also mentioned that they were very optimistic about the potential of technology and wished they could implement the technology faster. The new CIO was surprised by the creative suggestions that came from users during the interviews.

What events do you think are responsible for the new attitudes on the part of users? How can the CIO take advantage of them?

as we shall see in Chapter 4, requires more than technology; management has to adopt a new philosophy as well. In the examples we shall see, the technology will not turn out to be all that sophisticated. However, management will use it in creative ways to define new organizational structures and modes of operation.

Examples of companies in this category include "T-Form" organizations; others have described virtual organizations and networked companies that fit in this category. While the technology here is often simple, the entire change program is risky. I estimate a 50 percent chance of obtaining a return from investing in technology for the purpose of transforming the organization. This estimate is low because firms introduce many, many applications without obtaining the changes they expect. Often the failure to obtain organizational changes occurs because management expects the technology to be enough to change behavior. If you are looking for a major change in the organization, then you might exert a significant management effort to create a transformation.

What Is Value?

The most common meaning of value is monetary worth; in the marketplace buyers and sellers place a value on goods and services that is measured in dollars. When an investor seeks a return on capital, it is expressed as a percentage of the original investment. However, the term **value** sometimes has a very remote connection with money; for example, a manager describes an employee who makes a valuable contribution to the firm. It might be possible to trace this contribution to the company's profits, but that is not the intent of the comment.

Some investments demonstrate traditional returns that can be expressed in monetary terms. Other examples require an effort to estimate an indirect return from an IT investment. Sometimes, it appears that an IT investment has prevented a negative return, for example, when a firm develops a system to keep up with a competitor and avoid losing market share. In instances where technology becomes intertwined with the strategy of the corporation, the contribution of IT seems very valuable, but exceedingly difficult to value.

In justifying IT initiatives, you will have to be creative in predicting the value the organization will receive from its investments. It is important to realize that there is more to value than a measurable financial ROI and that different kinds of IT investments provide different types of value.

THE CASE OF CHRYSLER

Chrysler Corporation illustrates how technology has become a central component of a modern firm. It shows how IT was used to dramatically improve operations and efficiency, and contribute to saving a company that was near bankruptcy on two separate occasions.

The dramatic success of Japanese auto manufacturers created a movement toward **lean production** and **just-in-time (JIT)** inventory. While these two concepts are often described as synonymous, JIT is only one part of lean production. Lean production begins with a different concept of a factory than the typical mass-production manufacturing facility (Womack, Jones, and Roos, 1990). In a lean production facility, space is kept to a minimum to facilitate communications among workers. One sees very few indirect workers like quality control inspectors, people who add little value to the final product. You are likely to find only a few hours' worth of inventory at each production station (yes, this is the just-in-time inventory).

If a worker finds a defective part, he or she might tag it and send the part to a quality control area to receive a replacement part. Each worker is probably able to pull a cord to stop the assembly line if there is a problem, yet the focus is on solving problems in advance.

When developing new products, a lean firm is likely to use matrix management and design teams. The chief designer of the Honda Accord "borrowed" people from appropriate departments for the duration of the project. Key decisions are made early in the design, and the team is not afraid of conflict. Because manufacturing representatives are on the design team, an effort is made to see that the new product can be manufactured efficiently.

A key aspect of lean production is coordinating the supply chain. A modern automobile contains some 10,000 parts, many of which come from outside suppliers. In a lean auto plant, over 70 percent of the components are likely to be purchased from external vendors. In the Japanese auto industry, the strategy is to establish long-term relationships with suppliers. The manufacturer will help the supplier improve production and quality; savings are split between the auto maker and the suppliers. What one gives up in terms of choosing from competing suppliers has to be made up by dependable and high-quality parts from the chosen suppliers.

This description of lean production has concentrated on the production process itself. The most important component of lean production, however, continues to be management and its beliefs about how the firm should operate. The GM-Toyota experiment known as the NUMI plant in Fremont, California, shows clearly how management's beliefs and attitudes affect innovation. The idea of the joint venture was that GM would learn lean production techniques from Toyota, and Toyota was in overall charge of the plant with various GM managers as a part of the management team.

The plant, using rather limited automation, achieved better production results on a number of measures than plants GM was heavily automating at the time. In spite of the clear benefits of lean production, it was resisted throughout the rest of GM, contributing to the ongoing crisis at the world's largest automaker.

An excellent example of lean production and just-in-time inventory comes from Chrysler which committed itself to lean production. It already was close to Toyota in the number of parts purchased externally—about 70 percent, compared to GM's 30 to 40 percent. Lean production at Chrysler meant working with some 1600 external suppliers that ship materials to 14 car and truck assembly plants in North America. This example shows how information technology, especially communications, enabled Chrysler to achieve its production goals.

Key to lean production and JIT inventory is **electronic data interchange (EDI),** in which electronic messages replace paper documents exchanged with suppliers. EDI is a common format for the electronic exchange of information between companies. In implementing lean production, Chrysler had some 17 million transactions per year with suppliers. These transactions included orders for parts, scheduling and rescheduling of deliveries, and payments upon receipt of the goods. The automaker began lean production in 1984, and by 1990, it reduced on-hand inventory from 5 days to 2 days, eliminating more than $1 billion from inventories. Information technology enabled JIT by providing high-speed electronic linking with suppliers and by making it possible to handle the huge volume of transactions in a short time.

Chrysler also followed the model for lean production set by the Japanese. It studied components and options, and redesigned them to reduce complexity. Engineers worked with suppliers to be sure parts were packaged so that they would not be damaged in transit; there was little buffer inventory to make up for a bad part. The marketing staff developed forecasts to stabilize schedules for the assembly line. A stable build schedule is important for suppliers so they know what goods to deliver and when to send them. Chrysler moved to in-sequence building to provide predictability for parts suppliers. A car begins the production process in a sequence and stays in that position until finished; you do not pull a car off the assembly line for special work.

Pay-as-Built is a program Chrysler has begun with some suppliers to further reduce transactions costs. In this program, Chrysler counts the number of cars built each day and computes the number of a vendor's parts in that car. The computers then wire payment to the vendor for the materials used during the day. If Chrysler built 1000 Jeeps with Firestone tires, it would pay Firestone for 5000 tires (four plus a spare) for that day. The vendor does not have to bill Chrysler, and Chrysler has many fewer transactions to process.

Chrysler also took advantage of its JIT capabilities to reduce **less-than-truckload** (LTL) delivery costs by 15 percent. With a predictable schedule on what is to be built, Chrysler developed scheduled pickup loops. A carrier now follows the same route each day, picking up from multiple locations. As a result, the LTL shipments are "consolidated," and the truck is chartered to Chrysler. Much like a school bus route, the same driver makes the same stops each day. This program has allowed Chrysler to trim some in-plant inventories from 2 days to 4 to 6 hours.

A study of Chrysler's efforts produced an estimate of a $60 per vehicle savings for the typical assembly plant attributed to electronic data interchange. (Mukhopadhyay, Kekre, and Kalathur, 1995). These savings come from reduced inventory holding cost and reductions in obsolete inventory, premium freight, and transportation costs. In addition, the researchers estimate that EDI saved $39 per vehicle in information handling costs, for a total savings of $100 per vehicle. At current production levels, the savings total $220 million each year for Chrysler.

The kind of production process described here could not function without information technology. The production automation of manufacturing systems includes forecasting, building plans and materials requirements planning, and creating the kind of stable production and advance notice required for lean production and JIT to work. Because the flow of parts has very little room for error, communications to suppliers must be instantaneous. Electronic linking and communications and electronic customer/supplier relationships are key to making JIT work. These design variables also contribute to efficiency, for example, through the electronic linking of the pay-as-built program.

What has happened to Chrysler's inventory? Where has $1 billion worth of goods gone? Chrysler now has a virtual inventory, and this inventory is no longer stockpiled at Chrysler plants. Instead, the inventory exists at suppliers and is linked to Chrysler through an electronic network. This network informs suppliers when goods are needed, and they in turn respond. But wait, what about the suppliers? Do they really have Chrysler's inventory in their warehouses? If Chrysler provides a supplier with predictable demand, then the supplier can practice JIT with its suppliers all the way back through the value chain for a product. Greater connectivity throughout the production system has driven out physical inventory and substituted the electronic flows of information. Certainly IT alone is not enough. The companies involved have to make many other changes in their operations. However, the technology described here is a crucial enabler of lean production and JIT inventory.

How does Chrysler fit our framework of Table 3-2? The JIT and lean production effort affected individuals, workgroups, the organization, and external organizations. Workers cannot count on having more than a few hours' worth of parts on hand; they depend on information systems to communicate with suppliers and on suppliers to deliver parts. The JIT effort involves managing and controlling the organization, decision making, interorganizational relations, reporting, and designing products and business processes. Technology includes transactions processing, databases, communications, networks database, and interorganizational systems.

CHAPTER SUMMARY

1. A framework helps to conceptualize a diverse field like information systems.
2. Simon as well as Gorry and Scott Morton provide insights into the different types of systems and decisions that one finds in an organization. The distinction between structured and unstructured decisions is important as we think about applying IT to problems in organizations.
3. An organization is a complex entity with many different components; the environment for applying technology is quite complex. As a result, we find a variety of technologies in place in firms. The prototypes include transactions processing, decision support, and communications-oriented applications.
4. We shall use a framework in the text that stresses the organization and its components: individuals' workgroups and links to external organizations. Individuals face a number of managerial tasks, and it is possible to support these tasks and the organization through a rich variety of technologies.
5. Different kinds of IT investments provide differing types of value to the firm. It may not always be possible to show a measurable financial return on an IT investment, but the investment may have a great deal of value for the firm.
6. The Chrysler case illustrates how a variety of information technologies enabled management to implement a lean production system, a system that has probably saved Chrysler from disappearing as a U.S. auto manufacturer and made it an attractive merger partner for Mercedes Benz.

IMPLICATIONS FOR MANAGEMENT

As a manager, you are interested in results. Why should you care about different kinds of technology? You will be using this technology to produce results, to solve problems, and to initiate new strategies. You may restructure the organization around IT. Unless you are fortunate to be starting a new enterprise, you will encounter a collection of hardware and software that has grown in the organization over time. Some of Chrysler's systems were first developed in the 1960s; they have been heavily modified, but they are still in use. You cannot afford to discard all old technology and replace it with new IT overnight, any more than Chrysler can rebuild its manufacturing plants every year. You will have to adapt and use a combination of old and new technologies to accomplish your objectives.

KEY WORDS

Architecture
Batch
Client-server
Command and control
Database
Edit
Electronic data interchange (EDI)

Electronic mail
Framework
Infrastructure
Interactive
Internet/Intranet application
Interorganizational system
Just-in-time (JIT)
Lean production
Models
Net present value
On-line transactions processing (OLTP)
Personal computer
Value
Virtual components

RECOMMENDED READING

Gurbaxani, V.; and S. Whang. "The Impact of Information Systems on Organizations and Markets." *Communications of the ACM,* 34, no. 1 (January 1991), pp. 59–73. (An interesting article on the impact of IT on the marketplace.)

Lucas, H. C., Jr. *Information Technology: The Search for Value.* New York: Oxford University Press, 1999. (A book that attempts to place IT investments in perspective.)

Mukhopadhyay, T.; S. Kekre; and S. Kalathur. "Business Value of Information Technology: A Study of Electronic Data Interchange." *MIS Quarterly,* 19, no. 2 (June 1995), pp. 137–156. (An interesting study of the impact of EDI at Chrysler.)

Stohr, E.; and B. Konsynski. *Information Systems and Decision Processes.* Los Alamitos, CA: IEEE Computer Society Press, 1992. (An excellent collection of papers on how information technology can support organizations and decisions.)

DISCUSSION QUESTIONS

1. How can information technology contribute to unstructured decisions?
2. Is there any role for batch processing given today's technology?
3. Why do you suppose inquiry-only applications were developed instead of fully on-line systems?
4. What are the advantages and disadvantages of providing access to a firm's transactions processing systems through the Internet?
5. Looking at Table 3-4, in what category does the Sabre reservations system fit best? Is there more than one category for this system? Please explain.
6. What are the major characteristics of the client-server model?
7. What advantages does client-server computing provide for users compared to mainframe applications?
8. What are the drawbacks of mathematical models applied to management problems?
9. What are interorganizational systems?
10. Why are standards important for the Internet?
11. What role does information technology have in managing a global business?

12. What are the social issues involved in having massive files of personal data available on-line?
13. What are the major differences between transactions processing and decision-support systems?
14. How does the Internet present a possible model for the future of technology?
15. One critic has suggested that management information can never be automated. What is your reaction to this statement?
16. What are the special requirements for a system like the one that controls air traffic?
17. Inventory control is a key management task. How does technology affect inventories? What has the impact of better inventory control been on the economy?
18. An entire industry exists for selling information. Make a survey of some of the data for sale and classify them by functional area, such as marketing, finance, or economics.
19. How does electronic data interchange enable lean production at Chrysler?
20. How can an IT innovation have value but not show a monetary return on investment for a company?

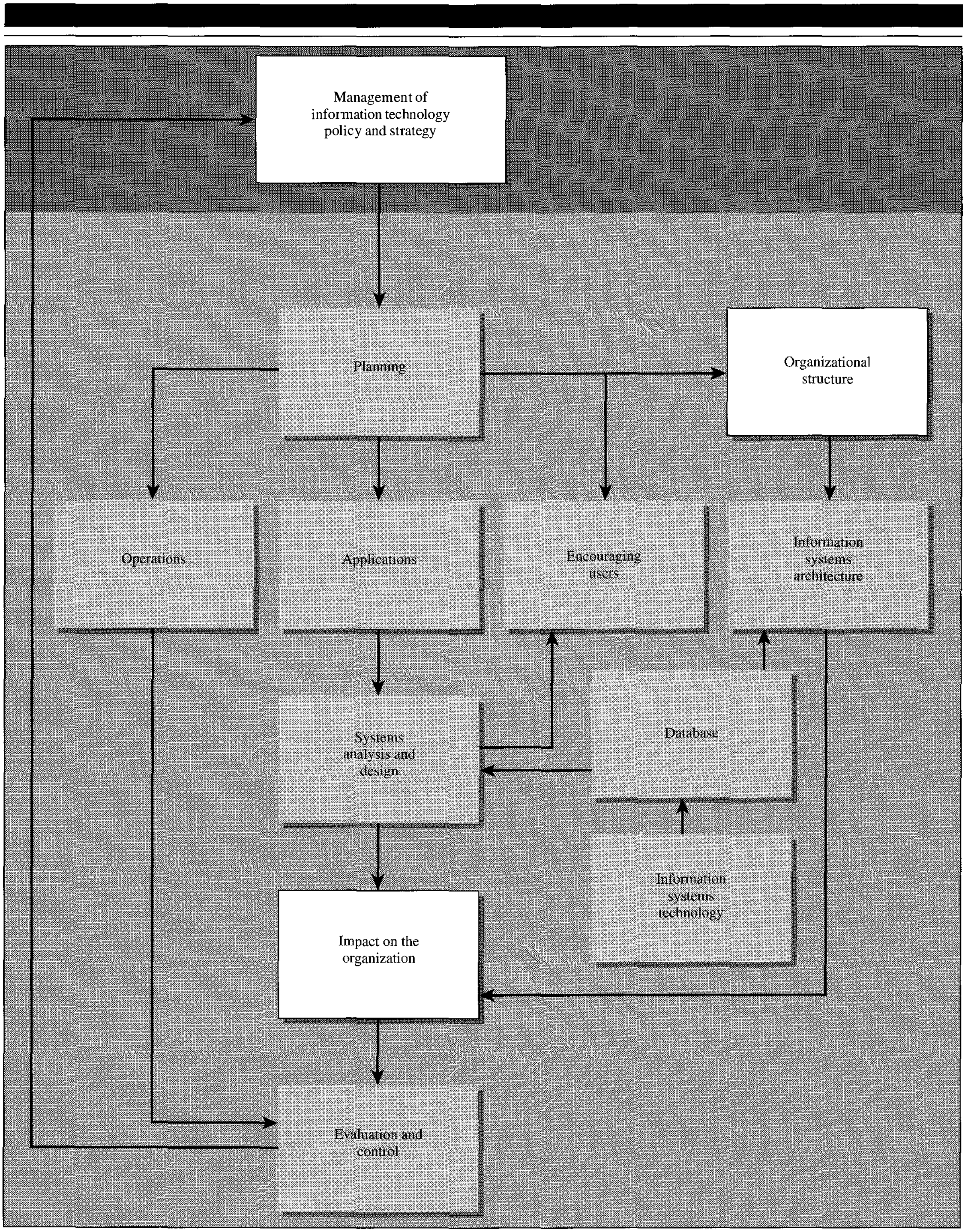
CHAPTER 3 PROJECT

Information Systems Critiques

There are information systems all around us. We encounter them at the university, in stores and banks, when making airline, hotel, or rental-car reservations, and in many other aspects of our daily routine. For this project, choose an information system and critique it.

First, describe the system: What are its objectives? Who are the users? What is the underlying technology including computers, databases, and communications network? Trace the input of the system to determine who inputs what information. Look at the output of the system. Is it a physical document? Often, systems have to store data on a more or less permanent basis in files or in a database. Can you figure out what is in the database for your system?

Draw a diagram of the input, processing, database, and outputs of your system. What are the major strengths of the system? Do you see any problems with it? What can you suggest to improve the system?


Management of information technology policy and strategy
Planning
Organizational structure
Operations
Applications
Encouraging users
Information systems architecture
Systems analysis and design
Database
Information systems technology
Impact on the organization
Evaluation and control

PART TWO

ORGANIZATIONAL ISSUES

In this part we emphasize how technology is used to create flexibility in the organization and how it provides new variables for managers to use in designing organizations. IT offers new ways to change the structure of an existing organization or design an entirely new nontraditional one. No longer is a physical location and time as important in constructing organizations. Technology can substitute for physical proximity and contact in a number of situations. *The design of information technology and the design of organizations have become the same task.*

Top management has a key role to play in the management of information processing activities in the organization. There is much emphasis today on using information technology as a part of corporate strategy, a topic that is addressed in depth in Chapter 5. We also see how difficult it is to sustain a competitive advantage when you have achieved it. Once you decide to be competitive with technology, you must continue to invest and develop new systems and services.

In this part, we also discuss information systems policy. What are the key areas for the involvement of top management? What policy should top management establish for the information systems effort in the organization? A successful information services function begins with strong and effective leadership at the top levels of the organization.

The last chapter in this section examines IT and international business. Firms are developing their international markets in order to grow and prosper; they are adopting a global strategy. What is the impact of IT on international business? What special problems do global operations create for managing information technology?

The Impact of Information Technology on the Organization

Outline

Focus on Change

In this chapter we see how technology can be used to dramatically restructure organizations, permanently changing the way they do business. In particular, note how technology has contributed to flexibility when looking at the organization as a whole, even though users may consider individual applications to be inflexible. The information technology variables discussed in this chapter have the greatest potential for transforming the organization because they provide a way to significantly change the structure of an existing organization or design an entirely new nontraditional one. Over the next few years, the ability to use technology to create novel organizational structures may turn out to be IT's most significant contribution yet.

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Information systems exist in the context of an organization; they do not operate in isolation. There are a number of definitions of organizations. For our purposes, an **organization** is a rational coordination of activities of a group of people for the purpose of achieving some goal. The activities of the group of people are coordinated; that is, there is a joint effort. In most organizations some division of labor and a management layer provide for the rational coordination of activities. The definition also contains the goals of the organization; there are many different types of organizations with different kinds of goals.

The formal organization is what appears on the organization chart, usually with well-defined reporting relationships among managers and workers that describe its structure. Social organizations, on the other hand, are patterns of coordination that arise spontaneously from the interaction of a group. Social organizations have no rational coordinated structure and generally lack explicit goals.

The informal organization is the pattern of relations and coordination among members of the formal organization that is not specified on a formal chart. It represents the social interaction and is a more realistic portrayal of the formal organization because it reflects how people actually interact. For example, a group of workers may form an informal task force using electronic mail or conferencing systems on a computer network; this task force cuts across traditional organizational boundaries and constitutes a temporary, informal organization.

We must be careful to avoid designing information systems that follow unrealistic standards and procedures. We may find that these prescribed rules are not actually followed and that our system is unworkable because we have adhered too closely to formal organizational considerations. It is hard to observe and describe the informal organization as it depends on the personalities of specific individuals and patterns of behavior that have developed over time.

MODERN ORGANIZATIONS

Unfortunately, we cannot point to one unified picture that has emerged from various approaches to the study of organizations. We still are confronted with many different ideas about organizations and the way they operate.

Organizational Structure and Design

There are many factors that influence the structure and design of modern organizations. New information technology also offers opportunities to create exciting new forms of organizations.

Uncertainty One of the major factors influencing organizations is **uncertainty.** Many authors suggest that managers try to eliminate or reduce uncertainty. An organization and its managers confront many different types of uncertainty. There are frequently technical uncertainties about whether a new product can be manufactured or whether it will work. Market uncertainties exist when the firm does not know how a product will be received, potential demand, response from competitors, and so on. The internal management of an organization also creates uncertainty. Key personnel may leave or individuals may not adequately perform their assigned tasks. Thus, the organization and its managers face many different types and degrees of uncertainty.

The importance of uncertainty is seen by examining organizations that face differing environments. Consider a chip manufacturer like Intel confronted with the dynamic environment of technological change versus the staid, conservative atmosphere of a regulated utility facing virtually no uncertainty. There is some evidence that uncertainty is most effectively handled by decentralizing decision making to a management level in the organization with information to resolve it.

Specialization Another major consideration in organizational design is specialization. Are specialized skills or conditions required for some tasks? Consider the activity of running a complicated machine tool versus sweeping the building; certainly, the former requires a specialist. From our standpoint, the information services department is highly specialized and requires a level of technological proficiency on the part of its staff.

Coordination When there is specialization, one task of management is to coordinate the diverse specialties to achieve the goals of the organization. Management must balance differing orientations and resolve disputes between specialized subunits. For example, the marketing department may want to produce a particular item in each style and color for every warehouse. This plan is best for reducing uncertainty and providing good customer service. On the other hand, manufacturing may want to make products of the same color and model because this procedure reduces the uncertainties in production; that is, there are fewer setups and smoother production runs.

Management must resolve these differences and coordinate the specialists. There are a number of integrating mechanisms to reduce the effects of differentiation or specialization. Sometimes organizations create special liaison positions or even departments to foster coordination. A major advertising agency has a group of expediters who see that the details of purchasing advertising time and space are organized and that the ads appear in the right place at the right time. We shall see later how information technology can also be used to help managers coordinate groups in the organization.

Interdependence The last factor we shall consider in organizational structure is interdependence; that is, how do the different departments or subunits within the organization depend on each other? Thompson (1967) has described three types of **mutual dependence.**

Pooled interdependence occurs when two organizations depend on each other because they are all components of a larger organization; one unit does not depend directly on another. For example, the different divisions of a conglomerate exhibit pooled interdependence.

Sequential interdependence occurs when the output of one unit is the input to another. For example, the painting and finishing department depends on outputs from component assembly. We can view each succeeding station on an assembly line as an example of sequential interdependence.

Reciprocal interdependence occurs when the output of each unit becomes the input for the other. For example, a student depends on the professor to explain concepts in class so that she can do her assignment and the professor depends on students to prepare for class.

Interdependence is an important consideration in organizational design. The type of interdependence affects the amount of power one unit has in the organization. In designing an organization or modifying the design (for example, through the development of a new information system), various interdependencies must be coordinated. The easiest type of interdependence to handle is pooled, the next hardest is sequential, and the most difficult is reciprocal.

What Is Organizational Flexibility?

Flexibility is the ability to adapt when confronted with new circumstances. A flexible organization defends quickly against threats and moves rapidly to take advantage of opportunities. Flexibility provides the organization with the ability to adapt to change and respond quickly to market forces and uncertainty in its environment.

Technology changes the pace of work. It has speeded up order routing and processing on the stock exchange. Technology has made it much faster to search a library book catalog, to communicate with someone at a remote location, and to perform a number of tasks. Technology can also be used to shorten product development cycles. In general, technology speeds up the pace of work and increases the capacity of the organization to process information.

Information technology also alters the space and time boundaries of work. Using electronic mail and computer conferencing, colleagues working on a project do not have to be in the same physical location. Even people who work together in the same office can communicate easily if traveling. With a portable computer and modem, you can conduct some kinds of business from virtually any location at any time of the day or night.

Thus, we see that technology has the ability to change the pace of work and to alter **time and space boundaries** for work. These impacts of technology can be viewed as increasing organizational flexibility. With properly designed systems,

TABLE 4-1

ORGANIZATIONAL FLEXIBILITY IN THE AIRLINE AND SECURITIES INDUSTRIES

Boundaries	Time	Nature and pace of work	Responsiveness
	Airline CRS stage 1*		
Remove boundary of manual centralized processing; make reservation from anywhere	Make reservation anytime	Confirmed reservation made instantaneously	Alter schedules in response to loads
	Airline CRS stage 2		
Boundary for making reservation shifts from airline to agent; airport boarding pass moved to travel agency	Extra service by agent, e.g., 24-hour assistance	Travel agent becomes more productive	Yield management programs allow instantaneous adjustment to demand for seats
	Securities firm back office		
Make data available to brokers on-line	Eliminate need to close exchanges early	Greatly speed processing of trades	Create new products and services
	Securities industry trading at exchanges and member firms		
Able to route orders without intervention of floor broker; floor becomes an extension of brokerage office; may remove need for floor, e.g., NASDAQ, London Stock Exchange	Movement toward 24-hour trading; passing the book around the world for currency; New York City to London to Tokyo; trade anytime	Able to execute trading decisions instantaneously	Enable new investment strategies

*Computerized reservation system (CRS).

the organization can increase its ability to respond to customers, competitors, and the environment in general.

Impact on Flexibility

Table 4-1 describes the history and impact of technology in the airline and securities industries.

Information Technology Runs the Airline

In the early days of airline travel, few people ventured forth on the relatively small propeller aircraft. If you wanted to make a reservation, everything was done manually, and there was no actual record associating your name with your flight. The airline allocated a number of seats to the departure city and to a few other cities. When the number of available seats began to dwindle, a reservations office would have to call a central location to be sure it could sell a seat. One never knew for sure if he or she had a reservation because a name was never associated with a reservations record.

In the late 1950s, American Airlines realized that its manual reservation process could not keep up with the expected growth in travel. At this time almost all civilian information systems ran in batch mode; that is, all data were collected at once, key punched, and used to update computer files at a later point in time.

Such an approach would not work for an airline reservation system because people throughout the country need to be able to update and inquire against files instantly. Fortunately, IBM had at this time completed a defense system called SAGE, which allowed operators to interact with real-time data from radar. The operator could display different information processed by computers from a console.

IBM and American Airlines established a joint project to develop an automated airline reservation system that would be on-line. IBM would develop the control programs that managed on-line processing, while American would write the applications program that provided the logic for making airline reservations. Surprisingly, the system was completed shortly ahead of schedule, though with a large cost overrun, and provided a basis for the development of others like it by competing airlines.

The computerized airline reservation systems maintain a large database that contains the names of passengers associated with their flights. In the early days these systems were known as passenger name reservation (PNR) systems because the idea of keeping a name with a flight was so novel. The difference in service is incredible when the computerized reservation systems (CRSs) are compared with their predecessor manual system.

What was the initial impact of the airline reservation systems? They removed the limitation of a manual, centralized reservations group. In terms of time and space, you could make a reservation anytime of the day or night from virtually anyplace in the world.

The features of these systems contributed to their secondary impact: a competitive advantage based on customer service. Airlines with reservation systems could provide better service to their customers. They could also better manage the airline because they had historical data on reservations and boardings. Using their reservation system as a base, airlines have added many functions ranging from meeting special dietary requests to balancing the loading of the aircraft.

A third effect is that one would have great difficulty starting up an airline without a reservation system. Donald Burr, chairman of People Express, pointed out the lack of a decent reservation system as one of the factors that contributed to the demise of his airline. People Express had too few reservation lines; it was not unusual for customers to be unable to reach them from early morning until late evening because of the large number of callers.

In addition, in recent years the airlines developed yield management systems; these programs look at future flights and dynamically adjust the number of special-fare seats depending on the number of reservations so far. Burr felt that the airlines could use their systems to target People's flights, and competitors could selectively lower their fares on competing routes and still keep up their margins on other routes.

Co-opting the Travel Agent

For several years the airline industry waited for an agreement on a common reservation system to be placed in travel agents' offices. Finally, United and American decided not to wait any longer and began placing terminals connected to their systems in travel agencies. This move proved to be a tremendous benefit for both the agent and the airline.

One first-order impact was a dramatic increase in the productivity of the travel agent. One of the most tedious and time-consuming tasks in an agency is writing tickets; the agency CRS came with ticket printers. Once the agent made a reservation, he or she could have the ticket printed automatically. Immediately each employee of the agency could write more tickets in a day.

Another major first-order impact is the change in organizational structure and boundaries for reservations. The travel agent has become an extension of the airline's own reservations operation. Enhancements to the systems allowed agents to issue boarding passes with tickets. Thus, part of the boarding process has moved from the airport to the travel agency. Information technology takes care of the first part of boarding the plane well before the day of the flight. Today many airlines offer electronic tickets; you do not receive a physical ticket and the airline does not have to process your ticket! IBM estimates that it costs $8 to print a physical ticket and less than $1 to create an electronic ticket. What will the impact of E-tickets be on travel agents?

Each airline tried various approaches to using a CRS to increase its own bookings. First, the host carrier (the airline whose system is used by the agent) would list his or her flights first. That is, on American's SABRE system, American's flights between two cities always appeared first. Because over 90 percent of flights are booked from the first reservation screen, the host airline enjoyed a tremendous advantage.

Delta and other airlines complained about this inherent bias in computerized reservation systems. The Department of Transportation investigated and issued a series of rules requiring listings that did not unduly favor the host carrier. The carriers made the changes, grudgingly. By this time, American and United had spent well over $250 million each on their systems and they felt they deserved the rewards from that investment.

A second-order impact of the system is a revenue-generating feature. In addition to the "halo" effect of more bookings from CRS-equipped agencies, the airlines with agency installations gained revenue. When an agent using American books a ticket on Northwest, Northwest must pay American a booking fee of about $2.50 to $3.00 per leg. There is one story of a travel agent in Minneapolis who booked most flights on Northwest, but used the United Apollo system and in one year generated $1,000,000 in fees for United.

Recent suggested prices place the market value of SABRE at $3 billion. A third-order impact is the high value of this CRS resource.

The airline CRSs provide flexibility for the airlines, travel agents, and travelers. Technology has affected the booking of flights and managing of passengers from reservation to flight completion. Service is speeded up and is more convenient. The boundaries in time and space in making a reservation have changed as has the entire process of booking a flight and boarding a plane. Not only is the airline CRS an example of flexibility, it also illustrates the first-, second-, and third-order impacts of information technology.

Technology Transforms the Securities Industry

Historically, stock exchanges have seen constant increases in volume. From an information processing standpoint, of course, the value of a transaction does not affect back-office functions. If one share or a million shares change hands, the same processing is required. In the 1960s the New York Stock Exchange was closing early because it could not keep up with the paperwork for processing and clearing trades. Yet the volume then was a fraction of today's volume; in October of 1998, the Stock Exchange had its first day in which trading exceeded one billion shares.

As shown in Table 4-1, the securities industry invested in extensive automation of back-office functions, first for handling trades and then to provide information for stockbrokers and traders. Data became available on-line to account representatives, showing them their clients' position so that they could provide better service. These systems eliminated a bottleneck of time in processing by speeding up the flow of transactions. The New York Stock Exchange developed systems to facilitate routing orders faster to the floor without requiring a floor trader. Brokerage firms also streamlined their communications with floor brokers so orders got to the broker quickly. A second-order impact of this technology is its ability to make possible new trading strategies; for example, program trading is greatly facilitated by rapid order execution.

Program trading involves buying or selling a basket of stocks that mirrors a stock index like the S&P 500. At the same time, the program trader must buy or sell the corresponding futures index on the Chicago exchange. The trader sells the more expensive of the two and uses the proceeds to buy the less expensive. This kind of arbitrage has generated a great deal of trading volume and controversy.

First, program trades are created through computer programs that contain the logic used by the program trader. These programs search for an imbalance in the price of the stock index future and the underlying basket of stocks that make up the index; the programs then notify the trader who can then generate the appropriate buy and sell orders. The orders are probably created by the computer and sent to automated exchange systems for execution. Because the price difference exists for only a short period of time, it is important for the buy and sell executions to be as fast as possible. If an order is too large for an automated exchange system, the trader can generate a large number of trading documents for floor brokers using the computer again. Various studies of program trading do not blame it for increased market volatility or reduced liquidity. In terms of third-order impact of the technology, it seems logical there is an effect on volatility and liquidity as technology facilitates large-sized holdings and trades.

When the stock market crashed in October 1987, one mutual fund sold more than $1 billion worth of securities. Without information technology, could that firm have managed a multibillion-dollar portfolio? Without technology, could it have generated enough sell orders to liquidate a billion dollars' worth of securities? That day other firms liquidated securities worth hundreds of millions of dollars. The combined impact and demand for liquidity sent prices downward, possibly reinforced by another tool called portfolio insurance. It is possible that program trades and portfolio insurance interacted early during the crash to put pressure on prices. (Later, however, price information was running so far behind that program trading does not seem to have been possible.)

Natural Growth Generates an Impact

Technology dramatically affected the securities business. At first, the use of technology was for routine transactions processing. Soon the brokers realized the value of the back-office information since it enabled them to know their customers' positions. Traders also adopted technology to facilitate new trading strategies. The confluence of all of these trends has led to a highly automated industry critically dependent on information technology.

Several exchanges are entirely automated or moving in that direction. The "Big Bang" in London, which eliminated fixed brokerage rates and encouraged off-floor trading, has emptied the floor of the exchange. The NASDAQ computer system for over-the-counter stocks in the U.S. has no actual exchange floor; technology has eliminated the need for a physical place to meet to buy or sell stock. By 1995 there were days in which the volume of stocks traded on the NASDAQ exceeded the volume on the New York Stock Exchange.

By 1999, all the major exchanges were looking at replacing or supplementing their trading floors with electronic exchanges. Today several exchanges offer after-hours trading—even 24-hour trading may become routine. After-hours trading will take place only through computers and communications networks. Within a few years, it should be possible to trade securities from virtually anyplace in the world, anytime of the day or night. (Currently you can enter trades at several brokerage firms like Charles Schwab and E-TRADE at any time, but they are executed only when the market is open.) Technology will completely remove time and space requirements for trading.

Conclusions

These examples show how information technology affects organizational flexibility in two major industries. It undoubtedly contributes to flexibility in other firms and industries as well. Technology has the ability to change the nature of work, primarily by speeding it up, and to alter the time and place of work. In some instances, flexibility has surprises and unanticipated consequences. The government has placed certain requirements on the securities markets and on the ways in which airlines can use their computerized reservation systems. Certainly we want to encourage flexibility, but we must also anticipate the impact of technology on our firms and industries.

CREATING NEW TYPES OF ORGANIZATIONS

Technology makes it possible to create new forms of organizations through the use of different design variables. A variable is something that takes on different values. For example, one calculates the interest payment (P) on a simple loan by taking the interest rate (i) times the loan's outstanding balance (B) or $P = i\ B$. In this equation, P, i, and B are all variables; they can take on different values. The interest rate might vary for different customers or types of loans. Obviously the outstanding balance will differ among loans.

For organizations, we have design variables like the span of control, a number that can take on different values. An organization that has chosen a span of control of 7 subordinates for each manager will be hierarchical while one that chooses a span of 20 will be much flatter.

Table 4-2 shows examples of key organization design variables that you can use to build organizations. This table contains two types of variables: those labeled conventional and those that come from information technology. Information technology is defined to include computers, communications, video conferencing, artificial intelligence, virtual reality, fax, cellular and wireless phones and pagers, etc.

The problem with conventional organization design literature is its failure to recognize the new design variables enabled by information technology. In the case of linking mechanisms, IT such as e-mail or groupware can be used instead of conventional solutions such as task forces or liaison agents. The new IT-enabled variables may be totally distinct from traditional design variables as we shall see when we examine "virtual corporations." IT-enabled variables may also be an extension of traditional variables, as in the case of linking mechanisms.

In Table 4-2, conventional design variables drawn from the literature on organization design are contrasted with new kinds of IT design variables. The first column of the table groups conventional design variables into four categories: structural, work process, communications, and interorganizational. The third column presents new organizational design variables made possible through information technology. These electronic variables are:

Structural

Virtual components: The organization can use IT to create components that do not exist in conventional form. For example, some manufacturers want parts suppliers to "substitute" for their inventory. The supplier is linked through electronic data interchange with the manufacturer. Using overnight delivery, the supplier provides parts to the manufacturer just as they are needed for production. The manufacturer now has a virtual raw materials inventory owned by the supplier until it arrives for production.

Electronic linking: Through electronic mail, electronic or video conferencing, and fax, it is possible to form links within and across all organizational boundaries. New workgroups form quickly and easily. Electronic linking also facilitates monitoring and coordination, especially from remote locations.

TABLE 4-2

CONVENTIONAL AND *IT* DESIGN VARIABLES

Class of variable	Conventional design variables	IT design variables
Structural	Definition of organizational subunits	Virtual components
	Determining purpose, output of subunits	Linking mechanisms
	Reporting mechanisms	
	Linking mechanisms	Electronic linking
	Control mechanisms	
	Staffing	Technological leveling
Work process	Tasks	Production automation
	Workflows	Electronic workflows
	Dependencies	
	Output of process	
	Buffers	Virtual components
Communications	Formal channels	Electronic communications
	Informal communications/collaboration	Technological matrixing
Interorganizational relations	Make versus buy decision	Electronic customer/ supplier relationships
	Exchange of materials	Electronic customer/ supplier relationships
	Communications mechanisms	Electronic linking

From Lucas and Baroudi, 1994.

Technological leveling: IT can substitute for layers of management and for a number of management tasks. In some bureaucratic organizations, layers of management exist to look at, edit, and approve messages that flow from the layer below them to the level above. Electronic communications can eliminate some of these layers. In addition, a manager's span of control can be increased since electronic communications can be more efficient than phone or personal contact for certain kinds of tasks, particularly those dealing with administrative matters. Technology makes it possible to increase the span of control and possibly eliminate layers in the organization, leveling it in the process.

Work Process

Production automation: The use of technology to automate manufacturing processes is well documented in magazines and newspapers. IT is also used extensively for automating information processing and assembly line tasks in the financial industry. In cases where the product of a firm is information, IT is the factory. For white collar workers, intelligent electronic agents that roam networks provide one type of automation.

Electronic workflows: Interest in process reengineering has led to the development of workflow languages and systems. As organizations eliminate paper and perform most of their processing using electronic forms and images, workflow languages will be used to route documents electronically to individuals and workgroups that need access to them. Agents that can traverse networks to find information and carry messages will facilitate electronic workflows. Electronic workflows also contribute to the monitoring and coordination of work.

Communications

Electronic communications: Electronic mail, electronic bulletin boards, and fax all offer alternatives to formal channels of communications.

Technological matrixing: Through the use of e-mail, video and electronic conferencing, and fax, matrix organizations can be created at will. For example, a company could form a temporary task force from marketing, sales, and production using e-mail and groupware to prepare for a trade show; participants would report electronically to their departmental supervisors and to the team leader for the show, creating a matrix organization based on technology.

Interorganizational Relations

Electronic customer/supplier relationships: Companies and industries are rapidly adopting electronic data interchange (EDI), Internet, and Intranet technologies to speed the ordering process and improve accuracy. These technologies help the organization monitor and coordinate relationships with other organizations, for example, firms acting as virtual components.

It is interesting to note that there is no specific IT variable next to the traditional variable "control mechanisms." Firms have used information systems to provide control after the organization has been designed. Examples include budgets, project management applications, and similar monitoring systems. For example, Mrs. Fields Cookies uses a variety of traditional and IT variables in creating an organization with extensive controls. However, even in this case, there is no one IT control variable in the design.

Examples of Designs Using IT Variables

The variables in Table 4-2 can be used to create the T-Form (technology form) organization. In addition to the T-Form, it is possible to characterize four new organization structures that make use of the IT design variables. These prototypes show a mixture of conventional and IT design variables and suggest some of the rich organization forms that will appear in the future.

Table 4-3 shows each organization and how the IT design variables contribute to its development. In some cases the IT variable has a substitution effect for traditional

TABLE 4-3

***IT* DESIGN VARIABLES AND FOUR PROTOTYPICAL ORGANIZATIONS**

Organization variable	Virtual	Negotiated organizations	Traditional	Vertically integrated conglomerates
Virtual components	Substitute electronic for physical components	Substitute electronic for physical components	Use to replace isolated components	Force component onto electronic subsidiary
Electronic linking and communications	Essential part	Essential part	Optional	Essential part
Technological matrixing	Participate in matrixed group	Use for coordination	Use for various groups	Use for coordination and task forces
Technological leveling	Use to supervise remote workers and groups	NA	Use to reduce layers of management	Use to reduce layers of management
Electronic workflows	Crucial part of strategy	Crucial part of strategy	Use where applicable to restructure work	Key to coordinate work units
Production automation	NA	Communicate designs	Use where applicable	Coordinate production among work units
Electronic customer/ supplier links	Used extensively	Used extensively	Potentially important	Key to operations

From Lucas and Baroudi, 1994.

elements; in other cases it is necessary for the very existence of an organization form. In certain instances, the IT variable is optional or not applicable.

Conventional organizations have historically grouped workers together to establish communications and coordination. In contrast to physical presence, IT design variables allow for virtual organization structures. The virtual organization started 15 to 20 years ago as people began to see the possibilities of using technology for work at home. With electronic communications a physical organization is not needed for many kinds of tasks. For example, many catalog operations use individuals working from their homes using a phone connected to an 800 number.

The virtual organization creates new management and coordination challenges. The kind of virtual office described above may be necessary to assuage a manager's misgivings about supervision. Perhaps all members of this nonorganization will log in to virtual offices each morning to report in and have an electronic discussion with a supervisor. Microsoft offers Netmeeting on its network which makes it possible to coordinate work on PCs in different locations. CU-SeeMe is a program developed at Cornell. It is free and lets users on the Internet set up small videoconferences using inexpensive cameras.

MANAGEMENT PROBLEM 4-1

The traditional organization is characterized by tacit understandings among managers and subordinates. In some instances, the rights and responsibilities of each group are contained in a detailed contract, such as the one between a union and management. Under a tacit understanding, an employee responds to a supervisor for a number of reasons. Custom or habit is a very important reason; organizations throughout history have functioned through a hierarchical relationship like that found in the armed forces. A manager usually has the ability to determine the subordinate's pay and can even arrange to have the subordinate dismissed. Because there is a long history of this type of relationship, most people in organizations are quite comfortable with it.

In some of the organizations described in this chapter, managers form alliances with various partners. These alliance firms may provide a virtual component for your organization. However, the employees involved in this alliance do work for two different firms. How does a manager manage under these conditions? Suppose that your firm enters into a relationship with another firm to take over its inventory of raw materials and to become a just-in-time supplier. The partner firm hires your former inventory employees so they no longer work directly for you. Describe the role of a manager in working with an alliance partner that provides you with a virtual component of your firm.

At first, only technology companies like IBM and AT&T eliminated employee offices. AT&T found that eliminating commute time with a home office allowed the sales force to spend 15 to 20 percent more time with customers. Now, other firms like Chiat-Day, an advertising firm, have eliminated physical offices for a large number of employees. When Compaq Computer Corporation moved its sales force into home offices, sales and administrative expenses went from 22 percent to 12 percent of revenue partially due to this change. Perkin-Elmer, a scientific equipment manufacturer in Connecticut, based 300 sales and customer-service representatives in their homes, which allowed it to close 35 branch offices.

A second kind of IT-enabled organization is labeled "negotiated agreement." A flower company in California, Calyx and Corolla, is based on two negotiated agreements. (See Figures 4-1 and 4-2.) The first agreement is with Federal Express to deliver flowers overnight to any destination in the US at a favorable rate. The second agreement is with flower growers. Instead of selling exclusively to wholesalers, the growers agree to put together a number of standard arrangements. The final part of the organization is an 800 number staffed by clerks who take orders. The orders are sent via phone or fax to growers who prepare and address arrangements for pickup and delivery by Federal Express.

Through these negotiated agreements and communications technology, this company feels it can compete with the neighborhood florist and FTD. Calyx and

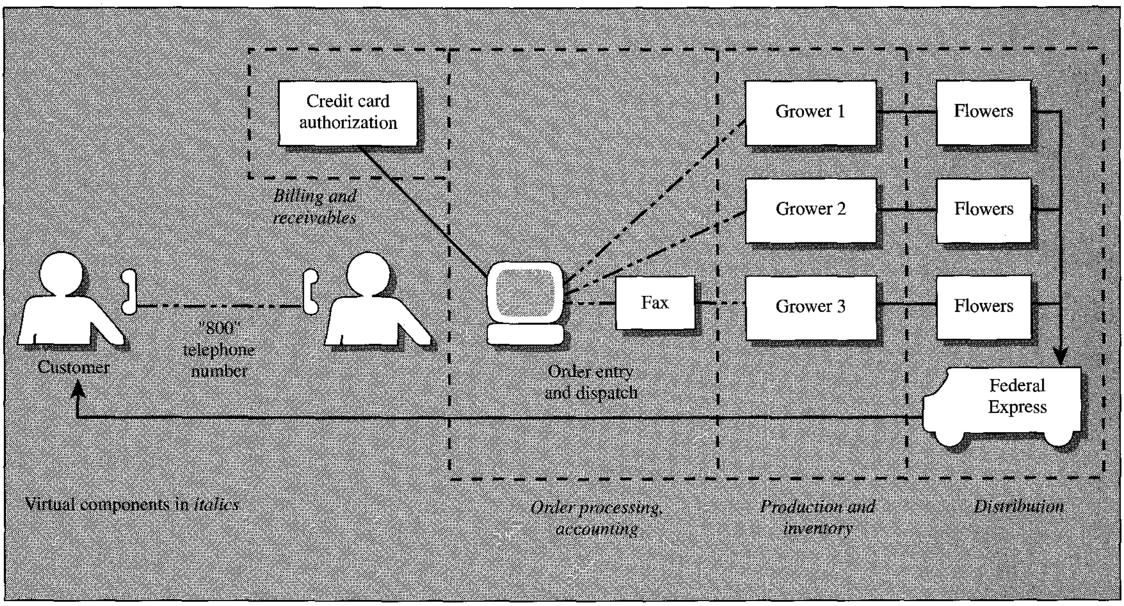

FIGURE 4-1
A virtual negotiated-agreement organization.

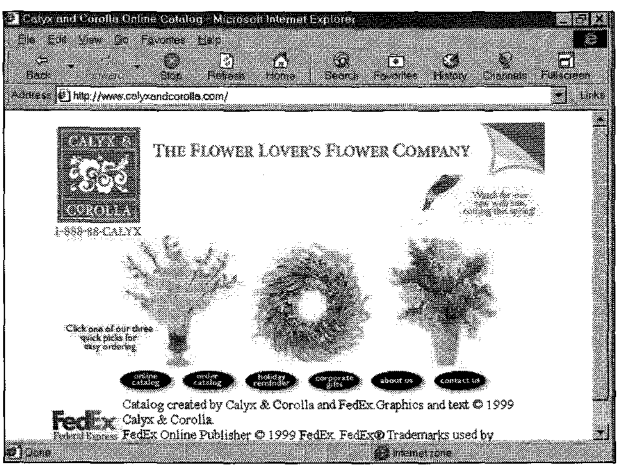

FIGURE 4-2
The Calyx and Corolla web site.

Corolla is a negotiated organization in that its existence and profitability depend on the agreements it has with others and the service supplied to its customers by others. Calyx and Corolla is, in effect, a broker using IT to coordinate its negotiated production facility and its negotiated delivery system.

The management challenge for the negotiated organization is to maintain service and quality. The firm depends on its partners to provide a product or service and yet has limited direct supervision of the business. Meeting service targets and deadlines and assuring adequate quality control can be difficult. As an example, the floral firm might place random orders with its growers to have flowers sent to its own management to test delivery time and product quality. Just as department stores have used "shoppers" to test their own personnel and service, and to check on competition, the negotiated organization will need "electronic shoppers." Unlike the purchase of some off-the-shelf product, an alliance that creates virtual components results in ongoing interdependence between the two partners.

The two types of organizations described above are quite different from conventional corporations. Traditional organizations are also using technology to make some changes in structure without making major modifications to the entire organization. An electronics manufacturer has set up a just-in-time electronic data interchange (EDI) link with a parts supplier, changing one component of the organization; the supplier can now be viewed as part of the manufacturer's raw material inventory.

The traditional organization may call its redesign efforts "reengineering." Merrill Lynch, for example, completely redesigned the way it processes physical securities turned over by customers. This effort resulted in the closing of two processing centers and the creation of a new processing site. The firm adopted image processing to dramatically reduce the need to physically handle securities. In this process redesign, the total number of individuals employed in handling securities has been cut by 50 percent. Finally, with the process running smoothly, Merrill Lynch outsourced its operations and systems to a third party.

There are many examples of the use of IT design variables to make changes in parts of traditional organizations. A management challenge in the traditional organization is to transform the organization enough so it can take advantage of the cost savings and competitive opportunities made possible by technology. The objective of process reengineering is to make dramatic improvements in how an organization functions. Today's business environment is characterized by rapid changes, and the traditional organization needs to take advantage of technological leveling to reduce layers of management, technological matrixing to improve coordination, and electronic workflows to reduce paper handling.

The traditional organization today is at risk unless it progresses toward the virtual model and the T-Form to improve responsiveness. IBM, one of the largest and most admired "blue chips" in the 1960s and 1970s, struggled for a number of years with declining market share and bureaucracies that resisted the kind of sweeping changes necessary to be competitive. IT organization design variables help restructure traditional organizations by making them more flexible. However, bringing about the kinds of changes that are possible given the technology is a formidable management task not well suited to the traditional organization.

We labeled the last IT-enabled organization prototype a "vertically integrated conglomerate," a form viewed with mixed emotions. The movement toward greater electronic exchange of data between customers and suppliers creates vertically integrated conglomerates. This form will more likely emerge if there is a large power imbalance between the customer and the supplier.

As an example, General Motors requires all its suppliers to use electronic data interchange. For some suppliers, GM is such a large proportion of their business that the supplier becomes a component of GM, responding to its orders and demands. GM sends orders to the supplier's production-scheduling system and is permitted to modify production schedules, priorities, etc. As a result, GM obtains a substantial amount of control and can sever the relationship at any time for little or no investment. Vertically integrated conglomerates may not be desirable for all organizations.

It should be made clear that managers must be careful when establishing electronic links. The efficiency is very appealing, but the link may lock a firm into a relationship that reduces its independence. Until the links are standardized—for example, using an industry standard or an X.12 EDI protocol—firms involved have more flexibility in switching business relationships. If a link goes beyond simple exchange transactions and actually gives a customer access to one's production-planning systems, then the supplier risks becoming a part of a vertically integrated conglomerate, for better or for worse.

Adding People to the Design

One reaction to the discussion so far may be that it is a bit sterile—that is, where are the people? When do we consider how individuals relate to one another, how they are rewarded, and what is the nature of the tasks they perform? Where are

A Town for Telecommuters

Telluride, Colorado, a ski resort high in the Rocky Mountains, has become a haven for hardy telecommuters. Community leaders decided that this remote town needed connections to the Internet (see Chapter 12) and with help from the nonprofit Telluride Institute, it has been able to provide Internet accounts for fully one-third of its 1500 residents. A few years ago, the town only had analog, party line phones! Town officials convinced U.S. West to replace these lines with private digital lines and to run a fiber optic trunk line to the town. The closest Internet connection was in Denver, which meant high phone bills to use the Net. With grants from the state, the town was able to buy two computers and create an Internet server for the town and a town bulletin board. These two servers are available through a local telephone call. Apple Computer heard about the town's projects and donated eight Macintosh computers to put in public buildings, creating an overnight sensation as residents took to "cruising the Net." The town is also providing high-speed wireless communications, though this service is much more expensive for users. Many vacation-only residents now live full-time in Telluride and use electronic communications in place of physical presence.

Just-in-Sequence at Mercedes Benz

In late 1997, Mercedes Benz began selling an aggressively priced sport-utility vehicle made in Alabama. The M-Class Mercedes costs a few thousand dollars more than a Jeep Grand Cherokee or Ford Explorer; it has already won praise from reviewers. The plant has gone one step beyond just-in-time (JIT) manufacturing, where suppliers build components like seats weeks in advance and deliver them a few days or hours ahead of production. Mercedes is trying just-in-sequence manufacturing.

As a vehicle goes through the paint shop, a computer sends an order to a supplier, like Johnson Controls in Wisconsin, to deliver a dashboard within a few hours. The plant assembles cars in which other suppliers manufacture 70 percent of the components. The objective of just-in-sequence manufacturing is to dramatically reduce inventory management costs. The company contracted with IBM to develop the system for its 2 million-square-foot plant; IBM has installed enterprise resource planning software from The Baan Company.

In this example, information technology provides electronic linking and communications and ties Mercedes to its suppliers. The objective is to reduce inventory management effort and costs while maintaining scheduled production.

organization politics? For the most part, politics and emotions in organizations are not of concern in IT-enabled organizations; they are no different here than in conventional organizations! Politics and the beliefs of senior managers are likely to determine the direction of the firm, its strategy, and how resources are allocated. The design remains neutral as its focus is on creating an efficient and competitive organization.

While politics and emotion are not unique to IT-enabled firms, people and tasks are an important component of any organization. The framework in the last chapter shown in Figure 3-1 shows that *in addition to structure and technology, an organization consists of people and tasks.* As some of the examples show, it may be difficult to change an organization if one only attempts to alter its structure. People and tasks may create the greatest challenge for the manager who wants to change the organization.

Table 4-4 adds people and tasks to the structure and technology to provide a more complete picture of organization design. The first three organizations in the table are conventional and show typical assumptions about people and task structuring along with examples.

In a rigidly hierarchical organization, tasks are separated and decision making is done within strict guidelines. Tasks are defined by rules and practice to avoid risk. Bureaucracies assume employees need to be motivated so they provide elaborate standards and procedures to tell them how to do a job. A professional services firm, on the other hand, is based on trust and professional conduct. For example, members of law and consulting firms tend to define their own tasks.

TABLE 4-4

ADDITIONAL DESIGN VARIABLES

Structure and technology (grouping, tasks, jobs, linkages)	People: Assumptions about motivation	Tasks—especially decision making	Example
Rigid hierarchy	People need external motivation	No delegation; tasks designed for employee	Military organizations
Bureaucracy	People want direction and procedures, are not good decision makers	Limited delegation and decision authority	Government, university (administration)
Adhocracy	Trust, professionalism	Loosely defined; individual decides how to best accomplish tasks	Law firm, university (faculty)
Virtual	Trust, self-control	Distributed decision making	Organization of the future?
Negotiated agreement	Trust in partners/alliances	Basic tasks defined in agreement; details left to individuals	Calyx & Corolla flower company
Traditional with electronic components	Mixed, some suspicion and self-control assumed	Tendency to define tasks for lower-level employees; some discretion for managers	IBM
Vertically integrated conglomerates	Control-orientation; individuals in linked organizations expendable	Tasks tend to be designed for employee, even those in linked organizations	GM

From Lucas and Baroudi, 1994.

The virtual organization has to be based on trust and minimal supervision. We expect that this type of organization will be more common in the future as a number of forces, from child care to clean air, argue for fewer, centralized workplaces to eliminate unnecessary commuting.

In a negotiated organization, one must trust employees who are in allied companies. An agreement may specify the required output or level of service, but it will be up to each member of the alliance to accomplish its tasks as it sees fit.

The traditional firm with electronic components tends to be large and will treat its employees in a variety of ways. Technology can be used to distribute responsibility to lower-level managers or to centralize control over the organization. This structure depends on the firm's assumptions about employees and how it defines tasks, especially decision making.

The vertically integrated **electronic conglomerate** is very control-oriented as it drives the systems of a different organization; it avoids the expense, the need for, and the risks of traditional vertical integration. As a result, it tends to specify clearly how the firms connected to it electronically must operate.

BUILDING A T-FORM ORGANIZATION

Chapter 1 introduced the T-Form organization. The IT design variables in Table 4-2 can be used to create organizations with the characteristics described in this first chapter. It is likely that you will use these variables to design organizations and their components. An example below shows how to create a new organization using information technology.

People in the T-Form

The pure T-Form organization operates with the assumptions about people found in the virtual and negotiated agreement organizations, where managers base supervision on trust in employees and their self-control. It is not possible to exert close physical supervision. Managers also have to trust partners in business alliances since both partners depend on each other. The details of how people define and execute their tasks is left up to the employee. Decision making is moved to the lowest level of the organization where people have the information and knowledge to make the decision. People and tasks are an extremely important component of the T-Form organization.

Other Design Possibilities

The T-Form organization is a generic model for a technologically enabled organization. The same IT design variables can be used in a variety of ways to create very different types of organizations, all of which have some of the characteristics of the T-Form. Figure 4-3 presents simple structural models of five different organizations.

Frito-Lay is a major producer of snack foods like Fritos Corn Chips. The company invested heavily in hand-held computers for its drivers and a satellite

MANAGEMENT PROBLEM 4-2

Boats-R-Us operates a group of 50 discount marine supply houses throughout the U.S., primarily on the east and west coasts and around the Great Lakes. The company has both walk-in and mail-order business. It has been organized traditionally as a retail store and several warehouses. A central order processing site accepts orders over 800 numbers and by mail and fax; this site distributes the order to the warehouse that is closest to the customer and that has the products requested in stock. A large number of purchasing agents is involved in determining what to stock and in negotiating purchases.

The president of the company has read about new organizational forms enabled by information technology. The only technology in place now is the order entry and warehouse inventory system. The president would like to make Boats-R-Us both more efficient and more responsive to its customers. What new kinds of organization forms for Boats-R-Us might be enabled by information technology?

communications network to transmit transactions data to headquarters. The firm developed a data warehouse and provided decision-support tools for district managers to use in planning their operations. The company vests decision rights heavily in senior and lower-level managers; there are relatively few middle-level managers.

Mrs. Fields Cookies developed elaborate in-store systems to guide its store managers in all aspects of the business. The company uses e-mail and voice mail to communicate with the store manager. It also has a very flat control structure with store controllers at headquarters closely monitoring sales results for each retail store.

VeriFone is a company that manufacturers devices to verify credit card payments and is active in offering electronic commerce solutions on the Internet. The firm views itself as a global corporation. The chairman compares it to a "blueberry pancake where all the blueberries (locations) are equal." Verifone uses technology extensively for communications and coordination in the firm.

We have already discussed Calyx and Corolla. Oticon is a Danish manufacturer of hearing aids that underwent a major restructuring when it lost considerable market share. The chairman created a "spaghetti organization" in which an executive committee agrees on tasks that the firm must complete and assigns them to a team leader. The leader must put together a team to complete the task; technology facilitates the work of these virtual teams.

FIGURE 4-3
IT-enabled organization forms.

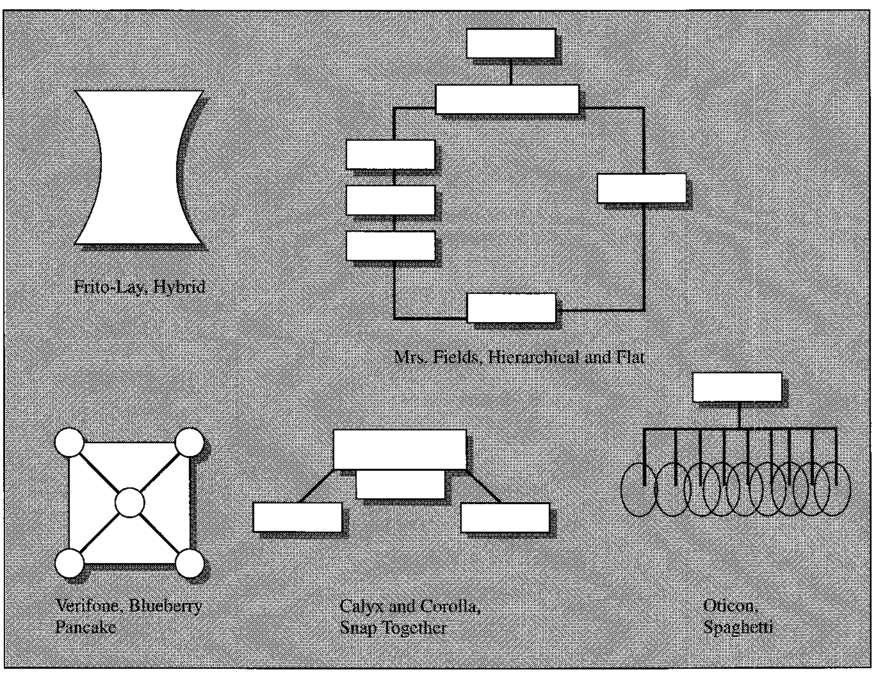

TABLE 4-5

COMPANY STRUCTURE AND *IT* DESIGN VARIABLES

Companies/IT design variables	Frito-Lay	Mrs. Fields	Verifone	Calyx & Carolla	Oticon
Virtual components		Presence of Mrs. Fields in each store	Extensive use of teams and alliances	Growers, FedEx, and credit card companies	Project teams
Electronic linking and communications	Extensive with route sales force, district managers, factories, distribution centers	E-mail and voice mail; PCs in stores	Extensive within company	With growers	Within firm
Technological matrixing			Global teams to solve problems		Project teams
Technological leveling	At headquarters	For store controller organization	Minimum structure and hierarchy		
Electronic workflows				With growers, credit card companies	
Production automation		In store systems			Redesign of factory
Electronic customer/ supplier relationships				With growers, credit card companies	

Table 4-5 shows how each of the firms in Figure 4-2 has used IT design variables to create a different structure. These structures help the firms enjoy the benefits described for the generic T-Form organization; they demonstrate the variety that is possible for the firm choosing to take advantage of technology for organization design.

Adopting the T-Form: An Example

An example illustrates how IT variables can be applied to the design of an organization. Assume that a traditionally structured manufacturing firm wishes to take advantage of new technology to become a T-Form organization. ABZ is an actual company whose name has been changed to protect the innocent and the guilty. ABZ is a manufacturer of electronic components.

Currently, ABZ has a very traditional organization structure; it has a headquarters with a small staff and a number of manufacturing plants in the U.S. and abroad. The largest of these plants is responsible for most information technology in the company. The firm has generally underinvested in technology and is behind its competitors in the industry. Fortunately for ABZ, its products are of high quality, and the company has not needed to compete on information technology.

Suppose that management has heard about the T-Form organization and would like to adopt it. What could the company do? Table 4-6 shows how management at ABZ could use the IT design variables discussed in this chapter to restructure the company. ABZ is currently being forced into becoming a **virtual supplier** by its customers who are moving to just-in-time production. ABZ needs to develop the capability to "inquire against" and monitor its customers' production control and scheduling systems so that it can send products *without the customer even having to order them.*

Electronic linking can be used to link production planning, order entry, and marketing. The sales force does not need individual offices. Representatives can use notebook computers and can work from home to concentrate on working with customers. Control can be enhanced by developing information systems which make control information available to various levels of management.

Technological leveling is accomplished by reducing layers of management and providing communications tools such as electronic mail and groupware to managers. ABZ has a large number of administrative support staff members and others not involved in direct production in the factories. It is this support staff that adds overhead and is an excellent candidate for leveling.

In the factory, the company has successfully moved toward production automation. Expanded efforts should focus on the creation of an electronic manufacturing environment. Orders arrive electronically from customers, and each order generates a bar code to describe the customer and product. When production begins, a worker attaches a bar code to the physical tray that holds the product through the production cycle. At each stage a worker wands the bar code at a workstation to bring up a screen with instructions on what operation to perform. At the end of production after quality testing, the only paper necessary is a label for the shipper.

Electronic mail and groupware can be used for technological matrixing. They address the informal communications vital to managing a company. ABZ can quickly form task forces and other informal groups to address problems. This approach is particularly valuable for communications among plants. For example, one U.S. plant sends "kits" of a product to be completed to a plant in Mexico. Various problems between the plants can be resolved quickly using electronic communications rather than physically traveling between sites.

Technological matrixing also facilitates a reduction in managerial levels as it encourages employees to take the initiative in solving problems. Suppose that a customer contacts a marketing manager to ask if it would be possible to access ABZ's production-scheduling system to schedule products to be built for the customer. In a matter of minutes, the marketing manager, using e-mail and

TABLE 4-6

AN EXAMPLE OF DESIGN FOR ABZ

Class of variables	Conventional design variables	IT design variables	Applied to ABZ
Structural	Definition of organizational subunits	Virtual components	Manage virtual inventory for distributors; connect with customer production systems for JIT; use a common-order entry system for a single point of contact; contract with overnight carrier for all distribution
	Determining purpose, output of subunits		
	Reporting mechanisms		Use more electronic communications to flatten structure, increase span of control
	Linking mechanisms	Electronic linking	Link production planning, order entry and marketing; notebook computers for sales force; eliminate private offices for sales force
	Control mechanisms		Develop systems to make control information more widely available
	Staffing	Technological leveling	Reduce the number of layers in the organization by substituting electronic communications and groupware
Work processing	Tasks	Production automation	Continue efforts at automation
	Workflows	Electronic workflows	Move toward total electronic tracking of order; use bar codes to coordinate production with an electronic traveler
	Dependencies		Coordinate with e-mail and groupware
	Output of process		
	Buffers	Virtual components	
	Formal channels	Electronic communications	Use e-mail and groupware, especially to communicate among distributed plants and headquarters
	Informal communications/ collaboration	Technological matrixing	Use e-mail and groupware to coordinate on production forecasts and special projects
Interorganizational relations	Make versus buy decision	Electronic customer-supplier relationships	Develop a home page on the Internet containing product information; as soon as feasible, use it or a commercial online service to allow customers to inquire on availability; other options would be EDI and groupware
	Exchange of materials	Electronic customer-supplier relationships	Same as above
	Communications mechanisms	Electronic linking	Establish electronic mail links with customers; consider commercial services, EDI, and/or groupware

MANAGEMENT PROBLEM 4-3

Harold Rubin has spent a career in banking. He now works for a large money-center bank that has a global presence. However, Harold is worried: He has seen the explosion in interest in the Internet and World Wide Web, and he thinks there will be profound implications from IT for banking. The picture is confused, however. Some banks are reducing the number of physical branches as they are expensive in terms of real estate and labor. The banks replace branches with ATMs and phone banking; other banks offer PC banking so that customers can do almost everything they can in a branch from home. They are usually able to pay bills via their home computers as well.

To Rubin, these changes seem evolutionary and rather mild. He has read articles about electronic commerce and even shopped on the Web to try it out. He also sees small firms becoming global as they advertise their products on the Web. What kinds of banking services will these firms want? How will changes in commerce and life styles influence what customers, both individual and corporations, want from a bank? Will a bank become "a piece of computer software on a network," a statement attributed to the chairman of Citibank?

groupware, can form a task force that includes personnel from production planning, marketing, information systems, and other interested areas. There is no need to pass this request through layers of management in different departments.

ABZ needs to connect electronically to customers to provide them with a **virtual inventory.** It can also take advantage of more extensive electronic customer-supplier relationships. For example, ABZ can put up a home page on the Web to describe its products and then allow its customers to order from the Internet.

What is the result of ABZ's adoption of IT design variables? Extensive use of electronic communications and linking results in fewer management layers and flattens the structure of the organization. Fewer layers combined with the availability of information at all levels in the organization will push decision making down to lower levels of management. Easy electronic communications encourage employees to contact appropriate colleagues to solve a problem, rather than refer it up the hierarchy through a supervisor. Employees will be able to take on more responsibility and have an IT infrastructure to support them.

Some employees, especially the sales force, at ABZ will no longer have offices. ABZ will move toward complete electronic integration with customers and suppliers. Electronic mail for informal communications, EDI for routine transactions, and in some cases direct links into customer information systems, will increase the firm's responsiveness to customers and suppliers. Electronic workflows in production will eliminate paper and, more importantly, provide better service. Production lots will not get lost if they are tracked electronically and production workers will have accurate information on what tasks to perform for each order.

JIT II-Suppliers in Your Office

Just-in-time (JIT) manufacturing has become extremely popular in the U.S. given the positive experiences that Japan's factories have shown using this approach. Just-in-time is a part of "lean production" and is designed to keep inventory at a minimum. Because there is little inventory, the quality of parts and the dependability of the supplier are critical.

An American at Bose Corporation, Lance Dixon, came up with a modification called JIT II; he invited suppliers' sales representatives to sit next to the factory floor and gave them free rein to move about the plant. These representatives can attend production status meetings, visit R&D labs, and access Bose's own production planning and forecasting systems on Bose computers. They can write a sales order of their own.

This new approach requires a great deal of trust between the customer and supplier. Not all attempts at establishing JIT II relationships have worked, but where they have, there can be many benefits. A Honeywell plant in Minnesota has 15 representatives from 10 suppliers in cubicles just off the production floor. Some of these representatives work on new product designs, but most oversee purchases. They think like Honeywell employees and look for ways to cut costs. Honeywell runs the factory with inventory levels measured in days rather than weeks; it also has reduced its purchasing agent pool by 25 percent. Some representatives will order from a competitor if it is best for Honeywell.

In retailing, the same concept is called efficient customer response (ECR); suppliers continuously replenish inventories as the store sells items. Vendors are linked to customer computers which have forecasts and point-of-sale data. The sale of goods "pulls" inventory to the shelves; vendors do not "push" their merchandise on the store. ECR has worked well for some customers and suppliers, but many firms are wary.

JIT II and ECR represent different ways of thinking; they are made possible partially because of information technology. However, to succeed they require management to support the concept and to create an atmosphere in which customers will trust their suppliers to act in the customer's best interests.

To accomplish this restructuring will take ABZ a long time since it has not kept up-to-date with technology. It will have to invest in a technological infrastructure and people to develop the kind of IT applications described in this chapter. ABZ's product quality has helped it attain a commanding market share, and adopting a T-Form organization will help it sustain this position and meet the threats of competitors who currently obtain more from their investment in IT than ABZ.

We should add a note of caution: IT is not the solution for every problem. Competent managers can use the IT design variables presented in this chapter to improve the organization. They can also use them to create significant problems. For example, a colleague recently reported on a company where a manager only communicates with the staff via e-mail and rarely listens to any of them. It is likely that his strong staff will find other places to work. IT design variables are one approach to improving the organization; outstanding managers will use them with good taste to design efficient and effective organizations.

CHAPTER SUMMARY

1. Information technology interacts with organizations and can be used to change the structure of the organization and/or its subunits.
2. One desirable impact of IT is when technology contributes to organizational flexibility.
3. Older legacy systems often perform critical tasks for the firm. These systems usually run on mainframe computers and are very large and complex. One management problem is deciding if and when to make massive investments to migrate these systems to up-to-date technology.
4. There are a variety of organization structures; some important considerations in studying organizations are uncertainty, specialization, coordination, and interdependence.
5. There are a number of IT-enabled variables that you can use to design organizations. They supplement and sometimes replace traditional organization design variables.
6. These variables can be used to create the T-Form structure or applied to produce a range of structures including virtual organizations, negotiated organizations, and vertically integrated conglomerates. The variables may also be used in subunits of traditional firms.
7. It is important to remember that organizations and people play an extremely important role in the development and success of technology.

IMPLICATIONS FOR MANAGEMENT

It is amazing that a technology barely capable of computing a payroll and processing orders when introduced in the 1950s can be the basis today for structuring the organization. The evolution of computers and networks has enabled IT design variables for creating new organizational structures. As a manager, you need to constantly search for ways to improve the organization. IT design variables offer opportunities to make major changes in the organization, changes that can improve both efficiency and effectiveness. *Today the tasks of designing technology and the organization have become one and the same.*

KEY WORDS

Electronic communications
Electronic conglomerate
Electronic customer/supplier relationships
Electronic linking
Electronic workflows
Flexibility
Mutual dependence
Organization
Pooled interdependence

Production automation
Reciprocal interdependence
Sequential interdependence
Technological leveling
Technological matrixing
Time and space boundaries
Uncertainty
Virtual components
Virtual inventory
Virtual supplier

RECOMMENDED READING

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DISCUSSION QUESTIONS

1. What kind of technology is least flexible? Most flexible?
2. The information services department is often considered to provide a support function. Can a support department really be powerful? Are there different kinds of power in an organization?
3. What kinds of management problems result from a lack of organizational flexibility?
4. Are there any organizations that are completely dependent on information technology for their operations?
5. What kinds of employees are most likely to be replaced by information technology? How does your answer depend on the type of system and the decision levels affected?
6. How would you measure the extent of unemployment created by the implementation of IT? What factors tend to mitigate the problem of increased unemployment if it actually occurs?
7. What signs might indicate the need to restructure or redesign an organization?
8. Is information technology creating more centralization in organizations? How do you define centralization? Why should technology have any effect at all on the degree of centralization?
9. How would you recognize a company that is using IT successfully? What signs would you expect to find?

10. How can IT be used to create "virtual" organizations?
11. How should managers introduce organizational changes that employ technology? What are the risks?
12. What alliances were key for the nationwide floral company described in this chapter?
13. Consider a typical manufacturing organization and describe the dependencies that exist among departments.
14. Why should users be involved in the design of systems? How much influence should they have?
15. What are the risks for a small company connecting itself electronically with major customers?
16. What are the problems with legacy systems? What are their implications for management?
17. How can IT be used to help design an organization?
18. What are the IT-enabled organization design variables? How do they supplement or replace conventional design variables?
19. What tools does the manager have available to influence IT in the organization?
20. As a user, to whom do you think the information services department should report? Should it be responsible to the finance department?
21. Should an organization that invests in developing an electronic market be free to build biases into the market that favor its own products and services?
22. Early forecasts suggested that middle managers would be reduced in number and stature as a result of information technology. Has this prediction been realized? Why or why not?
23. Does technology have an impact beyond the organization, for example, on stockholders or customers? What kinds of effects occur, and what problems are created for these groups?
24. What is the role of the traditional organization, given the kinds of structures that IT makes possible?

CHAPTER 4 PROJECT

Knowledge Worker Support

The task of supporting computer users in a university is a difficult one. A large number of schools separate academic and administrative computing because it is hard to give academic users attention when the payroll system for the faculty and staff is not working!

Even with a separate academic computing organization, it is often difficult to support users. Typically, a school has a number of users of its facilities, and management must try to assist them all—from the student who has never used a PC before to the faculty member who needs the power of a supercomputer. In addition to the problems encountered with mainframes or personal computers in central facilities, the academic computing staff may also be responsible for a series of PC laboratories.

Develop an organization chart for academic computing at your university. The chart should show the major entities, such as computer centers, the kind of equipment each offers, its users, and so on. Then describe the kinds of user support provided. Is there a help desk? What are the problems with the school's efforts at support? What recommendations can you make to improve the level of support students receive?

CHAPTER 5

Strategic Issues of Information Technology

Outline

Focus on Change

We have already shown how IT can transform organizations and industries when used in strategic applications. Examples in this chapter, plus our earlier discussions of the securities and airline industries, demonstrate the power of modern information technology to change businesses. As technology becomes integrated with strategy, the nature of business changes. Baxter Laboratories spun off Allegiance, a firm dedicated to providing hospital supplies and to helping hospitals manage their costs through information technology. A few years later, Cardinal Health Care bought Allegiance! Rosenbluth Travel, a firm discussed in this chapter, changed its focus from providing bookings and tickets to helping a company manage its travel costs through the creative use of technology. Technology and strategy are responsible for major changes in the structure and operations of the organization.

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A recent poll of more than 200 executives showed that they feel information technology is key to a competitive advantage. However, 52 percent of these managers also feel that they are not getting their money's worth from the technology. Andersen Consulting conducted the study, which involved chief executives, chief operating officers, and chief financial officers representing companies with annual sales ranging from $250 million to $20 billion.

This chapter discusses how technology can be used to gain a strategic, competitive advantage. We believe that many of the problems expressed by the executives in the survey just mentioned come from their failure to actively manage IT in the firm. After we discuss IT and strategy, we present some ideas on how you should manage technology so that it can contribute to corporate strategy.

What is competitive advantage? A firm has a competitive advantage when it is able to perform some function "better" than its competitors. Better may mean that it has a superior product, the most efficient manufacturing process, unique knowledge, or some other capability that its competitors lack. As an example, Intel considers its knowledge of how to build and operate a semiconductor manufacturing plant a competitive advantage. Some argue that Microsoft's control of the operating system provides it with too much of a competitive advantage in selling PC software, especially Web browsers. After obtaining a competitive advantage, the firm faces the challenge of sustaining it as competitors fight back.

INFORMATION TECHNOLOGY AND CORPORATE STRATEGY

A key task of top management is formulating corporate strategy. What opportunities for new directions are available? What are competitors doing? A firm can continue its present course, maintaining momentum where it is doing well. Alternatively, the corporation can dramatically change its strategy by deciding among competing alternatives for new ventures. What is the role of technology in its strategy? At Brun Passot we saw how IT and strategy become intertwined, with each influencing the other. A well-managed firm will strive for this kind of integration.

Some Examples of Technology and Strategy

Merrill Lynch is the largest stockbrokerage firm in the United States and plans to become one of the major financial institutions in the world. Two decades ago, funds in a customer's brokerage account earned no interest. There could be cash in such an account because of the sale of stock or because of dividends on stock held by Merrill Lynch for the client.

The firm developed a new financial product called the cash management account. At the time the product was conceived, interest rates were extremely high and a number of small investors were keeping their funds in liquid assets accounts. These funds buy and hold large securities with a value of $100,000 or more. The investor buys shares, usually with a par value of $1. The account requires a minimum deposit, possibly as low as a few thousand dollars. The funds keep the value of the ownership units at $1 by varying the dividends and buying short-term securities.

Now the small investor, instead of being limited to bank or savings and loan passbook accounts, can take advantage of higher interest rates previously available only to those with a large amount to invest. (Today banks and S&Ls are able to offer money market accounts, but they were not available at the time Merrill Lynch developed its new account.)

The firm decided an account that automatically invested idle cash in Merrill Lynch's own Ready Assets (liquid assets) Fund would appeal to its customers. In fact, the CMA (cash management account) is like a bank account and brokerage account combined. The customer can write checks against the account and even receive a bank charge card.

Has it been successful? At first the account was slow to win acceptance, but today Merrill Lynch has more than a million CMA customers. Other brokerage firms have hired Merrill Lynch employees to develop similar products. Merrill Lynch patented the account and asked for licensing fees from other brokers. In an out-of-court settlement, another brokerage firm agreed to pay $1 million for hiring a Merrill Lynch employee to set up a similar system. Merrill Lynch gained a significant competitive advantage with its cash management account system.

Could this system have developed without confidence in information technology? With a million accounts to update, the magnitude of the catastrophe if computer systems do not work is hard to imagine. In fact, this product could never be offered unless a firm had computer technology and could manage it. The volume of updating and the short time requirements would be just too great for a manual system.

On a smaller scale, information processing technology made it possible for a new market research firm to offer a service it could not obtain from its competitors. The company developed a strategy that is intertwined with information technology. The firm purchased grocery store point-of-sale scanning equipment and, at first, gave it free to 15 supermarkets in two towns selected on the basis of their demographic makeup. There are 2000 households in each of the two test markets using the scanning equipment, and purchases are recorded on the firm's computer in Chicago. Since each product is marked with the universal product code, researchers can pinpoint a family's purchases by price, brand, and size, and then correlate the purchase information with promotions such as coupons, free samples, price adjustments, advertising, and store displays.

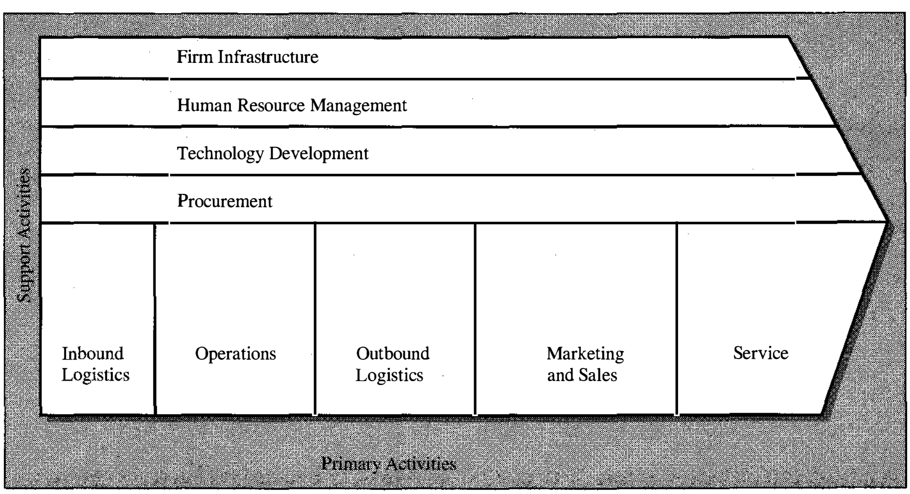
With this technology the company can conduct careful, scientific tests of marketing strategies to determine the most effective approach for its customers. For example, through cooperation with a cable TV network, the firm can target different TV commercials to selected households and analyze the resulting purchases. The imaginative use of the technology has allowed the firm to gain a competitive lead over much larger, more well-established market research firms. This firm has grown and recently was able to sell the software it developed for analyzing scanner data for a premium price.

These examples illustrate how the integration of information-processing technology with strategy formulation expanded the opportunities for each firm. In the brokerage firm, the technology made it possible to offer a new service that helped expand the firm's market share and increased the size of its liquid assets fund. Technology helped the market research firm gain a competitive edge and set a new standard for service in the industry.

The Value Chain

Michael Porter at Harvard has popularized the concept of the "value chain," the activities in an organization that add value to its products or services (Porter and Millan, 1985). See Figure 5-1. The primary activities in the value chain include inbound logistics, operations outbound logistics, marketing and sales, and service. Each of these activities adds value directly to the firm's output. Supporting these

FIGURE 5-1
The value chain.



primary activities are the firm's infrastructure, human resource management, technology development, and procurement.

What is the potential impact of information technology on the value chain? IT can create dramatic changes here. Consider Calyx and Carolla from the last chapter: Growers provide inbound logistics and FedEx is responsible for outbound logistics. Two alliance partners, linked by electronic communications in the case of growers, provide important components of the primary value chain. Various credit card companies provide part of the firm's infrastructure, accounts receivable. There are similar examples for all of the activities in Figure 5-1; IT can and does have a profound impact on the value chain.

Some Generic Strategies

Porter elaborates on his value chain analysis and suggests that firms follow one of three generic strategies:

1. **Low-cost producer.** Here the firm tries to have the lowest costs in the industry so that it can compete on price.
2. **Differentiation.** The firm tries to separate its product image from that of the competition in such a way that the customer wants its product. Luxury automobile manufacturers like BMW are very adept at differentiating their products from other cars. For example, if you buy a BMW, you are said to have "the ultimate driving machine."
3. **Market niche strategy.** A number of firms try to find a market niche and exploit it. A niche is some part of a market that is not being served by others. Hermes has stayed in its niche of producing high-quality, expensive products like women's scarves for a limited clientele.

In today's competitive economy, we have observed firms focusing on more specific strategies that are listed below. Most of the time, the firm adopts only one of these, but it is possible to follow two at the same time:

Customer Driven Here the firm focuses on its customers. How can we provide better customer service? How can we design products that meet our customers' needs? What technology exists so we can better serve our customers? Customer service is extremely important in commodity businesses, for example, the mail-order sales of personal computers.

Reducing Cycle Times A firm has a variety of **cycle times;** a typical one is the length of time it takes to design a new product or service. Detroit automobile manufacturers and Boeing are focusing on reducing cycle times. They now use parallel design and engineering where tasks are done simultaneously rather than sequentially. In addition to saving time, parallel development results in better coordination among team members working on the design of a new car or plane.

Global Competition As the unification of Western Europe continues and Asian economies become more open, some firms have decided to follow a strategy of

Reducing Design Cycle Time

Chrysler and Dassault Systems of France have developed a computer-aided manufacturing system that Chrysler hopes will allow it to reduce the time it takes to retool factories by 20 percent. The idea is to use the system to create a "virtual" factory so that engineers can design manufacturing tools needed for a new auto model more easily and quickly. Using the new system, Chrysler can retool a factory after approving the design for a new model in about 24 months, down from the 30 months that used to be required. Chrysler has been a low-cost leader in designing new cars, but it has been lagging behind Japanese manufacturers and Ford in retoolings its factories. This new system extends the computer-aided design tools to actually design the car to the plant floor where it will be manufactured.

The Boeing 777 series of planes was the first to enter production directly from design without flight testing. In addition, Boeing used a computer-aided design system to eliminate paper from the design process. The final assembled planes were within 0.023 inches of perfect alignment compared to 0.5 inches on planes designed using paper.

In this example, technology is helping with two strategies, cycle time reduction and low cost production.

competing in the global marketplace rather than only in local markets. A firm with global presence will need a variety of technologies to help coordinate and control all its activities. Information technology is a great facilitator for global operations.

Right-Sizing In the U.S., the first part of the 1980s was an economic boom, leading to a number of excesses. The late 1980s and the early 1990s were marked by economic downturns and slow growth. To compete in a difficult economy, firms have attempted to determine their "right size." Usually to right-size meant a serious reduction in the number of workers in the firm, and rather large write-offs for restructuring. Blue-chip companies such as IBM have reduced their levels of employment by tens of thousands of workers.

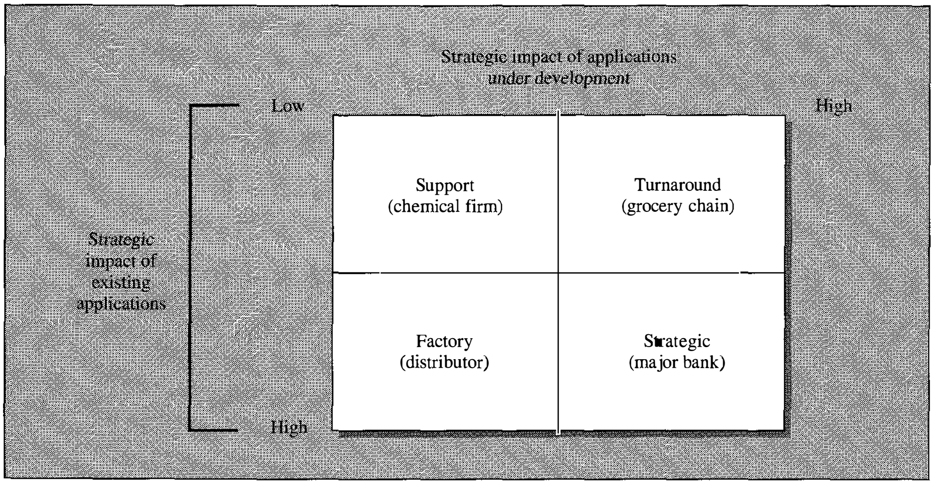
Quality Japanese manufacturers gained a large market share in a number of industries partially through a fanatical devotion to quality. Many firms around the world are focusing on quality in the hopes of getting ahead of the competition. Quality is an obvious component in the manufacturing sector, but the services firm can also be concerned about the quality of its output.

As we shall see in the rest of the text, there are many ways that technology can be used to support the generic strategies just described.

A Framework for the Strategic Use of IT

Figure 5-2 shows a framework for IT strategy that arrays a firm's existing applications against those that are currently under development (Applegate, McFarlan, and McKenney, 1999).

FIGURE 5-2
Information systems strategic grid.



Companies that are "located" in the strategic cell are critically dependent on the smooth functioning of information systems. These firms need significant amounts of planning and would be at a considerable disadvantage if information processing did not perform properly. The authors found one bank that fit this cell well. Without computers, the bank would be awash in a sea of paper and could not possibly keep up with the volume. The bank must think of how to use its systems strategically to offer services that will let it capture a greater market share. For instance, banks are offering new services connecting home computers to bank computers.

In a turnaround company, there is a need for planning, too. It is likely that corporate performance is inhibited by poor performance in the information-processing department. Applegate and her colleagues found a firm in this cell with adequate operating systems in production but limited new applications critical for keeping up with growth. Without new technology the firm could not maintain control over its rapidly expanding operations.

The authors argue that in the factory setting, there is not much to do but run existing applications. They maintain that strategic goal setting and linkage of information systems to the corporate plan are not too important here.

Finally, in a support environment, information processing is probably not critical to the firm, so strategic integration will not be essential for success. The authors expect to find low levels of senior management involvement in this situation.

This is the position of Applegate, McFarlan, and McKenney (1999) who argue that in the support cell, it is quite appropriate for management to be relatively uninvolved in information processing. Although this may be true for certain systems, the advice is bad in general because it encourages management to ignore information technology and the new opportunities it provides. It is quite possible that a firm in the support cell will be able to come up with a strategic application that allows it to gain a competitive edge. In fact, if the support cell position is characteristic of the industry, the firm that first finds a strategic edge through information technology may in fact move far ahead of the competition.

The framework in Figure 5-2 is a useful one for diagnosing the state of an organization. We can look at the nature of the business, its plans for the future, and its existing and planned applications. In a turnaround situation, we may want to emphasize to management the importance of leading the information systems effort, whereas in the strategic cell, management may already be aware of the importance of technology to the firm.

Those authors concerned with the use of information technology as a part of corporate strategy have all taken a slightly different approach to classifying systems. One common thread seems to run throughout the discussions: Technology can contribute to a firm's strategy in a number of ways. It can reduce costs to help an efficient firm compete, and technology can tie the firm more closely to suppliers and customers. The technology can also become a product itself, such as the Merrill Lynch's CMA or an airline's CRS, discussed in Chapter 4. Both of these allowed firms to gain a significant competitive edge.

Capitalizing on Information Technology

How does the firm take advantage of information? There are four steps to be followed by top management:

1. *Look for ways to incorporate technology in a product or service.* Does information processing provide an opportunity for a new approach to business? Does the technology make it possible to differentiate a product or service from that of the competition? Technology can help open a new market or increase an existing market share.
2. *Seek ways to use technology to connect with other firms.* There is great interest in interorganizational systems that link two organizations together. Your firm may be able to connect electronically to its customers so that it is easy for them to order from you. A firm can encourage its suppliers to provide links for placing orders. In these instances, the firms in question are drawn more closely together, making it difficult for the competition. These links include the Internet, which is becoming the connection mechanism of choice among firms.
3. *Look for ways to use technology to make dramatic changes in the way you structure the organization.* Use information technology organization design variables so management can structure an organization that is highly competitive, that uses its technologically enabled structure to become a formidable competitor. IT-based structures that focus on one of the strategies described earlier, for example, providing extraordinary customer service, can also provide an advantage.
4. *Integrate technology with planning.* To integrate technology with planning, managers have to understand (1) the operation of their business and (2) the capabilities of technology. In addition, the firm has to have invested in building a modern technological infrastructure so that it is ready to take advantage of new opportunities. Finally, management has to make information technology a part of its planning process.

One of the greatest impediments to using information technology for strategic purposes is an inability on the part of top management to successfully manage the information systems function. If executives do not believe they can control information processing services, they probably will be unwilling to rely on this technology to accomplish strategic goals.

CREATING AND SUSTAINING A COMPETITIVE EDGE

There are different schools of strategy that describe how a firm gains and then sustains a competitive advantage. Theories by Teece (1986) and Barney (1991) apply particularly well to the case of using information technology for achieving a competitive advantage.

Using Resources to Advantage

A firm has a number of resources available to it including its employees and their knowledge, capital, products and services, and physical resources that may include a significant investment in a production facility. Some of these resource are likely to give a firm a strategic advantage, but which ones? Resources, according to Barney (1991), must be valuable, rare, imperfectly inimitable, and nonsubstitutable to provide an advantage. Otherwise a competitor can develop exactly the same resource without much cost and duplicate your firm's strategy.

A resource must be valuable enough that a competitor will think twice before trying to acquire or create a copy. A rare resource is more difficult for a competitor

MANAGEMENT PROBLEM 5-1

Standard International (SI) is the subsidiary of a large manufacturing firm; it is responsible for marketing, sales, and distribution outside the United States. Standard International does not develop products; the parent firm creates all products it sells. SI has operations in 30 countries. In virtually all these countries the local SI operation is treated legally as a subsidiary of Standard International.

Recently a new president took control of SI. Historically the firm's systems were oriented to finance and accounting because the technology group reports to the vice president of finance. Accounting applications are important because so many different currencies are involved. The new president, however, is impatient and feels that technology should be able to do something for marketing and sales.

She asked you to consult with SI in the hope of finding a strategic application for information technology: "I want something that will give us a competitive edge," she said. What kind of process would you follow to try to identify a strategic application? What applications areas look promising? How does a firm like SI develop a strategic system? How does it establish and maintain a competitive advantage?

to acquire or copy. A strategic resource has to be "imperfectly inimitable" as well to deter creating a direct imitation. A resource has to be nonsubstitutable so that a competitor cannot find an easy substitute in the form of a different, more accessible resource that is easy to acquire.

Intel is an example of a company with resources that give it a competitive advantage. First, it has the knowledge of how to build and produce complex logic chips; Intel regards its ability to build and run a chip fabrication plant as a major competitive advantage. It has the knowledge and engineering resources to create and operate these plants that cost in excess of $1 billion. Intel is also large enough to have the financial resources to build such expensive plants. This combination of resources is valuable, rare, imperfectly inimitable, and nonsubstitutable.

Protecting an IT Innovation

Many innovations in IT are virtually impossible to protect from copying. It is difficult to copyright or obtain a patent on an application of technology. When FedEx established a Web site to let customers inquire about the status of their shipments, United Parcel followed with a similar Web service within a month. The term "regimes of appropriability" is sometimes used to describe how easy it is to protect an innovation. A strong regime means you can protect an innovation, while weak appropriability means that others can easily duplicate your innovation. Most IT initiatives seem to have weak appropriability regimes. While a firm may have the appropriate resources to create an innovation, it can be difficult or impossible to sustain it.

There are, however, some conditions that favor the innovator. For example, if you have certain complementary assets (resources) that are unavailable to others, you may be able to protect your innovation. When IBM brought out its first personal computer in 1981, it had a strong complementary asset in the form of a marketing organization with contacts in major corporations around the world. A cospecialized asset is one that has mutual dependency with the innovation. A good example of a cospecialized asset is the relationship between Microsoft's Internet Explorer and Windows 98. The Explorer depends on Windows since it must run on a computer controlled by this operating system; as the Explorer interface becomes a part of Windows, the operating system develops a dependence on this browser. It has been suggested that location can be a cospecialized asset in the placement of ATMs; the first banks that installed ATMs were able to get the best locations for them (Dos Santos and Peffers, 1995).

There may be ways to use the technology, itself, to strengthen your regime of appropriability; see Clemons and Weber (1991). One of the most popular ways to sustain an advantage is to be the first mover. The first mover may be able to create an insurmountable lead over the competition. Merrill Lynch has many imitators; in fact the "sweep account" is very common in the investment business. However, no one has been able to overtake Merrill Lynch's lead; it has by far the largest number of cash management accounts of any other brokerage firm.

Another way to sustain an advantage is to overwhelm the competition with technological leadership. United and American airlines have more than 70 percent of the domestic market for reservation systems in travel agencies. These firms had the resources to make large investments in technology and for developing skilled staff members who could implement reservation systems. The companies applied their resources to create the CRSs in the first place, and the CRSs themselves became resources for competing. Apollo and SABRE today are travel supermarkets that would be extremely difficult and expensive to imitate. By continuously investing in technology and managing it well, these two airlines provide significant barriers to entry for other airlines and vendors of potential reservation systems. (A consortium of several airlines now owns the original United CRS, Apollo.)

Closely related to technological leadership is continuous innovation. Successful strategic applications such as the classic American Hospital Supply/Baxter Health Care order entry system demonstrate continuous innovation. Today, with this system, Allegiance, a Baxter spin-off now a part of Cardinal Health Care, offers a service that is the virtual inventory for a "stockless" hospital. IT and a superb logistics system let Allegiance promise just-in-time deliveries to different departments in a hospital.

A final approach to sustaining an advantage is to create high switching costs. By making it very expensive or inconvenient to switch a customer's business to a competitor, you are assured that customers will continue to do business with you. The airline CRS vendors have been very clever at locking in travel agencies. At this time, almost all agencies in the U.S. are automated. Increases in the number of customers and market share only come from converting an agency from a competitor's CRS to your own. Each CRS vendor has created very high switching costs for an agency to convert to a competitor's CRS.

Simply finding a strategic application of technology and implementing it successfully are not enough. This approach should provide a short-term competitive advantage, but the innovator must constantly be searching for ways to sustain an advantage as the competition tries to imitate its success. When planning and developing a strategy, think about the kinds of resources you have to provide an advantage and the difficulties of protecting an IT innovation. Do you have specialized or cospecialized assets to enhance the innovation? Can you turn the IT innovation into a resource, itself, that is valuable, rare, inimitable, and nonsubstitutable through some combination of being the first mover, technological leader, continuous innovator, and/or the creator of high switching costs?

An Example of Technology for Competitive Advantage

Clemons and Row (1991) describe how a small travel agency expanded to a nationwide business through the use of IT. Rosenbluth Travel, headquartered in Philadelphia, grew from $40 million in sales in 1980 to $1.3 billion in 1990. It is now one of the five largest travel management companies in the United States and has more than 400 offices.

According to the authors, Rosenbluth was extremely effective in taking advantage of the opportunities offered by deregulation in the travel industry. The firm has used technology to help manage the complexity of modern travel and to obtain economies of scale. Rosenbluth invested in IT over a period of years. While the expenditure in any one year was not inordinate, Rosenbluth created a technology base that is extremely difficult for a new entrant or even a competitor to match.

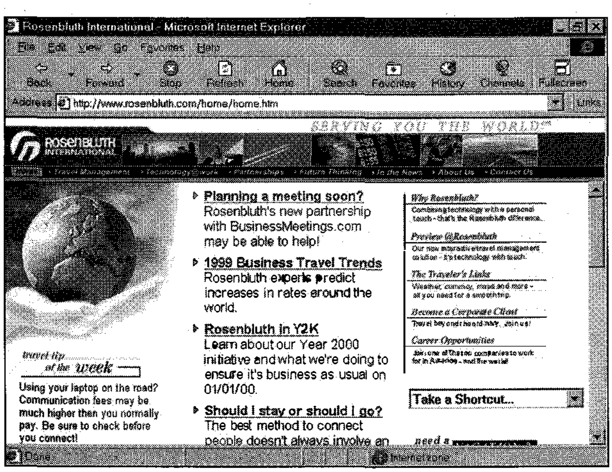
Prior to deregulation in 1976, travel agents wrote about 40 percent of all tickets. The role of the agent was only to make a reservation and distribute a ticket. Deregulation changed the role of travel agents and forced them to manage the increased complexity of travel. American Airline's SABRE system contains more than 50 million fares and processes 40 million changes a month. The airline reservation systems used by travel agents were biased toward the airlines, though no more so than one would find calling the airline itself for information. The travel agent, however, could be expected to help the client without a bias toward a particular airline. By 1985 travel agencies were distributing more than 80 percent of air tickets.

Businesses are very interested in managing their travel. It is the third largest expense for most firms after payroll and information technology. Firms began to negotiate rates with airlines, hotels, and rental-car companies. One of Rosenbluth's major business focuses has been the corporate travel market. See Figure 5-3.

The following list of critical technology moves by Rosenbluth illustrates how the firm has used IT for expanding its business:

- In about 1981 the firm experimented with processing data from airline computerized reservation systems (CRSs) to provide information for corporate accounts.
- In 1983 Rosenbluth introduced a product called READOUT that listed flights by fare instead of by time of departure. This program made it possible to see the fare implications of taking a particular flight. The normal flight display was by departure time, and the agent had to move to another screen to obtain fare information.

FIGURE 5-3
Rosenbluth web site.



- In 1986 a proprietary back-office system, VISION, created a highly flexible reporting system for clients. The system created a record of transactions made for a client at the time of ticketing regardless of the location of the agency or the CRS in use. This system gave Rosenbluth independence from the data provided by the airline CRS. During 1986 Rosenbluth estimated that it invested nearly half of its pretax profit in the system. The VISION system was more flexible and produced reports about two months earlier than agencies using only the airline CRS. Rosenbluth used VISION to negotiate special fares with the airlines on heavily traveled routes the system identified.

Instead of competing for corporate clients by offering to rebate part of its commissions, Rosenbluth tried to create a cooperative relationship with clients. It promised clients to reduce overall travel costs through lower fares and used VISION reports to document the savings.

- In 1988 Rosenbluth used a new feature in United's Apollo reservation system to support intelligent workstations. PRECISION, the new Rosenbluth system, made client and individual employee travel profiles, and READOUT, the database of flights listed by increasing fares, were made available to the booking agent. ULTRAVISION was another system that ran with the normal reservation process, monitoring transactions for accuracy and completeness.
- During 1990–91, Rosenbluth began installing USERVISION in its offices. This system lets the user make flexible queries about corporate travel. The data are one day old compared to the 45-day lag typical of the airline CRS data.

These initiatives were part of a tremendous growth period as Rosenbluth's sales increased from $400 million in 1987 to $1.3 billion in 1990 while the number of offices increased from 85 to over 400.

The firm has been extremely successful. Business and technology strategy were developed together in an integrated approach to growth. The firm took risks in developing new uses of IT and in-house expertise to successfully implement systems. Rosenbluth's technology strategy competes through value-added services rather than being the low-cost producer through rebates. It also took advantage of technology to market new services to its clients. The company meets jointly with its clients and service providers to help the client negotiate the lowest possible fares.

INTEGRATING TECHNOLOGY WITH THE BUSINESS ENVIRONMENT

One of the most significant management challenges during the coming decade will be to integrate business and technology. It is no longer adequate to think about technology after other business decisions have been made. Instead, managers must consider how technology affects their decisions and how their decisions affect the technology.

Figure 5-4 describes how a manager can integrate technology with decision making. First, the manager has to search for new technology to help create new

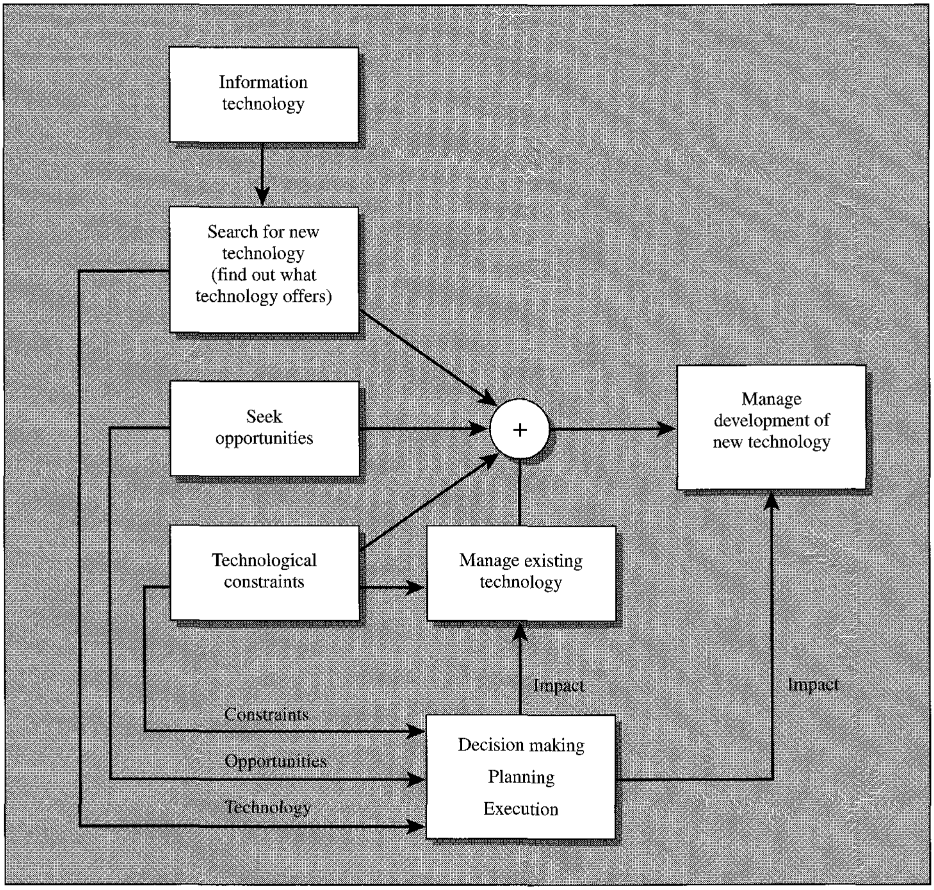


FIGURE 5-4
The management challenge of integrating information technology.

business opportunities. These opportunities, combined with the technology itself, lead to new development projects. The development projects are influenced by technological constraints. The firm cannot undertake a new marketing program in which customers inquire about their orders from the Internet if the firm lacks the skills to set up a home page on the World Wide Web and integrate the page with its existing order-entry system (see Chapter 12).

The box at the bottom of Figure 5-4 represents decision making, planning, and execution of decisions. Technological constraints and opportunities influence these decision-making activities. A firm cannot provide customers with inquiry capabilities until it allocates resources to develop a Web site. Management's decisions influence how it manages the existing business and technology. A decision to undertake a major factory automation project will result in a different type of production process to manage.

MANAGEMENT PROBLEM 5-2

Autozip sells accessories for cars through a chain of stores on the West Coast. The company started a catalog sales division 4 years ago that now accounts for 25 percent of sales. Customers like the convenience of calling a toll-free number and having the parts they order delivered via UPS or an overnight carrier such as Federal Express.

The president of Autozip realizes that the firm needs to have a presence on the Internet. He is trying to decide whether to accept orders on the Web, and if so, how. He is caught between two positions offered by his staff. The marketing vice president advocates taking orders on the Web. Her reasoning is: What have we got to lose? We have everything to gain; it's another market channel and our competitors are already there or will be soon. We save money because customers act as their own order entry personnel.

The controller disagrees. His reasoning is: Any advantage we gain will be temporary; it is so easy to set up a system to order on the Web that everyone will take Web orders and we won't gain a sustainable advantage.

The president has to make a decision. First, should Autozip accept orders on the Web, and second, if so, how? Should it go to a firm that hosts Web marketplaces, buy software and set up its own site, or develop its own software?

Successful managers must be able to integrate their knowledge of information technology and their business knowledge in making decisions. The manager should be aware of the opportunities provided by the technology and the constraints that already exist for the firm in developing new technologies. The manager should also recognize that as decisions are made, the alternatives chosen will have an impact on technology and its development within the firm. The next section presents a framework for this task of managing information technology.

MANAGING INFORMATION TECHNOLOGY

Figure 5-5 shows a framework for managing information technology. The arrows in the figure show the relationship between actions in the boxes for managing and controlling technology. The first step is to develop a vision for the organization and information technology. Next the senior manager looks at how technology can contribute to the structure of the organization using the IT design variables discussed in the last chapter. The structure of the organization influences and is influenced by corporate strategy. Strategy, structure, and the integration of IT into the firm help generate a **plan** for technology. This plan includes a structure for the IT subunit(s) in the organization along with a hardware/software/network architecture for the firm. The plan describes what new applications and what resources are needed to operate existing technology. It also describes the sources of services, for

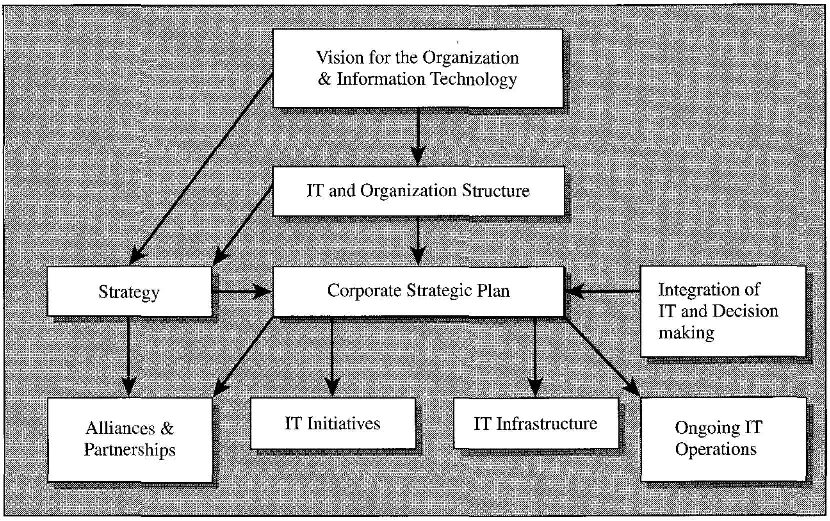


FIGURE 5-5
A framework for managing information technology.

example, from within the firm or from an outside source. Finally, the plan contains information on how management will control the technology effort.

A Vision of the Organization and Technology

Visions are rare and difficult to create; leaders are frequently criticized for lack of vision. An American president, concerned over sagging popularity in the polls, remarked that it was "that vision thing" that was responsible for his ratings. For an organization, the vision thing is important, especially given the ability of technology to change the structure of the firm, the nature of its business, and the basis for competition. A fundamental responsibility for management is to develop a vision for the business and for the role of information technology in achieving that vision.

The vision should describe the mission of the organization and identify the products and services it produces. It should identify the markets in which the firm will compete and its strategy for competition. Plans for mergers, partnerships, alliances, and acquisitions are all part of a vision. Information technology is likely to play an important part in shaping the structure of the organization and in supporting its value chain activities.

Technology for Structuring the Organization

In Chapters 1 and 4 we discussed the use of information technology design variables in structuring the organization. Because a firm's structure is highly interrelated with its strategy, these two aspects of the organization must be considered together. For example, a firm might decide to compete on the basis of extremely efficient operations, to become the low-cost, low-overhead producer in its industry.

This firm might use production automation to reduce costs and improve quality. It could use electronic customer-supplier relationships to process electronic orders from customers on a just-in-time basis and to order in a similar manner from its suppliers. The firm could employ technological matrixing to form electronically linked project teams to develop new products and services in parallel. To minimize overhead, it could employ electronic communications and linking with its sales force, providing them with electronic devices such as notebook computers with fax modems, wireless communications, and cellular phones in place of a physical office.

Strategy and structure must be considered together. Beyond the adoption of a generic strategy such as becoming the low-cost producer, management wants to develop technology that will give the firm a competitive edge. The most difficult part of gaining such an advantage is coming up with an idea. No text can teach creativity or give a formula for it. By reviewing what competitors are doing, staying abreast of the technology, and looking for analogies in other industries, you can develop new ideas for strategic advantage.

It is likely these strategies will include the development of interorganizational systems and alliances with other firms. For a manufacturing firm, IT strategy might involve technology embedded in a product, such as the computer chips found in automobiles to control the engine and exhaust, antilock brakes, traction control, and similar functions. A services firm might look for ways technology can add value to existing services, make it easier to do business with the company, reduce cycle times, lower costs, and make the other contributions discussed in the first part of this chapter. You also need to consider an Internet policy and presence on the World Wide Web. (We defer a discussion of this topic until you have read about the Internet and the Web in Chapter 12.)

Integrating Technology and Decision Making

A significant responsibility of management is to integrate technology with all business decisions. Integration means that the manager is aware of how new technology can create opportunities. The technology can literally change the way a firm does business. Concomitantly, the manager has to be aware of the impact of decisions on the firm's technology.

A decision to enter a new line of business has a direct effect on existing information-processing systems. For example, the creation of frequent flyer programs had a dramatic impact on computerized reservation systems. At least one major airline required flyers to attach a sticker to tickets to get mileage credit some two years after its frequent flyer program began. The airline finally was able to modify its reservation system to keep track of the miles when the traveler made the flight!

A Corporate Plan for Strategy

A corporate strategic plan comes from the firm's vision for its future activities. This plan includes the vision; it is a road map for bringing about the vision. Rather than a separate plan for information technology, IT should be an integral part of

Making a Strategic IT Transition

Citibank is a pioneer in electronic banking; it was one of the first to introduce electronic banking in 1985! Its early systems were new interfaces connected to legacy, mainframe systems. They were ponderous and slow to develop. Now, the mainframes keep every kind of account in a different system, for example, a system for checking accounts, for mortgages, for personal loans, etc. Instead of fitting a customer to a system, the bank wants to provide a range of services for each customer.

Citibank merged with Travelers to form Citigroup; after the merger the combined company serves 100 million customers. The company has a bold goal of having a billion customers worldwide by 2010. Management realized that electronic banking would be necessary to reach this kind of customer base; it also understood that its current electronic banking systems were too old, slow, and limited to accomplish its objectives.

Enter the Internet. A new technology officer made the decision to convert completely to the Internet for providing banking services globally. Not only will the interface for the customer be new, the bank is planning to replace the core of its back-office computer systems that maintain customer accounts. The original system has required an investment of hundreds of millions of dollars. Citigroup feels it must undertake this investment to catch up with the nimble new Internet companies like E-Trade. The bank is taking a major risk with this strategy as its back-office systems are complex and massive; they must work right or the bank could lose customers by the thousands.

Of course, there are offsetting gains if the bank is successful. Executives estimate that the cost of acquiring a customer over the Internet will be 20 to 50 percent of the cost through traditional marketing. The bank should also only incur costs of 10 to 20 percent of a branch customer in serving an electronic customer.

The rapid pace of technological change makes it difficult to retain leadership if IT is a part of your strategy. Citigroup is now planning a major, discontinuous change to prepare for a new business model: a worldwide electronic bank and financial services company. If it is successful, the bank will have transformed itself into a formidable, global competitor.

the firm's strategic plan. Given the contents of the corporate strategic plan, it is possible for managers in the IT function to develop a more detailed IT plan to support the corporation.

Many organizations agree that a plan is needed yet do not develop one. A frequent reason given is that the three-to-five-year information systems planning horizon is not compatible with the planning horizon of the organization. Yet it is both possible and highly desirable to develop an information technology; the technology is too pervasive and important for planning to occur by default or solely through decisions made by personnel in the information services department. We return to the topic of planning in Chapter 24.

Alliances and Partnerships

Companies today form a variety of partnerships and alliances if the information technology industry is any example. In fact, firms sometimes form alliances in one area with a company they compete with in some other aspect of business. Intel and Microsoft have a long history of cooperation, but Intel is also working to produce chips that run competing operating systems. Honda places a new badge on an Isuzu Rodeo and sells it as a Honda sport-utility vehicle; Acura does the same with an Isuzu Trooper. If another organization has a product or service that enhances your offerings or your operations, it can be very appealing to work with them. Information technology facilitates these kinds of cooperative arrangements by providing electronic linking and communications.

New IT Initiatives

Few organizations ever stop developing new information technology initiatives. As technology advances, it seems to stimulate new ideas on how to use IT to improve some aspect of the organization. The corporate strategic plan should identify broad areas in which technology can contribute to the firm. An IT plan adds further details and identifies specific applications of the technology for development.

Rarely today does anyone suggest completely unfeasible applications. Instead, a system that will be feasible can usually be undertaken to improve the organization. The question is, what system is both feasible and desirable? A corporate steering committee should choose applications areas as a part of developing a plan for information processing. The task then is to choose what type of system, if any, will be developed. Management must consider the existing portfolio of applications and provide guidance on the amount of investment possible and the balance of the portfolio.

Systems development is an area that requires a great deal of management attention. Managers must demonstrate that they are behind the development of a new system and see that there is adequate user input in the design process. Frequent group review meetings are important during the design process. Top management must participate in these meetings and make clear that it supports the changes likely to come from the system. Later in the text, we discuss system analysis and design in more detail, along with how the organization can implement successful systems.

The IT Infrastructure

In the next section of the book, we discuss information technology in some detail. The combination of the firm's various common technologies constitutes information infrastructure. For example, the organization provides networks to which various computers are connected. It would not make sense for individual users to each develop their own network or choose a different provider of network services. Some experts define the infrastructure as limited to common facilities the firm provides, like a network; this view of infrastructure is similar to that of society at large in which governments provide infrastructure such as roads and airports. Others take a broader view of infrastructure and define it as the firm's existing stock of technology that is available to users. Infrastructure is extremely important because it facilitates the development of new IT initiatives. If you wish to develop an interactive application available to all employees, the time and effort required will vary dramatically depending on whether the firm has an Intranet in place.

MANAGEMENT PROBLEM 5-3

Hershey and Sherman is a medium-sized consulting firm that specializes in helping clients install "enterprise software," the kind of applications packages that automate all aspects of a company's operations. The company has always stayed at a high level, and according to Sheila Hershey, "We deal with management to prepare a change program. We are not programmers." However, the tremendous success of several enterprise software packages, most notably SAP's R/3 and a series of applications from Oracle and PeopleSoft, have created a problem for Hershey and Sherman.

Clients are asking for recommendations from the firm on whether to purchase one of these packages, and then they want help implementing it. Sheila is confronted with several choices for responding. "We can try to hire more technical people, but everything we read and hear says that it is very difficult to find consultants with expertise in these systems. The demand is very high, and all of the big consulting firms have practices devoted to installing SAP. Hiring specialists would also change the character of our firm.

"Another option is to form an alliance with a firm that does have technical capabilities. We can continue to do our high-level management consulting and then bring in a firm appropriate to the client's needs. The problem here is that we may be helping provide our competitors with business—one day we are partners, the next day we are after the same client."

What advice would you give Hershey and Sherman? What are the pros and cons of strategic alliances in this situation?

Ongoing Management of IT

Visions and strategy are long term in nature; the firm still faces the day-to-day task of managing information technology. This work consists of two different kinds of tasks: developing new applications and operating the existing stock of applications. We shall discuss systems development later in the text. What does operations involve?

Consider Morgan Stanley, a leading investment bank and a major force in retail brokerage through its merger with Dean Witter in 1997. The investment bank's technology (without its new acquisition) is a 24-hour-per-day, seven-days-a-week operation. There are 15,000 computers used to process 100,000 trades a day. The firm has an estimated 100 million lines of software code and an Intranet with 10,000 users. Each night, its batch-processing cycle executes 34,000 jobs. Morgan Stanley is a services firm and much of its business is information processing. Its "factory" is the IT division, which managers must be sure operates reliably and within deadlines so that the firm is able to "make its products" every day.

CHAPTER SUMMARY

1. The value chain identifies activities that contribute to the firm's products and/or services.
2. There are three generic business strategies including being the lowest cost producer, product differentiation, and marketing of niche products.
3. More specific business strategies include being customer driven, reducing cycle times, competing globally, and right-sizing.
4. Theories of resource-based advantage and protecting innovation can help establish and sustain a competitive advantage through technology.
5. IT strategy and organization structure are closely related; management can use IT design variables to create an organization structure to accomplish its strategy.
6. To use IT strategically, you have to be able to manage the technology. The first step in management is to develop a corporate strategy that incorporates information technology and to design the organization using IT.
7. The technological infrastructure—the pattern of hardware, software, and networks in the firm—is an important management consideration; the infrastructure plays an important role in determining the firm's flexibility in undertaking new technology initiatives.
8. Other IT management considerations include choosing applications and the day-to-day operation of the stock of existing systems.

IMPLICATIONS FOR MANAGEMENT

Applications that generate the most excitement are those that provide the firm with a strategic advantage. I was once asked by a company president to come up with a strategic system for his company. As you might guess, this request was not particularly welcome. An outsider may be able to suggest a process for finding a strategic application, but the actual application will come from within the firm. In fact, it is probably most likely to come from a general manager not working in IT. A number of strategic applications have evolved from rather routine transactions-processing systems. Airlines developed their reservations systems to solve the reservations problem. When they put the systems in travel agencies, they realized the strategic value of this transactions processing system. American Hospital Supply began its order entry system because it was having trouble providing supplies to a hospital in California. The best place to look for a strategic application may be among the applications you already have in place.

KEY WORDS

Customer driven
Cycle times
Differentiation
Low-cost producer
Market niche strategy
Plan

RECOMMENDED READING

Applegate, L.; W. McFarlan; and J. McKenney. *Corporate Information Systems Management,* 5th ed. Homewood, IL: Irwin McGraw-Hill, 1999. (A good book for managing information processing.)

Baker, R.; R. Kauffman; and M. Mahmood. *Strategic Information Technology Management.* Harrisburg, PA: Idea Group Publishing, 1993. (An excellent collection of articles about the strategic use of IT.)

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DISCUSSION QUESTIONS

1. Locate an article in the popular business press about the strategy of a corporation. Describe the interrelationship between technology and the strategy of the firm. Compare two firms and note the differences.
2. Why did most firms first develop systems to improve operational efficiency?
3. How can a firm sustain a competitive advantage?
4. What is the first mover advantage? Give an example of a firm that has achieved such an advantage.
5. How can users evaluate the quality of service from an information services department?
6. What are the characteristics of a resource that helps a firm obtain a competitive advantage?
7. What structural features of the organization influence the structure of the information services department in the firm?
8. What are regimes of appropriability? How do they apply to IT innovations?
9. Why do you think firms might have trouble simultaneously following more than one or two of the generic strategies described in this chapter?
10. How does strategic planning differ between a firm that offers services and one that manufactures a product? Is there a difference in the impact of technology on strategy in the two types of firms?
11. How can management assess the probable information-processing technology available over the next five years?
12. What criteria are the most important for an organization in choosing among competing alternatives for a particular application?
13. Why should the decision of what applications to undertake not be left to the manager of the information services department?
14. What do you think the role of top management should be in the design of a specific information system?

15. Some senior executives feel that they do not receive a return on their investments in technology. What factors might account for this feeling? Do you think they are right?
16. It has been said that problems with information technology start at the top of the organization. What does this mean? Do you agree or disagree? Why?
17. Why do priorities have to be set for new uses of IT?
18. What are specialized and cospecialized assets? How do they apply to sustaining an advantage with technology?
19. What strategies did American and United airlines follow to enhance and sustain the advantage provided by their reservations systems?
20. What actions can management take if information technology activities seem to be out of control?
21. What is the role of external expertise in the development of a strategy for information technology?
22. What should a vision for a firm include?

CHAPTER 5 PROJECT

Strategic Advantage

Developing systems for strategic advantage (or calling them strategic) has become very fashionable. As the examples in this chapter suggest, it is unlikely that what is strategic today started out that way. Companies developed systems for one set of reasons. Later they saw extensions that turned the systems into strategic or competitive applications.

When an organization exists to make a profit and functions in an industry with competitors, it is relatively easy to look at a system and determine that it is strategic. What happens in the case of a different organization, such as a university? Can you identify the "competitors" of your university? How can information technology be used to make your institution more competitive?

CHAPTER 6

International Business and Information Technology

Outline

Focus on Change

Businesses are turning themselves into global concerns. Information technology is an important tool in making this transformation and in designing the international organization. As tariffs fall, you can expect to see firms rapidly moving operations to different parts of the world to take advantage of special competencies and disparities in wage rates. Even a one-person company can have worldwide sales through the Internet! One researcher who studies international business suggests that information technology is the glue that can hold an international organization together and help coordinate its operations. All of our IT design variables that focus on communications, such as electronic links, technological matrixing, electronic customer/supplier relationships, and virtual components, are available to help manage and coordinate the global firm.

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Globalization has been one of the major trends in business in the last decade. It is estimated that 579 global corporations account for about 25 percent of the world's production. These companies range in size from $1 billion to $100 billion. The world's strongest economies are heavily trade oriented. The United States has been actively promoting free or reduced tariff trade, though some labor groups and members of Congress oppose this campaign. Chronic trade surpluses in Japan have focused attention in other countries on world trade and on lowering barriers to trade.

The **European Economic Community (EEC)** has eliminated almost all barriers to trade and has adopted a common currency, the Euro. The U.S., Canada, and Mexico have completed the NAFTA free-trade pact that will phase out most tariffs over a 15-year period. The consensus among economists is that free trade will eventually benefit all countries that participate. There are also emerging markets in Eastern Europe and the Commonwealth of Soviet States. Recent financial crises in Asia and Latin America may slow the liberalization of trade and global economic activity, but it is unlikely to stop it. Globalization can greatly complicate the task of managing IT in a firm. Yet, IT can greatly improve the management of firms with operations in many parts of the world.

THE IMPACT OF GLOBALIZATION ON BUSINESS

There are a number of impacts of globalization (Ives and Jarvenpaa, 1992):

- *Rationalized manufacturing.* Firms manufacture in locations with a comparative advantage for the type of manufacturing involved.

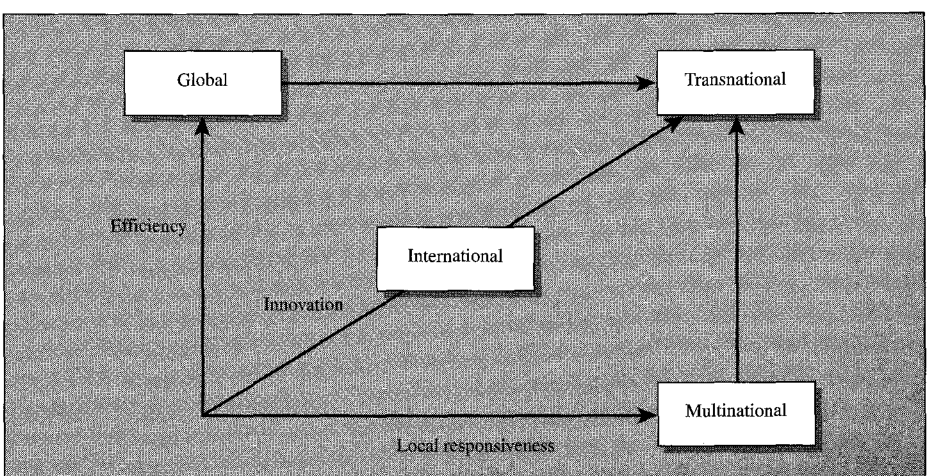
- *Worldwide purchasing.* Firms can purchase worldwide for their operations, giving them a great deal of leverage over suppliers.
- *Integrated customer service.* A multinational firm is likely to have multinational customers and can provide all locations with the same level of customer service.
- *Global economies of scale.* Size, if managed properly, provides for economies in purchasing, manufacturing, and distribution.
- *Global products.* Consumer firms have worked especially hard to market global brands such as Kellogg's cereals and beverages like Coke and Pepsi.
- *Worldwide roll-out of products and services.* The firm can test products and services in one market and then roll them out around the world.
- *Subsidizing markets.* The profits from one country can be used to subsidize operations in another.
- *Managing risk across currencies.* With floating exchange rates, doing business in many countries can help reduce risks.
- *The growing irrelevance of national borders.* Technology has far outpaced political progress in integrating different cultures. As electronic commerce plays an increasingly important role, the ability of national governments to control transactions will become more difficult.

One conclusion from the above list is that global business creates greater uncertainty and complexity. To handle these challenges, the firm will need faster communications and information processing. It will have to rely more on IT to manage the organization.

INTERNATIONAL BUSINESS STRATEGIES

Four major types of international business strategies are portrayed in Figure 6-1 (Bartlett and Ghoshal, 1989).

FIGURE 6-1
Global business strategies.



Multinational

The **multinational** strategy focuses on local responsiveness. Subsidiaries operate autonomously or in a loose federation. The advantage of this type of approach is that the firm can quickly respond to different local needs and opportunities. This strategy reduces the need for communications because local subsidiaries can make many decisions. There are heavy reporting requirements though because the results from the subsidiaries have to be monitored at a headquarters location.

Global

A **global** strategy stresses efficiency because there is strong central control from headquarters. Economies come from standard product designs and global manufacturing. An extensive communications and control system is necessary to centrally manage the global firm.

International

The **international** strategy is much like the multinational as there are autonomous local subsidiaries. However, these subsidiaries are very dependent on headquarters for new processes and products. A good example is a pharmaceuticals company. The research labs in the headquarters company develop products for introduction around the world. Local subsidiaries stress product approval by local governments and local marketing.

Transnational

The **transnational** firm attempts to do everything! It seeks global efficiency while retaining local responsiveness. The firm integrates global activities through cooperation among headquarters and foreign subsidiaries. This difficult strategy tries to achieve local flexibility at the same time that it obtains the advantage of global integration, efficiency, and innovation. We predict that the various types of firms will tend to strive toward the transnational model over time.

KEY ISSUES IN AN INTERNATIONAL ENVIRONMENT

Information Needs

An international corporation needs information to coordinate and control its diverse businesses. Reporting and early-warning systems are very important in this environment. Systems that summarize sales data and process accounting information are necessary, but they only reflect what has happened in the past. These systems represent traditional uses of IT for reporting and control.

Technology offers the international firm many more active tools to help manage the business. Coordination is a major problem for the global firm. IT provides a number of approaches to improving communications and coordination, for example, e-mail and fax. The emergence of groupware products is very important to international business. These systems let workers in different locations create a shared, electronic environment. Intranets encourage the sharing of information and

Bringing a Global Organization Together

An Intranet uses Internet technology to share information; access is restricted to the members of one organization. As an example, Medtronic, Inc., a medical device manufacturing firm in Minneapolis, has created an Intranet that ties together 13,000 employees in 60 countries. The Intranet provides reports for employees on worldwide customers, products, and special interest groups. Multinational companies are using Intranets to streamline distribution networks that cut across national boundaries, to spread common applications and business processes, promote company values, and to collect competitive information from distant markets. Intranets can become part of the glue that brings an organization together, says one consultant.

Continental Airlines has a global Intranet it calls the Electronic Service Center. The applications on the Net allow Continental to streamline operations at airports and operating centers around the world. Workers will be able to arrange time off and trade hours with others online. The company is making its flight profitability system available on the Intranet so that managers in foreign countries can get up-to-the minute information about which flights are profitable. Such a system will be especially valuable to managers on Guam where Continental Micronesia, a subsidiary, is based.

Pfizer is using its Intranet to give employees in 70 manufacturing plants in 30 countries access to over 250,000 Material Safety Data Sheet documents containing detailed data on chemicals used in production. EDS uses its Intranet to help share its value system around the world. Its 100,000 employees in 42 countries access the system. The first application describes the company's community affairs program that involves EDS applying technology to aid local communities. This content will be available in 11 languages.

Marine Power Europe, a division of outboard engine manufacturer Mercury Marine, has an Intranet–Extranet (allowing people outside the company access) that has customer credit, warranty, and order-processing information available in eight languages. Branch offices in nine countries as well as 20,000 independent dealers access the Net. The network has allowed Mercury to centralize much of its dealer support in Belgium. The Intranet cost $600,000 to develop, and the company expects it to save $1.2 million a year.

Internet technology has the potential to help coordinate the operations of a global firm, an important contribution to company success.

provide for coordination as well. For example, the design studios in different parts of the world of a car manufacturer can work on developing the same new automobile. Each studio posts its most recent design drawings on the company's Intranet, making them instantly available to designers in different locations. The Intranet provides the mechanism for coordinating the diverse design groups. As discussed in Chapter 4, the manager can use IT in a variety of ways to design the structure of the global organization. We can see that technology plays a crucial part in the design and operation of international firms.

Implementing International IT

The ultimate objective for the global firm is to process data anyplace in the world and share information without having to worry about the type of platform used for processing. What kinds of problems do you encounter trying to achieve this objective in an international environment? (For a discussion of some of these issues, see Deans and Kane, 1992.) The following section outlines some of the typical problems faced by a manager of a global organization.

The first problem is managing local development when the foreign unit does not coordinate with headquarters. The foreign subsidiary may be duplicating development efforts under way in other parts of the world. It also may not have a talented staff and may end up with poorly conceived and designed systems. The question of headquarters–subsidiary coordination and management is a central one in pursuing an international corporate strategy.

The counter argument from the local company is that it knows the needs in its location. A distant headquarters unit cannot set specifications for foreign countries. This contention leads to the second development issue: How does the firm develop a set of common systems shared across different countries to take advantage of economies of scale? Headquarters does not want each country to develop its own accounting and sales reporting systems. Different countries have different laws and regulations, so it may be impossible to share programs among foreign locations without making special modifications for unique requirements in each country.

The third development problem is that when designing applications, there are real and perceived unique features in each country. Designers, especially those representing headquarters, must recognize what features are required for a system to work in a country and what features are there as an exercise in local independence. For example, Straub (1994) studied the use of e-mail and fax in Japan and the U.S. He found that cultural differences predisposed managers in each country to a choice of communications vehicles. Straub suggests that high uncertainty avoidance in Japan and structural features of the Japanese language explain why Japanese managers have a lower opinion of the social presence and information richness of e-mail and fax, though American and Japanese managers rated traditional communications media like the telephone and face-to-face communications about the same.

Managers must also be aware that more and more firms want to build a worldwide communications network to take advantage of communications and coordination tools to move data freely around the world. This effort can be a major challenge because of different technical standards and regulations. Certain countries regulate the kind of telecommunications equipment that can be used on their network. In a number of foreign countries, PTT (postal, telegraph, and telephone) monopolies regulate communications and may restrict the ability to transmit data. Some underdeveloped countries may not have adequate communications capabilities to support private networks. Countries also may prohibit importing certain kinds of computer equipment in order to protect domestic competitors. Different kinds of communications networks and standards can greatly increase the difficulty and cost of building worldwide communications capabilities. One of the most attractive features of the Internet is that it has open standards and a presence in almost all countries. It is pervasive in Asia and the West and has much less penetration of Africa and the Middle East (except Israel).

A number of government requirements may impede the development of global information systems (Steinbart and Nath, 1992):

1. A requirement to purchase specific equipment in the foreign country that may not be compatible with the equipment used by other parts of the global firm.
2. A requirement to do certain kinds of processing in the host country before data can be sent electronically to another country.
3. Restrictions on the use of satellites and special requirements for building private networks.
4. Limited access to flat-rate leased lines or a requirement that all transmission be made on variable cost lines.
5. Restrictions on Internet access and efforts to censor Web sites.

A sixth major issue arising from international IS efforts is **transborder data flows.** Moving data across a boundary may be curtailed by government regulation, ostensibly to protect its citizens and their privacy. Another impact of regulation is to reduce the economic power of foreign companies or limit the imposition of foreign culture on the host country. Many of the transborder regulations seem to be motivated by a desire to protect local industry. Countries may have a legitimate concern about the privacy rights of their citizens. This reason is probably cited most often for instituting data controls. To implement control, a country can establish regulations through its telecommunications ministry, levy tariffs, and/or require formal approval of plans to process data in the country.

Examples of barriers to data flows include:

- Restrictive regulations that require processing of data originating in a country in that country only, making it difficult to transmit and share data.
- Exorbitant pricing of communications services by government-owned post, telephone, and telegraph ministries. However, a wave of "privatization" is sweeping countries and many PTTs are becoming private or quasiprivate companies.
- Attacks on computers by various hackers throughout the world have pointed out how difficult it is to secure networked computers.

As with any international venture, language and cultural differences can also present a challenge to developing IT on a global scale. Time differences can make communication difficult for different parts of the world, though fax and e-mail have eased this problem considerably. Some firms stress joint development teams with representatives from different countries to avoid problems stemming from developing a system in any one country or language. Foreign subsidiaries may be more willing to adopt an international system developed by a cross-cultural team.

Designing Around the World

Ford Motor Company has business locations in the U.S., Europe, and Asia. It has design centers in Dearborn, Michigan, Ford's headquarters, Valencia, California, and five other centers in Cologne, Germany; Dunton, England; Turin, Italy; Hiroshima, Japan; and Melbourne, Australia. Ford has launched a "Studio 2010 Computer Aided Industrial Design" unit in Dearborn. The objective of this project is to establish interactive video links among the seven design centers to facilitate collaboration among its engineers. Designing a new car today costs in the billions of dollars; Studio 2010 is designed to reduce that cost while encouraging collaboration among Ford designers worldwide. Currently there are high-speed data links between Dearborn, Valencia, England, and Germany.

The company plans to share multimedia information in videoconferences. A presentation might include videoclips and three-dimensional images developed on the computer-aided design workstations. Ford is a good example of information technology being used to coordinate a global firm; regardless of where an engineer sits or in what time zone he or she works, it is possible to contribute to a design project. Linking the world together was a logical step after Ford's engineers had been equipped with computer-aided design workstations. These workstations contributed to the productivity of the individual engineer; the communications links will contribute to the productivity of the team that is working on a design project.

Ford is also using technology to outsource some of its design activities. The company has plans to turn over more than half of its new auto design efforts to parts suppliers. Ford is linking several hundred suppliers around the world to its computer-aided design and manufacturing system so they can be a part of an interactive design process. Ford's objective is to tap the expertise of its suppliers rather than try to duplicate that expertise within the company.

The system works through file transfers and e-mail notification. As an example, a seat supplier sends the design for a new assembly from a Unix workstation from Japan to the Ford product data management system where the plans go into a product design database. The system notifies all concerned parties through e-mail. A Ford engineer then reviews the design to be sure it will fit as specified; if there are any problems, he or she sends the designer a file with data on the surrounding parts of the car.

Here, technology is being used to coordinate diverse individuals and companies to form a "virtual" design team for Ford.

MANAGING INFORMATION TECHNOLOGY INTERNATIONALLY

What can the manager do to solve the problems raised above? Some of these impediments to IT require political action or deregulation, for example, the policies of foreign PTT utilities. In other instances, management has to take action to solve problems, and managers have to be involved in efforts to develop systems that will be used in multiple countries. It is management that has to sell its vision for the firm's global technological infrastructure and resolve conflicts over IT requirements.

TABLE 6-1

STRATEGIES FOR MANAGING GLOBAL *IT*

- Concentrate on interorganizational linkages
- Establish global systems development skills
- Build an infrastructure
- Take advantage of liberalized telecommunications
- Strive for uniform data
- Develop guidelines for shared versus local systems

Roche (1992) presents a number of strategies for managing information technology in a global environment. See Table 6-1.

Concentrate on Interorganizational Linkages

The strategy of creating linkages with suppliers and customers can be extremely effective internationally. It can also be very difficult to set up these linkages because of differing telecommunications capabilities in different countries. In some regions phone systems do not work well and transmitting data over them is probably not viable. Other countries, like France, have an extremely well-developed infrastructure for business communication, which is discussed later in this section. The Internet is one solution for quickly establishing these linkages.

Establish Global Systems Development Skills

There are problems managing IT development projects when all participants are from the same country and work in the same location. Coordinating multinational project teams presents an even greater challenge. Language and distance make them difficult to coordinate. A New York bank has a development team with members in New York, Lexington, Massachusetts, and Ireland coordinated through groupware. In some foreign countries, hiring staff with the appropriate skills to work on technology can be difficult. Interviews with IT managers for multinationals in seven countries found dramatic differences in their accomplishments and their capabilities. Lack of personnel skills can be a major impediment to developing international systems; not all countries have educational programs to prepare individuals for systems analysis or programming jobs.

Build an Infrastructure

Justifying expenditures on infrastructure can also be extremely difficult. Infrastructure is the part of technology that does not have an immediate benefit. The easiest example is a worldwide communications network. One money-center bank carefully costed out an international, private network and found that it had a negative net present value: The economic criteria suggested not to undertake the development of the network. However, the bank went ahead and found that the new IT provided a number of benefits that were hard to quantify. Basically,

MANAGEMENT PROBLEM 6-1

Bill Roberts is the chief information officer for a multinational company. He reports to the company president and has a staff of 50 at headquarters. This group runs systems for the headquarters operation and also tries to provide standards for subsidiaries in foreign countries.

Headquarters has developed a standard library of financial and accounting applications that runs on most of the computers in the subsidiaries. (Bill was successful a few years ago in getting all the subsidiaries except the largest to agree on one model of computer.) Since many of the subsidiaries are not large and have trouble recruiting skilled technology staff members, they are quite happy with the library of programs.

Each country has its own information services department manager, generally reporting to the controller or possibly the president of the subsidiary. Bill and his staff travel extensively to try to help each subsidiary better manage its technology effort.

Bill is facing a major problem in at least two countries; he and his staff think the local person in charge of information systems is not doing a good job. "After several years of working with the people in charge in two countries, I have come to the conclusion that we really should let them go. However, I have no real responsibility; these people report to a manager in the country, not to me."

How can Bill help the company solve this problem? Do you think they need to reorganize the structure of their IT units? Does it make sense to have foreign operations reporting to Bill? If not, how can he influence what goes on in subsidiaries outside the U.S.?

with this network the bank could "plug in" any application to the network and offer it anyplace in the world it did business.

Take Advantage of Liberalized Electronic Communications

The trend toward deregulation in the U.S. is also sweeping foreign countries. France has split France Telecom from the PTT and established it as a quasi-public organization. In the past two decades, France Telecom has replaced an outmoded phone system and added a mass market communications network called the Minitel system. It is also a leader in providing packet-switched data communications through Transpac. (Packet switching is discussed in Chapter 12.) Changes such as these facilitate the development of the international communications networks, which is essential to managing in a global environment.

Strive for Uniform Data

One of the major problems in sharing data is identifying it. A story is told that a large computer vendor once looked at its logistics systems and found that "ship

Worldwide Access

If you are trying to find products to purchase for sale or use in manufacturing from around the world, the Web can help. Before the Internet, a purchasing manager would comb through industry magazines and catalogs, and travel to endless trade shows. A members-only service called World Merchandise Exchange (Womex) in Norwalk, Connecticut, is designed for worldwide merchandise trading. The service has a database containing thousands of products from manufacturers around the world. It provides members with free electronic mail, online discussions and links to industry publications. A buyer logs onto the network, searches the database and finds detailed specifications about a product. These specs include photographs, packaging data, weights, and pricing estimates. Using e-mail, the buyer conducts negotiations with potential trading partners. Since it is so economical for a supplier to list its products, the buyer has access to many more sources electronically than he or she did before the Web. It is services like Womex that help level the playing field between large, well-financed firms and smaller companies, often in less-developed countries, that are trying to engage in global trade.

date" meant six or seven different things depending on the system involved. In one system it might be the promised ship date, and in another the date the item left the loading dock. To obtain economies of scale from sharing data and systems, the firm must have a common vocabulary of terms and definitions.

Develop Guidelines for Shared versus Local Systems

We can add another important strategy to Roche's list: You need to develop guidelines for when a system should be shared and when a local, autonomous system is more appropriate. The obvious advantages of shared systems are economies of scale and the ability to share data. The problem with shared systems is that they tend to become very large and complex. Also, individual locations and users have special needs that must be incorporated into the system. As the number of exceptions increases, the system becomes more cumbersome and difficult to program.

The advantage of a local system is that it can often be developed quickly in response to a local condition. If it later becomes necessary to coordinate this system with other applications, special interfaces will have to be created. If each location ends up needing a similar system and cannot share this one, the firm has paid for many systems when possibly one would have sufficed.

There are no firm guidelines for making this kind of decision. Firms have had success and failure with both approaches. Systems development in an international environment (or even a domestic one where there are many locations) leads to this problem. Management has to recognize that the problem exists and compare the alternative of local versus global, shared systems.

THREE EXAMPLES

Standard Pharmaceuticals International

Standard Pharmaceuticals International (SPI) is the international division of a multinational drug company headquartered in the United States. The international division consists of 30 foreign subsidiaries located throughout the world. SPI is dependent on the U.S. parent company for all research and new products.

A major challenge for pharmaceuticals firms is to obtain government approval for the sale of new drugs. This process can take many years of testing and the submission of literally a truckload of documents to the Food and Drug Administration (FDA). The firm then must wait until the FDA approves or disapproves the sale of the drug.

Some foreign countries will accept U.S. FDA approval as sufficient to market the drug, but many will not. This practice means that the SPI foreign subsidiary must conduct clinical trials in its own country and submit the results to its government for approval. Once approved, the SPI subsidiary markets the drug to physicians and hospitals.

SPI's information services (SPIIS) department has a "federal" organizational structure. The head of the department reports to the SPI controller (based on historical precedent; it has been recommended that this individual report to the SPI president). Each country has its own information services manager who reports to the local controller. (In a similar vein, it has been recommended that the local IS manager report to the SPI local subsidiary president.) The headquarters IS group provides advice to the subsidiaries and tries to set standards. However, the local subsidiary staff does not report to the headquarters IS manager.

Because of the historical reporting relationship, it is not surprising that most of the applications at SPIIS involve finance, accounting, and sales reporting. The headquarters IS group developed a standard library of applications that most of the smaller subsidiaries adopted. Larger subsidiaries do not necessarily have the same equipment, and several of them have significant IS staffs and portfolios of applications.

Recently the parent company appointed a new president of SPI. This individual wants to change the strategy of the IS group to emphasize supporting the sales and marketing departments. He has commented, "I have yet to see how one gets a competitive advantage by closing the books each month two days before the competition."

SPIIS is trying to adjust to this change in strategic focus. One example of the problems they are encountering is the sales representative notebook computer project. The sales and marketing department launched a separate effort from IS to develop applications for a notebook computer for sales representatives. The portable computer should provide information to the sales representative about his or her territory with access to a commercial database of prescription drug sales. These sales reps visit physicians in their offices and at hospitals to explain the company's new products and leave samples for the physician. The system should also keep track of sales calls and keep a record of drug samples left with the physician. (This record is often required by governments in order to limit the number of samples distributed.)

The marketing and sales groups tried to keep IS from becoming involved in this project because they felt IS was interested only in financial systems. The IS manager was concerned that the notebook-computer team lacked adequate technological expertise and would waste a large amount of money.

Because of country differences, marketing tried different types of systems in different countries. In one country, marketing bought a package system and invested a reported $1 million before canceling the trial. The greatest success has been in France, where the Minitel system made it easy to implement all of the needed functions using existing technology.

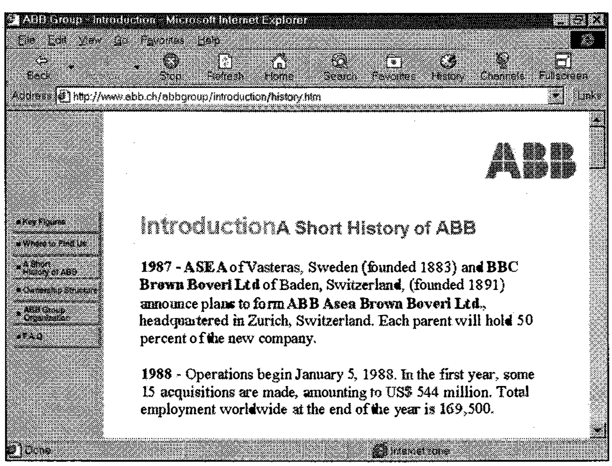
SPI is caught in the dilemma of a local system versus shared systems development. In addition, the president of the division wants to more than double sales revenues while keeping administrative expenses at current levels. Without providing more resources to the IS staff and investing in a worldwide network, it is unlikely that the president will be able to accomplish his goals.

Asea Brown Boveri

Asea Brown Boveri (ABB) is a Swiss-based electrical company described as one of the most successful transnationals in the world. The company was formed by a merger between Asea, a Swedish engineering firm, and Brown Boveri, a Swiss competitor. The dynamic chairman at the time, Percy Barnevik, added more than 70 companies in Europe and the U.S. to this pair of firms. ABB is larger than Westinghouse and is competing directly with GE in the United States. See Figure 6-2.

ABB is a transnational firm as depicted in Figure 6-2. The chairman wants local managers to concentrate on their markets, but he also wants to strive for global

FIGURE 6-2
Asea Brown Boveri history from its web site.



efficiencies and take advantage of the purchasing power generated by ABB's size. The company is organized as a matrix. Along one axis, the company consists of distributed subsidiaries, each of which makes decisions without regard to national borders or other ABB units. In the second dimension, the firm appears as a group of traditional national companies, each serving its home market. The chairman and a 12-person executive committee provide the glue that holds the two dimensions of the matrix together. Some 50 or so leaders of business areas report to the executive committee.

The business areas are further grouped into eight segments with a member of the executive committee responsible for each segment. The business leader is responsible for optimizing the business globally. Business leaders know no borders, and are located in many different countries. These leaders allocate export markets to factories, share expertise by job rotation, create temporary multinational task forces to solve problems, and devise global strategies. Within each country, there is a traditional structure with a CEO for ABB operations in that country. The CEO reports to a local board of directors, and the business in that country produces its own financial statements. The CEO may have a number of subsidiaries operating in his or her country. There are approximately 1100 local ABB units around the world (Taylor, 1991).

One significant challenge in this environment is reporting results and finding problems. Shortly after the creation of ABB, the company developed and implemented a new information system called ABACUS. This system collects monthly performance data from 5000 profit centers in 1300 companies that employ more than 200,000 people in 140 countries. It compares actual performance with budget and forecasts. Local units submit data in their currencies and the system translates all numbers into U.S. dollars for comparison purposes. The chairman looks at variables such as new orders, invoicing, margins, and cash flows around the world to spot trends. As an example, he might see that an industry segment is behind budget; looking for more detail, the problem appears to be in one business area. Further study shows that the problems are in one country and that margins are off. The conclusion is that a price war has broken out. The next problem is to decide on a course of action; the system has alerted management to the problem, but they will have to decide on the appropriate course of action to solve it (Simons and Bartlett, 1992).

The company has only two IT staff members and a part-time manager at headquarters. An IS steering committee serves major geographic and business entities. Each of these groups meets several times a year to approve budgets and ensure that technology plans fit the corporate plans. IS managers work for each of three geographic regions, five business segments, and 45 business areas. Each business chooses its own application. The company is trying to standardize on Lotus Notes as a corporate groupware environment, and has over 13,000 users (see Chapter 21).

VeriFone

Hatim Tyabji, the recently retired chairman of VeriFone, believes in a flexible organization structure and in the importance of being close to customers to provide a fast response to their needs (Galal et al., 1995). VeriFone faced strong competitors in its early days from AT&T, GTE, Northern Telecom, and Mitsubishi, to name a few. In 1997 Hewlett-Packard acquired VeriFone in order to advance its efforts in electronic commerce; HP plans to keep VeriFone as an independent subsidiary. See Figure 6-3.

VeriFone's mission is "to create and lead the transaction automation industry worldwide." In 1996 the company's products processed an estimated 65-70 percent of credit card transactions in the world. Much of the business is in custom software that runs in the verification "boxes" and on other parts of the transactions network. VeriFone offers over 1600 programs that run on its verification devices. The firm has also formed alliances to verify and process payments on the Internet, including agreements with Netscape, several banks, and Discover.

VeriFone does have an ongoing structure, similar to most organizations. What makes VeriFone unique, however, is the constant "organizing" that occurs within this structure that is accomplished through cross-functional teams. Any employee can form a task force to address a problem. These teams come in and out of existence regularly. They are virtual in the sense that they span different organizations and members may be in different locations. The constant formation, activity, and deactivation of teams are the mechanism through which VeriFone is constantly organizing.

In addition to teams within the firm, VeriFone forms alliances with other organizations. A virtual team might span organizational boundaries. Today the company has a number of alliances including one with Microsoft to deliver commerce-enabled Internet products for retailers and another with Digital Xpress to offer bundled ISDN services to various customers.

While organizing is a key activity at VeriFone, there is a conventional organization chart that shows reporting relationships and titles. The organization is relatively

FIGURE 6-3
VeriFone home page.

flat with the chairman having eight direct reports and the executive vice president six. Tyabji's corporate model is a decentralized network of locations; he refers to this structure as the "blueberry pancake." "All berries are the same size; all locations are created equal" (Galal et al., 1995). His least favorite location is corporate headquarters. Regardless of formal structure, an employee can access any other employee directly through e-mail.

The focus is not on hierarchy and status. Rather, VeriFone defines the "right organization structure" as one that locates employees near customers so that they continually put the customer first. The idea is that a customer in a country using VeriFone products can meet with a design engineer located in the customer's country; that design engineer can make changes in the product without approval from anyplace else. VeriFone operates in 53 locations with over 2900 employees.

The management culture and norms at VeriFone allow it to operate in an organizing mode. Two of the key characteristics of VeriFone that emerged from discussions with company officials are "fast response" and "a culture of urgency." As one employee described it, there is "never time to rejoice" after finishing a project because there is always something else to do. A lack of organizational hierarchy makes it easier to respond quickly.

Because of geographic decentralization and the existence of many virtual teams, an employee is often on his or her own; it is not unusual to be located in Atlanta and to report to a supervisor in Paris. VeriFone counts on individual initiative to achieve its goals. VeriFone believes, according to its stated corporate philosophy, that those who perform a job know best how it should be done. It is clear that this culture involves mutual trust. Employees trust the company to support

MANAGEMENT PROBLEM 6-2

The Internet presents a major dilemma for governments that control citizens' access to information. A telecommunications official of an Asian country referred to the "evil Internet," something that his government could not easily control. Often the objections are made in terms of adult content and material. However, this official was more blunt: "We need to control the information that people in our country receive to be sure it is correct."

The official, however, was caught in a dilemma. He realizes that to be competitive, companies in his country have to be connected to the Internet; they need to have a presence on the Web. Many of them could benefit from electronic commerce as it tends to level the playing field between large and small firms. Even a small company can have a Web site so that anyone on the Internet can find its products.

How would you recommend the government resolve this conflict? Does the Internet promote a certain value system with respect to free information? Will it have a long-term impact on governments that like to control information for citizens?

their actions and to encourage experimentation. VeriFone trusts its employees to take the initiative and act in the best interest of the company. VeriFone tries to maintain this culture with a minimum of rules.

Communications is a key activity at VeriFone. A corporate philosophy of distributing power to the lowest level of the organization possible reduces the amount of communications required to operate. At the same time, the global nature of VeriFone's operations creates significant demands for communications, especially for virtual project teams. Managers themselves communicate with e-mail; there are no secretaries to print messages or enter responses. Executives in different countries might work together on the same spreadsheet in preparing a proposal. These executives can access information on bookings, shipments, and revenues from an on-line database with worldwide availability.

VeriFone uses 32 different tools for communications. Travel, face-to-face meetings, and task forces are all communications mechanisms. Frequently task forces work "around the world" with conference calls scheduled so that members take turns getting up at 2 A.M. to participate.

VeriFone stresses the need for employees, while a part of a virtual firm, to interact physically on a regular basis. Large rooms in local offices facilitate group gatherings and the firm has annual meetings of different employees who work in similar functions. Every six to eight weeks, the senior management team gets together for a meeting in a different part of the world. (A recent VP of human resources lived in Dallas; the former CIO and current advisor to the board has homes in Hawaii and Santa Fe, while the retired chairman lives in the San Francisco Bay area.) Senior managers feel it is important for employees to know each other so they can use information technology effectively. The cost of face-to-face communications is constant travel; Tyabji reports traveling over 400,000 miles in a year. About one-third of the company's employees are on the road at any one time, leading to an annual expenditure of over $5 million on hotels and airfare (Galal et al., 1995).

VeriFone suggests that the virtual organization does not necessarily want to substitute electronic for physical interaction completely: rather the electronic and face-to-face (FTF) communications complement each other. At VeriFone, occasional face-to-face communications enable more regular and routine electronic communications with its advantage of reducing the constraints of time and space on interaction.

In addition to communications mechanisms, VeriFone believes in sharing information. The former CIO prepares a daily "flash" report that goes to 300 VeriFone employees daily. The report is a method for evaluating progress. Recipients can easily access the data behind the interpretation so they are not dependent on one person's view of performance. The firm provides so much information that it has registered more than 10 percent of its employees as "insiders" with the Federal Trade Commission.

VeriFone also shares information and knowledge with its customers and alliance partners. Before e-mail became easily available through service providers, VeriFone had suppliers and alliance partners on its own e-mail system. Today

VeriFone provides videoconferencing equipment for these firms. Before going public, when it had to be concerned about releasing information, VeriFone shared its daily "flash" report with some partners.

VeriFone uses "appropriate technology," not the newest equipment. It spends about 60 percent as much as comparable electronics firms on information technology. Its e-mail system ran for many years on VAX computers using a text-based mail program. The daily "flash" report is character-based. Current technology efforts include the development of an Intranet to facilitate information sharing. The responsibility for providing content on the Intranet will be distributed; for example, a new product group will create and maintain pages for its product.

For a VeriFone employee, the organizing character of the company, management culture and norms, and information sharing leads to self-governance. The employee may not have extensive physical contact with a supervisor. This employee is encouraged to take the initiative in coming up with new ideas for improving VeriFone, its products, and/or its service to customers. She will communicate using a variety of media with customers, alliance partners, and other VeriFone employees. She may start a virtual, cross-functional team and be a member of several others. Her major focus will be on quick responsiveness to conditions in her local environment.

However, information technology means that she is not confined to local solutions; VeriFone is able to marshal its global resources to solve local problems. An actual example helps to illustrate this global search. A customer told a sales representative in Greece, based on a VeriFone competitor's statements, that VeriFone lacked a certain product. The sales rep sent a single e-mail to "ISales," which reached all sales reps worldwide, asking whether VeriFone had a product for this customer. A sales manager in San Francisco took on the task of heading this virtual task force. He collated 100 replies and constructed a Powerpoint presentation for the sales rep in Greece (while the rep slept). The sales manager had the presentation translated to Greek, and the sales rep took it to his client the next day. VeriFone won the account.

TRANSNATIONAL VIRTUAL FIRMS AND IT

ABB and VeriFone provide evidence that a transnational firm depends on information technology for information and knowledge sharing, communications, and coordination. However, technology alone is not enough to create either a transnational or a virtual corporation. Senior management determines the structure and culture of the firm. At both ABB and VeriFone senior managers shaped and created organizations that encouraged local autonomy and fast response to the environment. Technology facilitates the creation and operation of these companies, just as it can play a crucial role for any organization that wants to become a transnational. The benefits of a virtual organization like VeriFone in international business suggest it as a model for other firms.

The Global Reach of the Computer

Less-developed countries, for years on the outside of the computer revolution because of cost and import restrictions, have displayed a ravenous appetite for personal computers. In Brazil where PCs were almost nonexistent a few years ago, computers have become a major part of the culture. It is estimated that tens of thousands of Brazilians are banking at home. PCs can be found in Poland, Indonesia, Uganda, and Bangladesh.

Many of these computers are being used in business, narrowing the competitiveness gap between firms in the less-developed countries and developed nations. Because these organizations do not have old technology, they can start with highly cost-effective PCs and a client-server architecture (see Chapters 8 and 13). A bank in Prague with no computer systems moved from paper to a client-server network on Dell computers, allowing it to connect for the first time with worldwide monetary trading networks. Chile's export-promotion agency connected 160 PCs around the world to a group of Compaq servers in Santiago so that prospective buyers could review Chile's export products.

In Latin America, Chile is one of the leaders in applying PC technology. Many small stores use a PC for tracking inventory and preparing invoices. Larger companies like the winemaker Concha y Toro and the dairy Loncoleche equip their sales force with hand-held terminals or notebook computers. Compania de Petroleos de Chile uses PC-based systems to keep track of diesel fuel sales and monitor the growth of trees. The Chilean government is spending $3 million to put computers in schools. Even still Chile has 3.3 PCs per 100 people compared to 30 per 100 people in the U.S.

Brazil has relaxed import tariffs on computers, and sales have soared. A grocery wholesaler in central Brazil was never able to afford a computer, especially given interest rates of 12 to 14 percent *per month* on capital. Its major competitor used a mainframe computer to route trucks. However, the wholesaler sent its trucks on the same routes each day whether there were orders or not. With a $3000 PC and a package from a Maryland firm, the wholesaler has been able to deliver 30 percent more goods with a 35 percent smaller fleet of trucks. It has reduced warehouse employment from 95 to 80 people. The company also installed bar code scanners to track inventory and a central server to track orders. For the first time, it is ahead of its competitors in applying technology.

BUSINESS MODELS AND IT MANAGEMENT

Based on their research, Ives and Jarvenpaa (1992) suggest that an international firm goes through the following stages in developing its management of information technology, which are outlined in Table 6-2.

Independent Operations

In the 1960s and 1970s many multinationals gave considerable autonomy to foreign subsidiaries, which acquired hardware and software from local vendors. The applications implemented differed considerably across countries. There was little interaction with headquarters or the IT staff there. Headquarters might have

TABLE 6-2

INFORMATION TECHNOLOGY APPROACHES IN GLOBALLY COMPETING FIRMS

	Approaches			
IT activities	**Independent operations**	**Headquarters (HQ) driven**	**Intellectual synergy**	**Integrated global IT**
Applications development	Total local autonomy	Modify a working U.S. application for global use	Joint high-level requirements analysis; implementation under local control	Multinational user/IS team designs and oversees implementation of the system
Applications maintenance	Total local autonomy	Centralized maintenance	Total local autonomy	Centralized maintenance on common core modules; localized maintenance on others
Systems software, hardware	Total local autonomy	Headquarters' decision	Total local autonomy	Common worldwide architecture
Staffing senior IT positions at subsidiaries	Total local autonomy, a local employee	HQ's decision, often a U.S. expatriate	Advice from HQ's IT group, a local employee	Joint decision, a global search for eligible candidates
Control over IT operations	Total local autonomy	Run from centralized data center	Local autonomy, but incentives from HQ	Local systems run locally; common system run from local/regional data center
Relationship between subsidiary and HQ's IT heads	No formal relationship, little or no informal contact	Subsidiaries' IT heads report to HQ's IT head	Dotted-line relationship; considerable informal exchange	IT heads around the world are peers; considerable informal and formal exchange
Diffusion of IT innovation	Little or no diffusion across country boundaries	One-way, from HQ to subsidiaries	Two-way	Two-way "centers of excellence" established around the world
Primary basis for common systems	Consolidated financial reporting requirements	Economies of scale in IT activities	Experience accumulated in other parts of a multinational firm	Global business drivers

imposed a chart of accounts or financial reporting standards on subsidiaries, but these data were rarely transmitted electronically.

Headquarters Driven

During the 1980s the focus of multinationals turned to efficiency in information technology operations. Headquarters based in the U.S. sought to implement

TABLE 6-3

BUSINESS AND *IT* MANAGEMENT APPROACHES

Business model	IT management approach
Multinational	Independent operations
Global	Headquarters driven
International	Intellectual synergy
Transnational	Integrated global IT

worldwide applications at subsidiaries to reduce development and operating costs. The apparent motivation for this approach was efficiency, and local subsidiaries did not see much to be gained.

Intellectual Synergy

This approach to IT returns control to the local subsidiary. Headquarters tries to use influence to guide the choices of the subsidiaries. The firm might host worldwide planning conferences. If this model is working, the subsidiaries should request advice from headquarters. Headquarters tries to coordinate the subsidiaries to reduce duplicate development efforts and encourage resource sharing.

Integrated Global IT

This approach is often adopted because of pressure from global customers. The firm must provide more consistent customer service internationally. Systems design requires input from around the world. The firm must standardize its data and will probably consolidate data centers. Headquarters will specify certain applications as common systems, such as order entry. There will be limited customization of these systems to fit a subsidiary.

Ives and Jarvenpaa suggest that there is a relationship between the company's approach to IT management and the business models presented earlier (see Table 6-3).The multinational firm is expected to favor independent operations. A great deal of autonomy on information technology decisions is given to the local subsidiary. The focus of the strategy is on local response.

The global business model stresses efficiency. We would expect to find a headquarters-driven technology strategy with this approach to business. Headquarters will try to coordinate and centralize to reduce duplication and encourage common systems.

An international business model will probably be combined with an IT strategy of intellectual synergy. Subsidiaries depend on headquarters for guidance and for new knowledge. Headquarters tries to influence subsidiary technology policies through planning and sharing information.

The transnational firm is most likely to follow an integrated, global IT strategy. Headquarters will define core systems that will provide uniform customer service in a global market. Management of the firm realizes that information technology is an important element in its strategy.

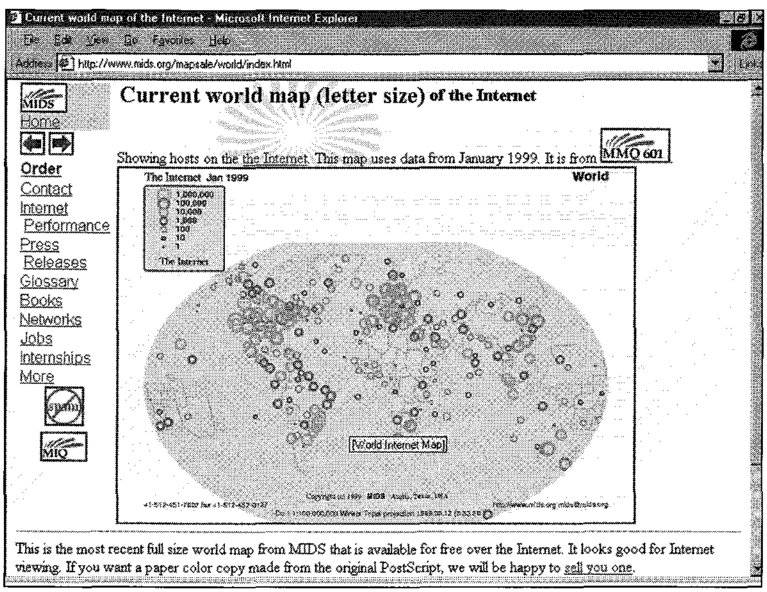
The Global Village

For years commentators have described the transportation and communications systems as creating a global village by bringing people around the world closer together. On the communications side, two developments contribute to the creation of a global village, the Internet and satellite communications systems.

The map in the accompanying figure shows the worldwide expanse of the Internet. While access is limited in Africa and the Middle East, there are host servers on every continent except Antarctica! When the Starr report on President Clinton was posted to the Internet, it became instantly accessible to over 100 million people around the world. This rapid publication is something no newspaper or television system could equal.

Satellite phone systems also provide the opportunity to reduce the perceived distances between people. We discuss these systems further in later chapters. Basically, they provide communications anyplace on the earth via a series of low-orbit satellites. While currently very expensive, as with other technologies, prices can be expected to drop as more competition develops. Imagine being able to phone home from the middle of the Arabian desert as easily as from London!

The Internet World.



THE INTERNET, IMPERIALISM, AND DEVELOPING COUNTRIES

Earlier in the chapter, we mentioned some of the barriers that countries sometimes put in place that inhibit the free flow of information. The representative of a developing Asian country, at a recent conference in Malaysia, stated that the "Information superhighway suggested by Vice President Al Gore was the latest example of American imperialism." During this person's talk, he complained about a number of issues with new technology and the Internet:

- His government had to stop censoring newspapers and magazines when fax machines became easily available because people called on friends in foreign countries to fax the excised material to them.
- There was no way to authenticate information on the Internet; some recent civil disturbances were "perpetuated" through unverified information on the Internet. The Army set up a Web site to provide accurate information, but no one accessed it.
- It was important for his country and others to participate in the Internet and electronic commerce, but it was also important to find ways to avoid being influenced by Internet content.

Clearly modern information technology, and particularly the Internet, puts less democratic governments that wish to control and limit information in a difficult situation. The Internet makes it possible for businesses in developing countries to do business with customers around the world, expanding their markets and increasing trade. However, this same technology makes vast amounts of information available to those with an Internet connection. More than the presence of information, the Internet culture emphasizes the free flow and availability of information. Many developing countries feature strong central governments that exercise considerable control over the economy. Leaders in these governments tend not to be in favor of providing transparency and full information to the public. How governments resolve this dilemma will determine whether they take part in the technology revolution or fall behind the rest of the world.

CHAPTER SUMMARY

1. There are at least four international business strategies, including the multinational, global, international, and transnational approaches.
2. IT can be used to facilitate international business, especially IT organization design variables that stress communications, knowledge sharing, and coordination. Headquarters–subsidiary coordination is one of the most significant challenges in managing an international business.
3. It can be difficult to implement international applications of the technology for a variety of reasons.
4. Many international firms find they need a global network, a technology infrastructure that ties together far-flung components of the firm. The Internet, and particularly Intranets, are helping to provide connectivity, information sharing, and coordination worldwide.

5. Firms building technology must trade off the advantages of local flexibility and freedom against the benefits and efficiency of common systems.
6. IT challenges in an international environment also encompass issues like standards, uniform data, and dealing with the different quality and regulation of telecommunications in various countries.
7. Developing countries with strong central governments face a conflict between the need to participate in the growth of technology, especially the Internet, and their desire to control their economies and information.

IMPLICATIONS FOR MANAGEMENT

One of the major trends in business is globalization. The IT organization design variables discussed in Chapter 4 are well suited to helping you manage a transnational firm. You will want a technological infrastructure that features a worldwide network. Building on this infrastructure, you can use groupware, e-mail, conferencing, and other communications technologies to coordinate far-flung operations. Intranets facilitate information and knowledge sharing, and contribute to global coordination. A virtual structure like the one used by VeriFone seems well suited for a transnational corporation. The virtual organization can be designed to provide a fast response to local opportunities along with access to the firm's worldwide knowledge base. This example demonstrates how organization structure can be a strategic variable, letting you compete via the speed and quality of your response to customers and competitors.

KEY WORDS

European Economic Community (EEC)
Global
International
Multinational
Transborder data flows
Transnational

RECOMMENDED READING

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Ives, B.; and S. Jarvenpaa. "Global Information Technology: Some Lessons from Practice." *International Information Systems.* 1, no. 3 (July 1992), pp. 1–15. (An insightful article that presents several of the models described in this chapter.)

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Tan, B.; K. K. Wei; R. Watson; D. Clapper; and E. McLean. "Computer-Mediated Communication and Majority Influence: Assessing the Impact in an Individualistic and a Collectivist Culture." *Management Science,* 44, No. 9 (September 1998), pp. 1263–1278. (This research study found that the impact of computer-assisted communications in an experiment was influenced by the culture in the country of the experiment, showing that cultural factors have an important impact on the use of technology.)

DISCUSSION QUESTIONS

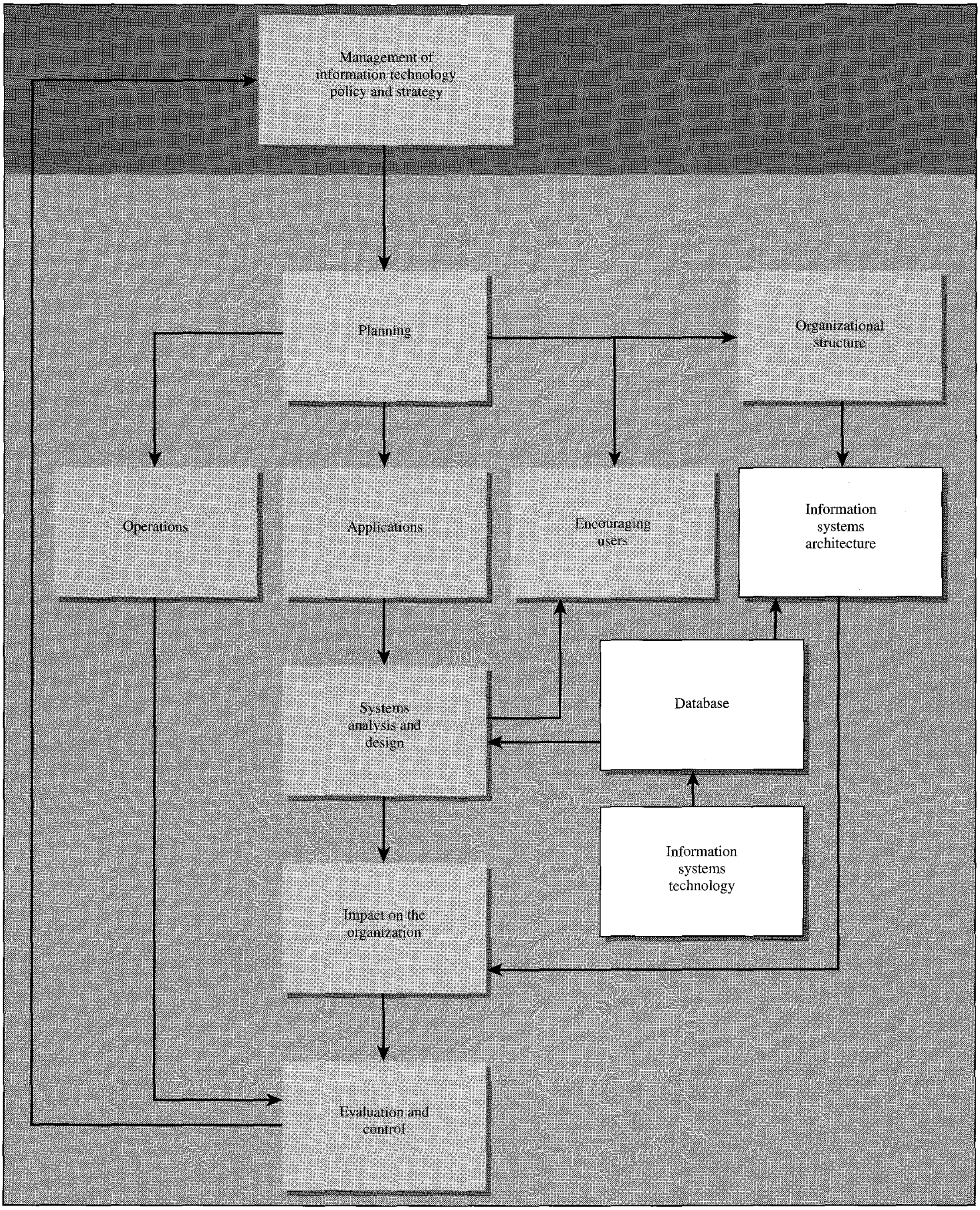
1. What has motivated the current interest in global business?
2. Why might a country want to regulate the data collected within its borders?
3. One study reported that managers found concerns about regulations on transborder data flows to be unwarranted. Why do you suppose this issue has not surfaced?
4. What are the advantages of providing a subsidiary with a great deal of local autonomy?
5. What are the disadvantages of local autonomy for subsidiaries?
6. How should a manager determine whether a system should be "common" across a number of subsidiaries, or uniquely developed for each subsidiary?
7. Why do you suppose Standard Pharmaceuticals International primarily developed financial and accounting systems?
8. What can the president of SPI do to change the division's strategy toward marketing and sales support?
9. How can information technology support a marketing-oriented strategy in the drug industry?
10. What are the key features of VeriFone's structure?
11. What are the risks of a global IT strategy? What are its benefits?
12. What impediments do you see to worldwide networks for coordinating the activities of global firms? What is the role of the Internet in this process?
13. How can an international firm see that local staff members have enough expertise to develop and apply IT?
14. What are the problems of establishing common data elements in a global organization?
15. Why does a firm need common data elements and structures?
16. How can IT help coordinate a global firm? Where can it help save money while making the firm more responsive?
17. Roche (1992) advocated a number of interorganizational linkages in conducting international business. What problems do you see in connecting a global firm to its many customers in different countries?
18. What kind of business activities do you think are most amenable to common systems in different countries?
19. What are the advantages of making product design information available around the world? How might you use this capability to organize product development?
20. If company management or custom dictates a fairly independent and autonomous IT effort in subsidiaries, what approaches can management take to coordinate these activities?
21. What Internet access policies would you recommend to the government of a developing country?

CHAPTER 6 PROJECT

Implications of NAFTA

The United States, Canada, and Mexico are working to eliminate trade barriers among these three trading partners. Some South American countries envision a completely free trade zone in the Americas. Using recent articles in the business press, develop a list of the positions, pro and con, taken by various interest groups, such as business, labor, and politicians, on free trade in the Western hemisphere. What impact does the Mexican peso crisis of 1995 have on your arguments? What about the plunge in Asian currencies in 1997?

If tariffs are drastically reduced or eliminated, what is the role of information technology in encouraging more trade? In managing firms in the hemisphere?


Management of information technology policy and strategy
Planning
Organizational structure
Operations
Applications
Encouraging users
Information systems architecture
Database
Systems analysis and design
Information systems technology
Impact on the organization
Evaluation and control

PART THREE

INFORMATION TECHNOLOGY

This part contains important material you will need to make decisions about technology, as shown in the accompanying figure. To make decisions intelligently, the decision maker must understand some of the technical issues involved. A basic knowledge of technology is needed to manage information systems activities effectively.

In Chapters 7 and 8, we discuss computer hardware. Users and managers are often involved in the selection of the appropriate technology for an application. Should the application run on a large or midsized computer, or on PCs connected on a local area network?

The user may be involved in the selection of the entire computer system. Possibilities here range from a personal computer to a large general-purpose computer system. It is also very likely that the acquisition of specific devices, such as laser printers, networks, optical storage units, and similar equipment will involve the manager. Finally, management must decide where computers will be located and what applications each computer will execute.

There are also many important decisions concerning computer software, a topic discussed in Chapter 9; for example, should a user buy a particular program for a personal computer?

Many organizations have developed comprehensive databases in order to run basic transactions processing applications. More recently organizations have compiled large amounts of data into "data warehouses" in order to gather information useful for providing better customer service and for marketing products and services. Database technology is the topic of Chapter 10.

The subject of communications is of great interest to management. Deregulation by the government, combined with the entry of new carriers, creates many choices for communicating both voice and data. How should computers be configured? What kind of network is desired? What are the opportunities to communicate directly with the computers of suppliers and customers? Chapter 11 introduces communications technology while Chapter 12 discusses the world of networks. Private and industry networks have existed for many years. The mass market networks like America Online are a more recent phenomenon. Of course, the most famous network of all is the Internet, and we shall explore its potential for business.

Today's manager is faced with a variety of IT architectures. Chapter 13 describes and provides examples of systems that range from large centralized computers to the more modern client-server architecture.

A manager is always concerned with the various sources available for products and services. In the technology field, there are many suppliers available for both hardware and software. We discuss some of the possibilities and their advantages and disadvantages in Chapter 14. Hundreds of new software products are announced each month for personal computers. Here the problem is not deciding on the source but having enough information to decide which package to buy for a specific application.

The purpose of the material in this part is not to educate technologists. Rather, the objective is for you to gain enough understanding of the technology to make intelligent decisions about it.

CHAPTER 7

The Fundamentals

Outline

Focus on Change

The computer is the device that started it all. The machine described in this chapter has been combined with communications technology, among others, to make dramatic changes in the way organizations are structured and operate. At first people viewed computers as large fast computational devices. An executive said to a class in the 1970s that he saw no reason to be interested in a machine that simply printed thousands of pieces of paper an hour. Over the last 20 years, the combination of computers, communications, and databases has increased the capabilities of the technology exponentially; one can do a lot more than just print! Incredible changes in technology have stimulated new approaches to the structure of organizations and markets. In the next two chapters we examine the technology that is responsible for these new business models.

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Why should one be interested in the way computer equipment works? You may already own a computer and find that you do not need to understand much about computers to use it. On the other hand, it is quite likely that you will be involved in purchasing computers, either for yourself or for other people. The numbers involved are hard to imagine! There are well over 150 million personal computers in the world.

Today's marketplace is a confusing one. There are a variety of computer vendors with different capabilities and prices. What is the bus, and how does it influence the speed of a computer? What are RAM and ROM? Does it matter if one computer has a higher clock speed than another? To make intelligent purchasing decisions, you must understand how computers work, and particularly how certain features influence their performance. In this chapter, we discuss the basics of computers. In the next chapter, we trace their evolution to provide background on how the industry reached its present state.

People invented computers and their associated equipment, and one of the most difficult aspects of computers is a consequence of this human design. Of the engineering and design decisions made during computer development, many appear arbitrary. Computer design is unlike a field such as mathematics, in which theorems are developed and proved rigorously. The reasons for a certain design feature may not be obvious even to a computer expert. Designers make decisions by balancing performance estimates of how the computer will be used against costs. Because of the arbitrary nature of design decisions, we discuss general concepts that underlie the operation of most computer systems, although specific machines differ from any general discussion.

The equipment we discuss in this chapter and the next is often referred to as computer **hardware**—the parts of the computer that can be touched physically. Chapter 9 is about computer software—the instructions in the form of programs that command the hardware to perform tasks. Physically, programs are entered in the computer through a keyboard. However, once inside the computer, a program cannot be seen and is represented electronically in computer memory.

THE COMPONENTS OF A PERSONAL COMPUTER

The computer you are most likely to encounter first is a personal computer. Generally, these computers feature a keyboard for entering data, a **CRT** or television-like output device for displaying data, and some form of storage. A typical, simple schematic for such a computer is shown in Figure 7-1. In this section, we present

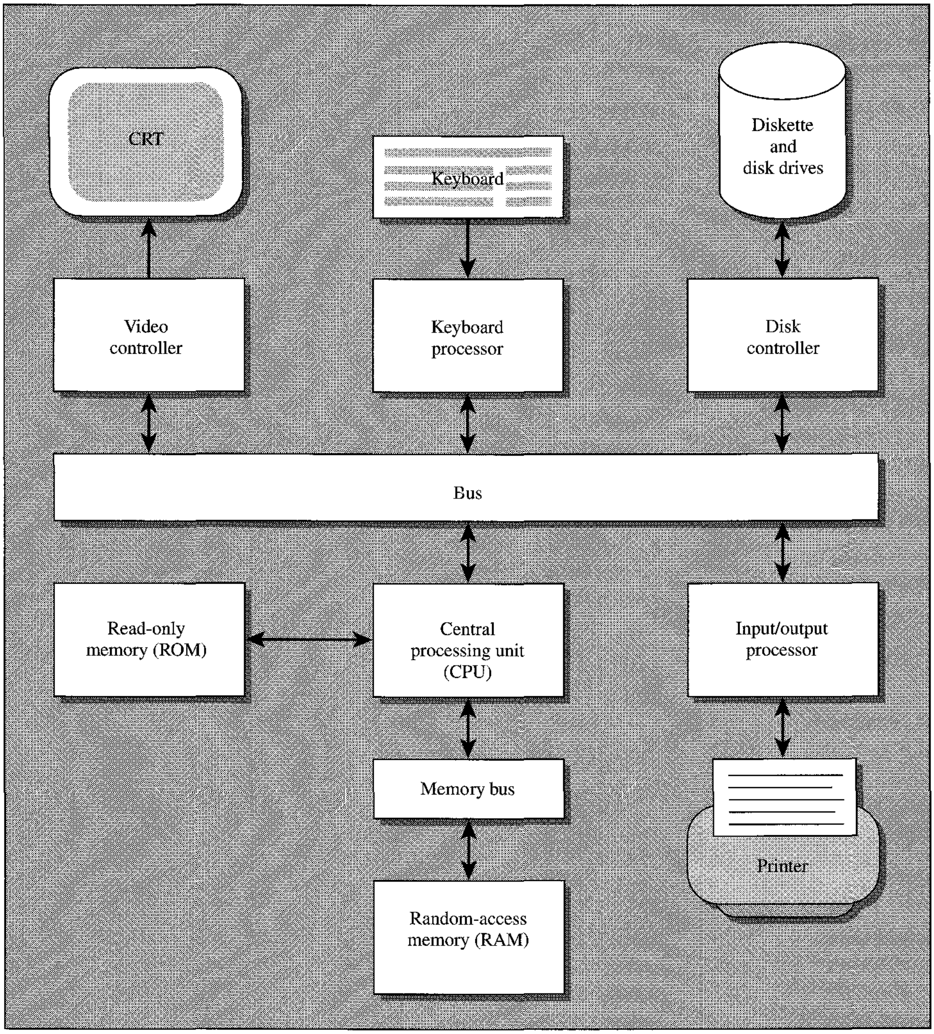


FIGURE 7-1
Schematic of a personal computer.

an overview of the parts of the computer; in subsequent sections, we discuss the components in more detail.

The heart of the computer is the central processing unit or **CPU,** which contains the logic that controls the calculations done by the computer. In most personal computers, the central processing unit is connected to a **bus.** The bus is a communications device, really a connection among various parts of the computer. The bus carries (1) instructions from programs telling the computer what to do and (2) data. On modern computers, there is a separate bus between the CPU and **random access memory (RAM),** or what is often called **primary memory.** A separate, high-speed bus is needed here because contemporary CPU and memory chips are so fast that the main bus, into which the keyboard and secondary-storage devices are plugged, is too slow for the CPU and memory.

Primary memory of the computer holds two kinds of information. The first is data, as one might expect. For example, if we want to add two numbers together, such as 178 and 256, these numbers are stored in computer memory. Once added, their sum, 434, would also be placed in memory.

Instructions in the form of software programs are also stored in primary memory. The instructions or software tell the CPU what to do. Instructions provide the logic of the computer and enable it to perform calculations and manipulate data. One main feature of memory is its passive nature: memory is only a storage place for information. The CPU executes instructions using registers that are a part of the CPU; it moves data back and forth to memory when it performs a calculation. Another way to look at memory is to consider that primary memory has no logic capability. It is a repository for data and instructions.

The **diskette** drive or **disk** is another form of storage. This **secondary storage** is usually larger than primary memory and is less costly. In Chapter 10, we discuss secondary storage in much greater detail. Note, however, the disk controller in Figure 7-1. There is logic required to connect or interface the disk to the computer, and the controller provides this logic.

Although the CPU contains the most logic in the computer, we can see there are other functions in which a component must display some logic, such as the disk controller. Similarly, there is a keyboard processor to interface the keyboard with the computer, and a video driver to control the CRT. Finally, we have an **input-output (I/O)** processor, which is dedicated to controlling devices such as printers.

The last component in Figure 7-1 is called **read-only memory (ROM).** Read-only memory stores instructions used by the computer, and they are, in essence, contained in hardware. Your personal computer has something called a ROM BIOS, which contains the basic input-output system of the computer and loads when you turn the computer on.

These, then, are the components of a typical personal computer. What the user sees is the keyboard, a systems unit, the monitor or CRT, and the printer. All the other components, as well as the diskette, **CD-ROM,** and disk drives, are inside the systems box.

Primary Memory or RAM

Although the central processing unit controls the computer, we need to discuss primary memory before examining the CPU to demonstrate how the computer stores data and instructions. In the next section, we see how the CPU processes the stored program and data to produce results.

The Arithmetic Basis of Computers

A computer can perform computations through an electronic counterpart to the arithmetic operations we perform on a routine basis. However, computer systems

MANAGEMENT PROBLEM 7-1

A business school in a major university recently constructed a new building and installed a state-of-the-art network using fiber-optic connections for the backbone of the system. This complex has 12 servers and a number of specialized processors. For example, there are two time-sharing computers running Unix for student and faculty use, and there are more than 900 personal computers on the network, along with a connection to the Internet "network of networks."

As might be expected with a major new installation, the school had a number of start-up problems. The network seemed to have great difficulty printing from standard personal computer software packages. Sometimes the printed output had different parts printed on top of other parts; other times the printed output vanished without a trace.

The manager of computing services had selected this particular network vendor because it promised a great deal of service. To faculty and student users, it seemed that something was amiss. Shared printing is one of the basic functions of a local area network. Why couldn't the network vendor solve these problems? Had it not experienced them before?

The dean's office suffered through a long semester of complaints from students and faculty. Finally, at the beginning of the second semester, the manager of computing asked for five additional staff members to provide service. He said, "We are in a much more complicated environment now, and we need people to keep the network running."

What would you advise the dean to do?

at their most fundamental level use a different number **base** from the common base 10 with which we are familiar.

The number 46 in base 10 can be represented as $4 \times 10 + 6 \times 1$. Furthermore, 10 is equal to 10^1, and 1 is equal to 10^0 (anything raised to the 0 power is 1, by definition). In our system of arithmetic, the position of a digit represents the power to which the base is raised before multiplication by the digit. For the number 46 above, 6 is in the 0 position and 4 is in the 1's position. We can represent 46, then, as $6 \times 10^0 + 4 \times 10^1$. This same procedure could be continued for more digits. For example, the number 346 can be represented as $6 \times 10^0 + 4 \times 10^1 + 3 \times 10^2$. Now there is a 3 in the 10^2 position that adds 3×10^2, or 300, to the number.

There is no reason to use the base 10 for arithmetic. It is convenient for human beings, but not for computers. A computer can be designed most easily to function in base 2, or the **binary** system. The two digits of the binary system (0 and 1) can be represented as "on" and "off," for example, through the presence or absence of an electrical voltage.

A binary number is represented in the same positional notation as a base 10 number. The number 101110 in binary, starting with the rightmost digit and working left, would be converted to base 10 as follows:

$$
\begin{array}{lll}
0 \times 2^0 = & 0 \times 1 = & 0 \\
1 \times 2^1 = & 1 \times 2 = & 2 \\
1 \times 2^2 = & 1 \times 4 = & 4 \\
1 \times 2^3 = & 1 \times 8 = & 8 \\
0 \times 2^4 = & 0 \times 16 = & 0 \\
1 \times 2^5 = & 1 \times 32 = & \underline{32} \\
 & & 46
\end{array}
$$

which adds to 46 in base 10.

At the most basic level, computers store and process data in binary form, but this is not an easy system for humans to understand. Therefore, the binary digits in computer memory are grouped together to form other number bases for performing operations. IBM mainframe computers group four digits to create a hexadecimal, or base 16, machine. Fortunately, even programmers rarely work at the binary level. For many applications, software or design of the hardware makes the machine appear to perform base 10 arithmetic from a programming standpoint.

All types of symbols can be coded and represented as binary numbers. For example, we could develop the following table to encode four alphabetic letters using two binary digits:

A = 00 B = 01 C = 10 D = 11

Thus, a series of binary digits can be coded to represent characters with which we are more familiar.

How Memory Is Organized

Now that we have a convenient way to represent numbers and symbols, we need a way to store them in memory. Different computer designers have adopted different schemes for memory organization. Generally, all computers combine groups of bits (binary digits) to form characters, sometimes called bytes. The number of bits determines the size of the character set. From the example above, we can code 2^n distinct characters with a binary number of n digits. For example, if there are 4 bits, there can be 2^4, or 16, symbols for data. Many modern computers use an 8-bit character, or byte, giving a possible character set of 2^8, or 256, symbols. The computer can display symbols such as uppercase and lowercase letters, numerals, punctuation marks, and so on.

After a character set is developed, the next design issue is to decide how to organize the memory of the machine. One basic use of memory is to store and fetch data, so we need a way to reference storage. An everyday example will help to clarify the problem. Suppose we are expecting an important piece of mail. The delivery will be made to the mailbox at our street address. We know that by looking in the mailbox at our address, we shall find the mail if it is there.

Now consider computer memory to be a group of mailboxes. We need an address to define each piece of data stored in memory so it may be placed in a particular location (mailbox) and retrieved from that location. It is possible to have an address for each character in memory, or sometimes groups of characters are combined to form words and the words are given an address. In some computer architectures, four 8-bit bytes are combined to form a word, though each byte also has an address. A word structure is convenient because many numbers will fit within a single word, as do many types of instructions.

Instructions, as well as data, must be stored in memory, and deciding on the instruction format is another design problem. At a minimum, the instruction must contain an operation code that specifies which operation is to be performed, such as add or subtract. The operation code is combined with one or more addresses. Suppose a computer has 8-bit bytes and that four bytes make up a word. Each byte can store either an alphabetic character or two numbers. An instruction on this computer might look like:

Byte	1	2	3	4
Contents	A	D	34	56

The computer could be designed to interpret this instruction as: Add the contents of storage location 3456 to the contents of a special part of the computer called an arithmetic **register.** (It is unlikely that the computer would treat bytes 3 and 4 the way we have above. It would most probably treat bytes 3 and 4 as a 16-bit binary number to identify a storage location.)

A single-address machine is designed with instructions that have one operation code and one address, as in the example above. For most instructions, the single address specifies the memory location for one piece of data to be operated on by the instruction. In the case of an add instruction, the address specifies the memory location whose content is to be added to some data already contained in the central processing unit.

Memory Technology

How does a computer actually store data? Remember, all we need is to distinguish between two states to represent a 0 or a 1. From these binary numbers, we can build an alphabet of symbols and numbers using other number bases. Today's computers all use semiconductor technology for primary or random access memory (RAM). A typical memory cell consists of electronic elements, including the transistor and **capacitor.** The designer of the computer would represent a 1 in memory by the presence of a voltage on the capacitor and a 0 by the absence of such a voltage. An important characteristic of RAM is the fact that it is volatile. When power is turned off, the contents of RAM memory are lost.

How does the computer access a particular memory location? Figure 7-2 is a diagram of primary memory. Note that there are address lines running in both directions through the array of memory cells. By turning on the address line in row 4 on the left and column 5 on the bottom, we select the shaded cell in the

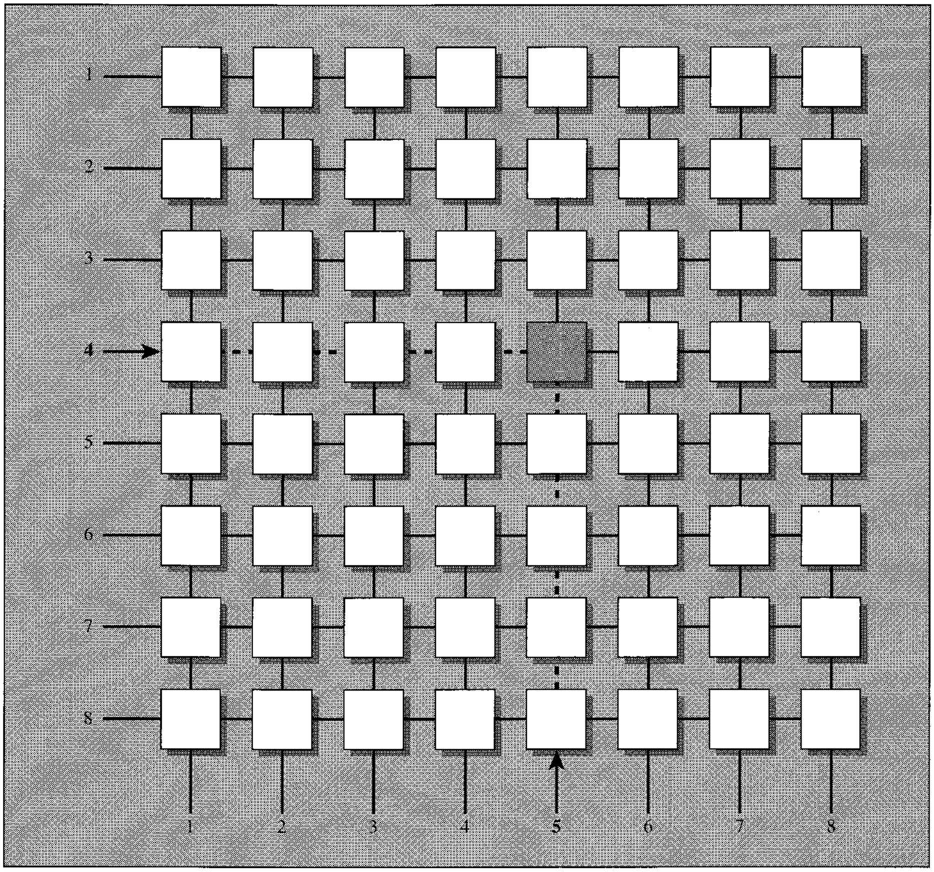


FIGURE 7-2
Semiconductor memory.

figure. A transistor in the cell acts as a switch to connect a storage capacitor to its address line. Using this approach, the computer can access any bit in primary memory.

The Central Processing Unit

As stated earlier, the CPU controls the operation of the computer because it contains most of the logic circuitry for the machine. Program instructions are stored in memory along with data. In a basic computer system, the instructions are stored sequentially beginning at some location in memory. By convention, the CPU always fetches the next instruction in sequence and executes it unless the program instructs it to do otherwise.

Doing Arithmetic

Computers can process several types of numbers. A fixed-point number is an integer; its decimal point is fixed and is assumed to be to the right of the rightmost digit. Examples of fixed-point numbers are 2512 and 671.

A floating-point number corresponds to scientific exponential notation. The position of the decimal point is indicated by digits associated with the number. For example, we might have a floating-point format of .1632E03, meaning that the number 0.1632 is to be multiplied by 1000. The number in conventional form, then, is 163.2. The number 16.32 would be presented by .1632E02. The exponent allows the decimal point to "float." It is also possible to have registers that perform decimal arithmetic.

Are arithmetic registers really necessary? One early computer without registers performed mathematical operations by looking up information in tables in memory! The presence of arithmetic registers, however, speeds computations. If registers are not used, a program requiring memory and execution time must be written to simulate desired arithmetic operations. Some early computers had only fixed-point addition and subtraction capabilities. Multiplication was accomplished by successive additions, and division by successive subtractions. In a similar manner, programs simulate floating-point operations on many personal computers. Most contemporary computers feature fixed- and floating-point registers for addition, subtraction, multiplication, and division. Most PCs today have chips with built-in floating-point hardware. The alternative is to use a floating-point coprocessor chip, or floating-point arithmetic must be simulated using a program.

How Does the CPU Work?

The central processing unit or CPU on most computers is found on a single chip. Figure 7-3 is a simplified diagram of an advanced CPU chip that contains the following components:

The **control unit** manages the CPU, initiating instruction fetch and execute cycles.

The **bus** interfaces the cache memory on the chip with random access memory chips (RAM). Note that there is a 64-bit-wide bus to move data back and forth between the CPU and memory. The address bus is 32 bits wide, and it transmits the addresses between RAM and the CPU to fetch instructions and to fetch and store data.

The **code cache** is a portion of very fast memory on the CPU chip. The chip copies a series of program instructions here from RAM so that the CPU can reach them faster than it could if they were only on memory chips. (See below.)

The **data cache** is also fast memory for keeping small amounts of data for faster access than is available from RAM memory chips.

The **instruction location counter** always points to the next instruction in a program to be executed.

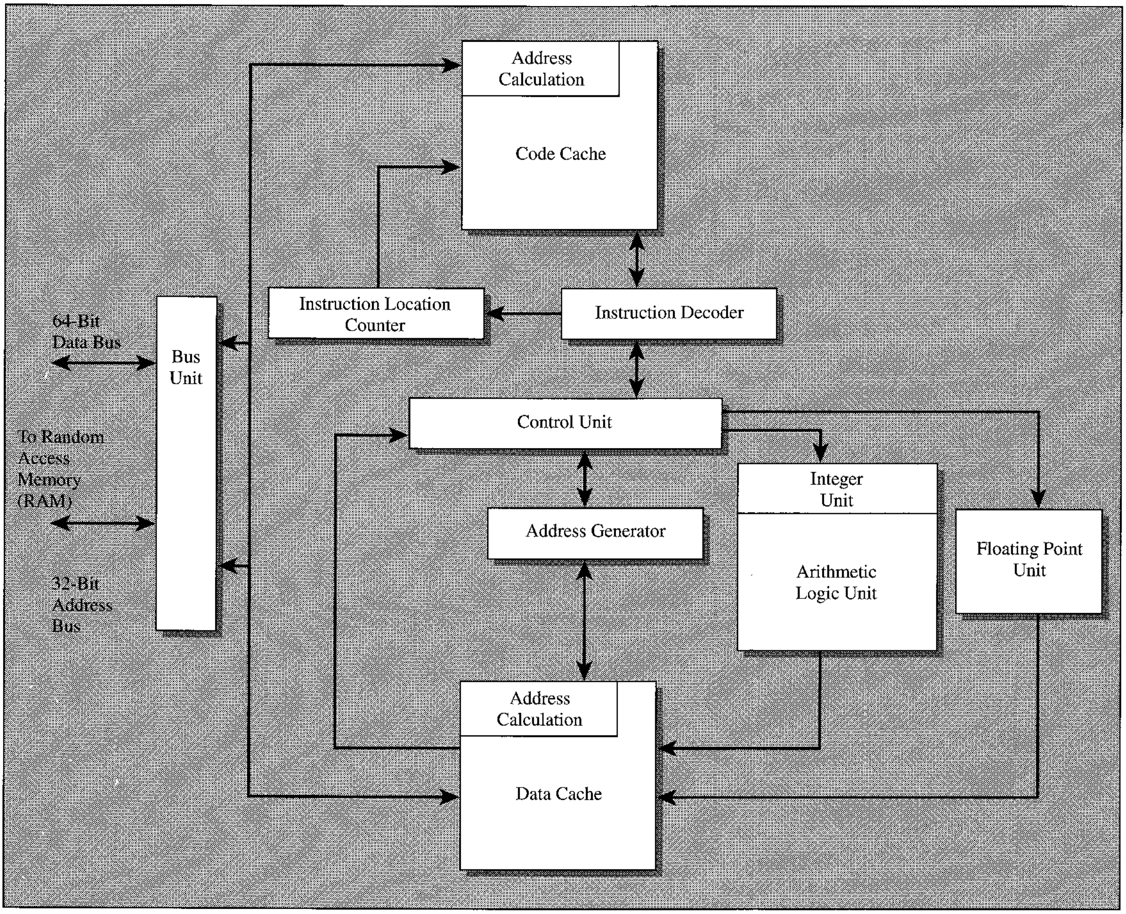


FIGURE 7-3
Simplified model of an advanced CPU.

The **instruction decoder** determines what each instruction means; for example, it analyzes the ADD instruction and indicates to the control unit that an add operation needs to take place and which registers are required.

Many instructions in the computer reference a location in memory. For example, the ADD instruction might say ADD X, where X is a piece of data in RAM. The **address generator** computes the address in memory for these data. (Note that the code and data caches also have the ability to work with addresses. They have to determine if requested data are in the cache or must be fetched from memory.)

The **integer unit** performs integer arithmetic, and the **floating-point** unit performs floating-point arithmetic. The **arithmetic and logic unit (ALU)** performs logical operations such as comparisons between two numbers.

The CPU typically executes an instruction in two phases. The first is the **fetch phase.** Its objective is to fetch an instruction, pointed to by the instruction location counter, and move it to the instruction decoder for processing. During the **execute phase,** the control unit manages the execution of the instruction; for example, the instruction might say to take data from a certain location in memory and add it to a number already in the integer unit. A clock on the chip determines the speed of operation. For example, a chip with a clock speed of 500 MHz has a clock that produces 500 million cycles per second. Some instructions can be performed in a single clock cycle, but many require several cycles. Floating-point operations usually require the most clock cycles due to their complexity.

Caching When reading product reviews of computers, you may see descriptions of different types of memory caches. The operation of moving data and instructions to and from RAM takes time (several clock cycles). Memory is available that can move data in a single clock cycle, but this faster memory costs much more than regular RAM. Designers build small **caches** or "holding areas" using this high-speed memory to hold the data and instructions currently used by the CPU. This strategy works because most programs need only a small number of actual memory locations at any one time so the cache will usually have the required data or instruction. When the CPU needs data or instructions not in the cache, additional delays are encountered while the slower RAM is accessed. CPU designers are responsible for caches within the CPU, which are called L1 caches. Figure 7-3 shows two of these L1 (on the CPU) caches. Computer manufacturers frequently add additional caches, called L2 caches, that may or may not be on the CPU chip. These are much larger and a little slower than the L1 cache but much faster than RAM. All other things being equal, if you buy a computer with a larger L2 cache, it will be faster than one without this feature.

An Instruction Set

What operations can be performed by a typical computer? Table 7-1 contains an outline of instructions for a processor, the CPU chip from Intel which is in "IBM compatible" PCs. Note the different classes of instructions in the table, including data movement, arithmetic, logical comparison, and branching. Large computers have repertoires of well over a hundred instructions, along with ten or more registers capable of performing arithmetic operations or serving as temporary locations for data.

CISC VERSUS RISC

The CPU is implemented in electronic circuits. Some instructions are implemented in a single, complex circuit capable of completing the entire calculation in a single clock cycle. Other instructions are implemented on several more general-purpose circuits under the control of **microprograms** that are stored in read-only memory in the CPU itself. These microprograms, which chip designers create, are not something a programmer ever sees. They are used to implement

TABLE 7-1

EXAMPLES OF CLASSES OF INSTRUCTIONS FOR THE INTEL CPU, THE CHIP USED IN PCs

Instruction	Meaning
	Data Transfer
MOV = Move	To move data between memory and registers
XCNG = Exchange	Exchange a register or memory with a register or a register with the accumulator
IN = Input from	Input from a fixed or variable port
OUT = Output	Output to a fixed or variable port
	Arithmetic
ADD = Add	Add contents of register or memory to accumulator
ADC = Add with carry	Add contents of register or memory to accumulator with carry
SUB = Subtract	Subtract contents of register or memory with accumulator
SBB = Subtract with borrow	Subtract contents of register or memory with accumulator
CMP = Compare	Compare registers and/or memory
	Logic
NOT = Not	Invert
AND = And	Register/memory logical and with register/memory
OR = Or	Register/memory logical or with register/memory
XOR = Exclusive Or	Register/memory logical exclusive or with register/memory
	Control
CALL = Call	Call a routine
JMP = Jump	Jump to a new location to begin execution without conditions
NET = Return	Come back to code from a call
J** = Jump on	**Become a series of letters indicating conditions like jump on less or equal, jump on equal, etc.

complex instructions and work by substituting a series of small or "micro" execution steps on several general-purpose circuits for an enormously large and complex circuit that would be required to do all the work in a single step.

A **CISC (complex instruction set computer)** processor is one that uses many such complex instructions. For example, one common CISC instruction specifies adding two numbers together in memory. Since memory cannot actually do that, the instruction is implemented by a microprogram that moves the data from the memory to registers, adds the values together, and then stores the sum back in memory. Implementing that many steps in a single electronic circuit requires an extraordinarily large and complex circuit; it is expensive to build and takes a very long time to design and test. Using a microprogram simplifies the design of complex instructions. The many general-purpose circuits the microcode uses are easy to design and can be built very inexpensively. However, developing and testing the microcode that implements a complex instruction does take a lot of time.

RISC (reduced instruction set computer) processors are designed with single, simple instructions, such as adding the contents of one register to another. RISC processors contain a large number of identical registers (typically between 64 and 256) that are used for storing intermediate results for immediate use. The objective of the RISC chip designer is to have all instructions execute in a single clock cycle. Compared to CISC, RISC processors are simpler and they execute individual instructions much faster. However, to accomplish the same task, a RISC CPU often must execute more instructions than a CISC CPU. The RISC CPU is likely to be faster and cheaper to build than a CISC CPU, but the two machines might accomplish the same task in the same length of time. Because the RISC processor is simpler, it takes less time to design and requires fewer circuits to implement than a CISC processor. The main disadvantage of RISC architectures is that the language compiler (see Chapter 9) has to be more sophisticated than the CISC language processor.

The debate between advocates of RISC and CISC may not be all that important because it appears that modern chips have components of each type of architecture. For example, one manufacturer is believed to use a RISC architecture to actually implement a CISC CPU in order to be compatible with previous computers. The two architectures may merge in the future so CPU chips will have elements of CISC and RISC designs.

WHAT MAKES A CHIP PERFORM?

What factors are responsible for the incredible performance of CPU chips? Table 7-2 contains data on the design characteristics of the popular Intel chip that powers IBM-compatible PCs. The performance characteristics of the PC processor chips form the rows of Table 7-2.

- *Clock speed.* The clock sets the speed of machine cycles. If all else is held constant, increasing the clock speed of a chip will increase its performance.
- *Data path.* The data path or size of the bus refers to how much data are moved between memory and the CPU with each instruction. If all else is constant, having a larger data path speeds the machine because fewer trips to memory are needed to process data.
- *Computation.* If the chip can do computations on more bits at a time, instruction execution will be faster because the instruction will have to be executed fewer times.
- *Memory size.* More memory often lets large programs execute more quickly. It is particularly important when using graphical user interfaces, or when more than one program is loaded at a time.

TABLE 7-2

CHARACTERISTICS OF PC PROCESSOR CHIPS

Performance characteristics of 8088 series chips	XT PC	286 PC AT	386	486	Pentium	Pentium Pro	Pentium II	Pentium III
Clock speed, MHz	4.77	6–12	16–33	16–50	66–200	120–200	233–450	500+
Data path, bits	8	16	32 16 (SX)	32	64	64	64	64
Computation size, bits	16	16	32	32	32	32	32	32
Typical memory size, bytes	640 K	2 M	4–16 M	4–64 M	4–64 M	16–64 M	64–128 M	128+ M
Floating point	Coprocessor	Coprocessor	Coprocessor	On chip except for SX	On chip	On chip	On chip	On chip
Number of transistors per chip	29,000	130,000	275,000	1.2 mil	3.3 mil	5.2 mil	7.5 mil	9.5 mil

- *Floating-point arithmetic.* If the chip has built-in floating-point arithmetic, many numerical calculations will be faster because they can be performed in hardware rather than software.
- *MIPS (million instructions per second).* This figure is an indication of the raw speed of the chip.
- *Number of transistors per chip.* The more densely packed the transistors, generally, the faster the chip.
- *Parallel processing.* The Intel Pentium II and III chips have three instruction registers so they can decode three instructions per clock cycle.
- *Pipelined execution.* A pipeline is a bit like a factory assembly line; instructions move through a series of steps as they are fetched and executed. Instructions start down the pipeline one after another so that more than one instruction is in the process of being executed by the pipeline at once.

Table 7-2 shows that the first IBM PC was a very slow machine by today's standards! (Few predicted the dramatic success of personal computers, nor did we forecast the huge increases in processing power and reductions in cost.) The 286 chip or AT (for advanced technology) had a significant impact on performance. Clock speed increased and the data path between memory and the CPU doubled in size. The current generation of chips, the Pentium, is extremely powerful, with a speed of more than 100 times that of the AT. These machines fetch 64 bits of data at a time and perform computations on 32 bits at a time.

Where Else Would You Use a Chip?

There are many applications in which chips are embedded in a product. For example, your microwave oven probably has an Applications Specific Integrated Chip (ASIC). Europe and Asia have taken to another application of an embedded chip: the "smart card." The technology, first developed in the 1970s, involves putting a chip in a credit card. Today's chips are much more powerful so the card can be more versatile. U.S. West is marketing its Telecard in Seattle. The chip in the card is loaded with digital cash for use in pay phones in the city, and the company wants to extend the card to retailers.

The idea of the card is to eliminate cash, something that will take a long time, if ever, to accomplish. *Business Week* estimated that people spend over $1.8 trillion a year on purchases of under $10, with $560 billion of that in the U.S. Merchants lose 5–7 percent of cash receipts to the cost of handling that money. Cash cards help speed checkout lines since a transaction takes only one or two seconds compared to making change at a cash register. The issuer of the smart card can keep the float, the money you pay for the card, until it is spent, unlike the credit card where the issuer provides you with float. They also get the "slippage," the cash that is never spent on the card.

A number of companies are looking into offering smart cards. Mondex is testing a system in the U.K., while Visa launched a card at the 1996 U.S. Olympics where 5000 terminals in Atlanta accepted the card. The smart card readers cost from $50 to $800 and the cards themselves run $10, much more than the familiar credit card.

Intel has created a family of products around the Pentium chip. The Celeron chip is a low-price, lower-performance Pentium processor designed for machines in the $1000 price range; it is a Pentium running at a lower speed, with no cache memory on the processor chip in its first versions. (Subsequent versions incorporate an L2 cache on the processor chip itself.) The Pentium III processor has 70 new integrated instructions for 3-D processing. The Pentium Xeon is available for servers.

What Techniques Increase Speed?

Although the characteristics above will help you select a computer, they are not enough because the manufacturers have come up with some techniques to make PCs faster. The first option is a **cache memory**—a high-speed memory that speeds up the slower memory that we first saw in Figure 7-3. Consider a disk drive where it takes 10 milliseconds on the average to access data. Instead of moving that data directly into main memory, it is placed in a cache memory. When the computer reads from the disk, the cache memory is filled with the data requested and with extra data nearby. (Often disk accesses occur close to each other.) If the next read is for material in the cache, it can be transferred to primary memory at memory speeds rather than at disk access speeds. Of course, if there is no "hit" on the cache, it means the desired data are not there and the computer must get them from the disk.

A cache can be used almost anyplace to speed up a computer. Many PCs use a cache with primary memory. A 64-Mbyte memory might come with a cache of 512 kbyte. You can also use a cache or separate memory with the video controller to improve video speeds.

As described above, a **pipelined** computer breaks down instructions into many small steps like an assembly line. Each of these steps or stages is handled by a separate circuit. When an instruction finishes one stage, it goes on to the next one, and the stage it just left begins work on the next instruction.

Also mentioned earlier, the Pentium chip features two integer execution units, each fed by its own instruction pipeline, also called **superscalar architecture.** This architecture allows the Pentium chip to execute two instructions per clock cycle. Programs that translate higher-level user languages into machine language (discussed in the next chapter) have to be modified to figure out which user program instructions can be split to operate in parallel. It is not likely that the chip will be able to execute two streams of instructions all the time, as some operations must be done in sequence.

Many of today's PC applications feature graphics, so manufacturers have turned their attention to the video controller and its role in the computer. Machines feature **local bus** video, a connection from the CPU to the video controller, that runs at a speed more like the bus between memory and the CPU than the bus used for peripherals such as printers or modems. Graphics accelerator cards are video controllers that actually have a processor chip and a large amount of memory (say, a megabyte or more) to offload the display task from the CPU.

Finally, you can purchase a computer with a wider and faster bus that connects the CPU to peripherals. In the first PCs all components used the same bus—video, memory, printers, and so on. As we discussed above, 32-bit CPUs have their own data path of 32 bits (in general) to memory. Computers generally come with a bus to peripherals, such as printers and disks, that carries more data than the standard 16-bit ISA (Industry Standard Architecture) bus. Today you will find three bus types, the Extended Industry Standard Architecture (EISA) bus, the PCI or Peripheral Component Interconnect, and the Universal Serial Bus, USB. The USB allows up to 127 components to be connected to a PC; it is "plug and play," meaning that the bus recognizes the component and the user does not have to set switches on printed circuit cards for it to work. It handles data at the rate of 12 Mbytes per second and is suitable for low- to medium-speed peripherals, for example, a digital camera.

All these factors can have a dramatic effect on the performance of a PC. It is not always the case that a computer with a higher clock speed is faster than one with a slower clock speed because there are many features that affect overall speed.

Input and Output

Computers process data in times measured in billionths of a second. Compared with these internal speeds, getting data in and out of a computer is very slow. Table 7-3 lists some of the most common input-output devices.

TABLE 7-3

POPULAR INPUT-OUTPUT DEVICES

Both input and output	Input devices	Output devices
PC	Keyboard	Printers
Terminal	Mouse	Laser
	Scanning	Inkjet
	Image	Voice
	Optical Character Recognition	Graphics
	Bar code	
	Touch screen	
	Voice	

Input-Only Devices

Terminals and PCs Most users interact with a computer through a keyboard to provide input to their system, whether it is a mainframe or a PC. Some of the interaction with mainframes or midrange systems is done through a "dumb" terminal, a terminal that is able to send and receive data from a computer. More often, personal computers replace terminals. In a client-server environment, the user interacts directly with a server using the full capabilities of his or her local workstation.

Bar Coding Bar coding is an extremely popular way of entering data into a computer. We encounter a form of bar coding in grocery stores equipped with checkout scanners. These devices use a laser to read the universal product code (UPC) stamped on grocery items. A laser device reads the bar code and software translates it into a product identifier. A computer looks up the price of the item and indicates the charge on a display. Similar types of readers are used in other kinds of stores to mark items. The advantage of such an input device is that a retailer can automatically keep track of inventory and sales.

Other types of bar codes are used extensively in the manufacturing industry. In a highly automated factory, parts are marked with bar codes. The codes direct the flow of the part through the factory and may even indicate to a machine what operations to perform on it. The use of bar coding can dramatically reduce the need for individuals who follow orders through the factory and keep track of where work in process is located, a form of indirect labor.

Scanners

Imaging Image scanning is used for desktop publishing systems based on personal computers. A user can scan photographs, drawings, and other items and place them on a page. The computer makes no attempt to understand what is being scanned. It simply transfers an image from one medium to another.

An **imaging** device or scanner uses a laser to digitize an image. This image consists of thousands of dots, say 300 dots per inch (dpi). Each dot is assigned to a

MANAGEMENT PROBLEM 7-2

The chairman of a major U.S. bank said that his bank had 80,000 employees and 90,000 computers. How could these numbers be correct? How can you have more computers than employees in an organization? What do you suppose these computers do for the bank?

Banks are an example of organizations that face profound changes brought about by technology. What opportunities are there for hardware, software, databases, and communications technologies to alter the nature of banking? What is the basis of competition for banks; what distinguishes one bank from another? Can a bank use IT to gain a competitive advantage? To sustain that advantage?

What would you advise the chairman of a bank regarding technology to change the structure of the bank and the nature of its services? How does a worldwide network like the Internet affect your recommendations?

memory location along with associated information. For example, if the scanner is capable of representing shades of gray or color, information about intensity or color of the dot is also stored. You cannot input an image containing characters directly into a word processing package or modify the scanned document. You need OCR software to do this.

OCR **Optical character recognition (OCR)** is an important input technique. Today OCR and image scanning are both sometimes referred to as "scanning." Technically speaking, the **scanner** is a piece of hardware that makes a digital image of a page. It is the same hardware that digitizes images. Once the image is created, an OCR software package, and there are several available, reads the image and converts the characters in the image to ASCII. The results can then be saved as a word processing document and changes made to it.

The performance of OCR software is highest on printed material and marginal, at best, on handwritten material. To recognize letters or characters, the OCR software compares the input with a series of stored characters attempting to find the best match. This task is far easier for printed characters that follow some standards. Handwriting defies description in many cases! There are opportunities for great labor and cost savings if OCR software can get to the point of recognizing handwriting. Consider the impact on the post office if machines could read 75 percent of the handwritten zip codes on letters.

OCR input saves typing data. One can take information that is not in machine-readable form and avoid retyping it. As one might suspect, storing the recognized letters requires far less storage than storing an image. For example, the Association for Computing Machinery (ACM) has an extensive digital library available on the Internet; the Association is scanning back issues of its journals because it is the most cost-effective way of capturing this older printed material.

Pen A number of pen-top personal computers are available on the market. The user works with a pen to print characters or check boxes on a form. These devices

Recognizing Voices

In an effort to serve its customers better, Charles Schwab, a brokerage firm, has installed a system called Voice Broker. The system responds to customer phone calls, answering requests for information. Schwab handles more than 15,000 equities, but the system has to be able to handle 100,000 different information requests because customers ask questions using different phrases. For example, you might ask for a quote on IBM or International Business Machines. Regional dialects and accents also complicate the task.

The benefits for the customer are obvious; there is no need to go through multiple touch tone menus to get information. For a firm with heavy peak demands, like a brokerage house, it would not be feasible to have enough human staff members available to answer the phone. This situation is particularly true for Schwab when there is a major movement in the securities markets.

Schwab formed a Voice Technology Group consisting of 20 staff members. They pilot tested the system, and it was so successful that the firm quickly developed a production system. This version of the system recognized voices with 95 percent accuracy and provides results in less than 2 seconds. The application at Schwab does require a lot of maintenance because the database changes so often, with mergers, new companies being listed on the exchanges, and companies that adopt a new stock symbol.

Manufacturers of voice recognition systems say that companies using them can save 90 percent of the costs of every call. These costs are made up of salaries and benefits for humans who respond to callers, a group that has 50 or 60 percent turnover in most firms. A voice equipment manufacturer estimates that a person can only handle about 28,000 calls a year, many fewer than a voice response system.

More advanced systems are under testing. For example, imagine calling an airline, stating departure and arrival cities and the date of travel, and getting a response from the reservations system. As this technology becomes more widespread, there will be an impact on the jobs of employees answering customer questions. The phone companies have worked to reduce the number of information operators through various forms of automation, including voice response for long-distance calls. From 1970 to 1996 the number of jobs for telephone operators fell from 400,000 to 164,000, with a fifth of the jobs being lost in the last six years since AT&T started using voice recognition for long distance calls.

are intended for individuals who do not like to type and for applications where portability is needed. To date they have been successful for service people like delivery persons who need to keep records. Pen-top computing has not been applied extensively to managerial applications.

Voice **Voice input** is changing the way we work with computers. Speech recognition and synthesis (turning a text into speech) technology have progressed remarkably. A $99 program allows you to use speech input to control the Windows desktop and to dictate documents. Original recognition systems could not handle continuous speech; the user had to pause between words. Currently available systems recognize continuous speech with acceptable accuracy, 90 to 95 percent after training the system with your voice and pronunciation.

There are a number of current speech applications, but they are mostly for workers whose hands are not free to type while they perform some task like sorting packages. There is limited professional use of speech input, but this situation is likely to change as users gain experience with this software. Several companies are working on devices to allow Internet access through special telephones; the Internet services will have to use speech recognition software that does not have to be trained for each user. These companies envision an environment in which you could dial an air travel Web site and ask about flights between cities; the system would display the result on your phone or with voice output. There has been much progress in the last few years, and it is likely that speech will compete with the keyboard for input during the next decade.

Touch Screens This technology provides a great alternative to keyboard entry when the users' choices are somewhat confined. By putting his or her finger on the screen, the user indicates a choice. A bank can use touch screens for its ATMs. A factory has touch screens for an operator to set up tests on a quality-control machine. The American Stock Exchange uses a touch screen for entering certain kinds of quotations, and many restaurant order-taking systems use touch screens. This type of input is appropriate when a small amount of information is to be entered, particularly when it is desirable to eliminate a keyboard.

Mouse PC users often work with an input device called a **mouse.** It directs a cursor around the screen and sends commands to programs when you press the mouse buttons. The mouse, or some pointing device, is necessary for machines featuring graphical user interfaces (GUIs) and icons. Placing the cursor on an icon and pressing a button on the mouse selects the item, that is, generates a command signified by the icon. This type of interface, called "direct manipulation," is a standard for personal computers.

Output Devices

Laser Printers The most convenient output device for a personal computer is the **laser printer.** These devices generally print with a resolution of 300 to 600 dpi or higher and produce high-quality output. The laser printing process is similar to photocopy technology. It offers various sizes and types of print, produces high-quality output, and is very fast compared with alternative techniques for obtaining hard copy output. Minis and mainframes also can use laser printers. These higher-speed devices print 30 to 40 pages per minute. Much of the output from transactions processing computers is done on laser printers.

Inkjet Printers Inkjet printers squirt charged droplets of ink onto paper. They are used extensively with personal computers and have a modest cost advantage over laser printers for monochrome output. Inkjets are the clear choice for low-cost, high-quality color printing.

Voice **Voice output** has been available for a number of years. Banks sometimes provide on-line inquiry about account balances. For example, keying in one's account number produces an audio response of the account balance. Voice output is used extensively for telephone information. The information operator indicates which number displayed on a terminal is the correct one, and a computer generates a voice response. The operator is free to answer another call while the first message is playing.

Reducing a Bottleneck

There are a variety of input-output techniques for computers. Despite the variety, however, moving information to and from a computer is slow. Most information is typed into computers, yet the world is populated by typists and nontypists. Alternative forms of interfaces such as voice, direct manipulation, and touch screen offer ways to encourage the use of computers. One major trend is to reduce the amount of human effort involved in input. Bar coding and the electronic exchange of information both serve to eliminate input labor.

CHAPTER SUMMARY

1. It is important to understand the basic components of a computer and how they work when making decisions about technology.
2. The heart of a computer is the central processing unit or CPU, which contains the logic of the computer.
3. Memory is another critical part of the computer. The CPU addresses specific cells in memory using the location's address.
4. A bus that carries data is used to connect the various components of a computer. Modern computers may have several buses to handle the different speeds of computer components.
5. The CPU has registers for performing operations, for example, doing arithmetic computations.
6. Computers calculate using the binary number system because it is easy to represent a 0 and 1 (the binary digits) as "off" and "on." Programs convert binary to the more familiar base 10.
7. The instruction set of a computer comprises all the instructions that the CPU can execute. Generally these instructions encompass moving data, performing arithmetic, logical operations, and control of a program.
8. The historical trend has been for computer chips to become more powerful, contain more components, feature more advanced logic, and cost less. This dramatic increase in power as costs decline is responsible for the proliferation of computers, which in turn encourages more and more applications of information technology.
9. The slowest parts of the computer deal with input and output. For this reason we try to capture data at its source and reduce the amount of data entry and output whenever possible.

IMPLICATIONS FOR MANAGEMENT

The question of how much a manager should know about technology is an emotionally charged one. There are managers who feel they do not need to have any knowledge of technology; they can leave these issues to staff members. On the other hand, IT is so pervasive in the modern organization, and so many firms depend on it for critical applications, that a manager needs to be able to make educated decisions about technology. This need suggests that you should have a modicum of knowledge about technology, but how much is that? During your career you are likely to be involved in decisions about what hardware and software to purchase, the hardware and software architecture of the firm, and numerous applications of technology that involve employees, customers, suppliers, and others. Given the demands these decisions will make, it would be difficult for you to know "too much" about technology. One of the objectives of this text is to provide you with a strong base of knowledge about technology. I hope you will be motivated to continue learning about the technology throughout your career.

KEY WORDS

Address generator
Arithmetic-logic unit (ALU)
Base
Binary
Bus
Cache
Cache memory
Capacitor
CD-ROM
Code cache
Complex instruction set computer (CISC)
Control unit
CPU
CRT
Data cache
Disk
Diskette
Execute phase
Fetch phase
Floating point
Hardware
Imaging
Input/output (I/O)
Instruction decoder
Instruction location counter
Integer unit

Laser printer
Local bus
Microprogram
Mouse
Optical character recognition (OCR)
Pipelined
Primary memory
Random access memory (RAM)
Read only memory (ROM)
Reduced instruction set computer (RISC)
Register
Scanner
Secondary storage
Superscalar architecture
Voice input
Voice output

RECOMMENDED READING

Bucki, L. *PCs 6-in-1.* New York: Macmillan, 1997. (An excellent handbook providing an overview of computer hardware devices and architecture.)

Gookin, D. *PCs for Dummies,* 6th ed.. Foster City, CA: IDG Books Worldwide, 1998. (A good introductory tutorial explaining basic operations of computer components, system configurations, upgrades, and troubleshooting.)

Holliday, B. *CPU Complete Educational Package.* Beverly Hills, CA: Fun Books, 1997. (A very helpful book for learning the basic operations of a CPU.)

Norton, P.; and J. Goodman. *Peter Norton's Inside the PC.* 7th ed.. New York: Macmillan, 1997. (This very popular book sold over a million copies (in all editions) and provides detailed descriptions on working principles and operations of computers.)

Pabst, T. *Tom's Hardware Guide: High Performance PC Secrets.* New York: Macmillan, 1998. (A comprehensive reference for computer hardware.)

Roman, S. *Understanding Personal Computer Hardware.* New York: Springer-Verlag, 1998. (A handbook with a thorough yet concise description of the entire PC, including its subsystems, components, and peripherals.)

DISCUSSION QUESTIONS

1. What is the role of the CPU in a computer?
2. What is the function of primary memory in the computer? How does it interact with the CPU?
3. Why do you think memory chips are easier to build than CPU chips?
4. Why is the binary system suitable for computers?
5. What two major items are stored in primary memory? How can you distinguish between them?
6. What is the advantage of having floating-point arithmetic registers?
7. Why would a designer try to make one computer execute the programs of another computer?

8. What is the role of the different components of the CPU shown in Figure 7-3?
9. What is the difference between ROM and RAM?
10. How do you store and retrieve data in memory?
11. What is a bus?
12. Why is there a need for a disk controller in Figure 7-1?
13. What are the key factors to consider in purchasing a personal computer?
14. What is the difference between the fetch phase and the execute phase in executing an instruction?
15. Why does a computer need a lot of instructions?
16. Why are there two caches on the CPU chip in Figure 7-3?
17. Explain how a CPU executes an instruction.
18. What changes in technology do you think are responsible for making personal computers possible?
19. What are the minimum features for a home computer? How about for a personal computer to be used in an office?
20. What kind of programs do you think are likely to make the most use of floating-point instructions?
21. What are the differences between secondary storage and primary memory?
22. What is the role of microprogramming in a CISC CPU?
23. What are the major differences between CISC and RISC architectures?
24. What is the difference between hardware and software? Where do the lines blur?
25. What are the advantages of using hardware for processing as opposed to software? Where is software advantageous? (*Hint:* Think of speed and then think of ease of making changes to a process.)
26. What are the advantages of scanning as an input medium?
27. Why is there such a mismatch between input-output and internal computer speeds? How can this mismatch be reduced?

CHAPTER 7 PROJECT

Simon Marshall Associates

Simon Marshall, the company introduced in the project in the first chapter, is interested in the possibility of using a computer to provide services to clients. John Marshall's brother, Scott, just finished getting an MBA with a specialization in information systems. When John saw Scott during his summer vacation, he told him about his problems with computers.

Scott advised, "Start with a personal computer and see where things go from there. The power of these machines is phenomenal. Let me give you a suggested configuration, both for hardware and software. You may need a little help with the programs so why not go to a local college and hire a student part-time to help you learn how to use it? Nothing could be much cheaper."

Scott recommended that Simon Marshall take the plunge and order one of the fastest PCs available. He recommended using Windows 98 and its Office software, explaining, "The software that runs under Windows offers so much that it is worth learning how to use it." Scott started John with a spreadsheet processor, database management system, and word processor.

Scott explained his recommendations to John: "The 500-MHz machine is a really fast computer. It should serve you for a number of years without requiring much of an upgrade. I've chosen very basic software. After you've begun to use it, I'll be happy to recommend other packages when you need them. This should be enough to get started with."

What is your reaction to Scott's recommendation? What criteria should Simon Marshall use to evaluate personal computers if the company decides to acquire one? Why would Scott recommend choosing one of the newest and most expensive personal computers?

CHAPTER 8

A Proliferation of Computers

Outline

Focus on Change

It has taken many years to reach the point where computers and communications can transform firms and industries. Firms that undergo a transformation know how to manage a diverse set of computers and other devices. They are successful in responding to trends in technology and to the ongoing changes in the cost/performance ratios of different types of computers. Users and managers confront a technology that has changed dramatically since the 1950s. We have moved from clerks preparing input on punched cards to managers using powerful desktop workstations connected to local- and wide-area networks of servers, minicomputers, and mainframes. As the technology has changed, it has opened up new possibilities for managers and the organization.

IMPLICATIONS FOR MANAGERS

This chapter and Chapter 7 contain a great deal of material about computer technology. What are the implications of this technology for management?

- The cost/performance ratio for computers continues to decline as the price continually drops for increased levels of computing.
- Logical functions are no longer the most expensive part of the computer. In the first generation, the CPU was the scarce and expensive resource. Today **very large scale integration (VLSI)** using current technology can put millions of transistors onto a small silicon chip. Processing logic is now readily available at a relatively small cost.
- Organizations are spending increasing amounts of money on computers because they are indispensable for many applications. Even though unit costs may go down, the total expenditure for information technology is increasing in most organizations.
- The ease of use and the appeal of a networked personal computer allow many more individuals access to computer technology. To compete in the coming years, a manager will have to be an intelligent computer user.

It is very difficult to define an appropriate hardware and software architecture for a firm, given the large number of competing demands and alternatives available. Rapid decreases in the cost of making very powerful chips means that workstations have better cost/performance characteristics than mainframes. We discuss architecture further in Chapter 13.

- Companies have a wide variety of computers because it would be very expensive to replace old computers and applications all at once.
- In addition to computers themselves, today's focus is on networks using telecommunications to link computers. It is no longer sufficient to consider computers alone since almost any computer will be a node on a network.
- A basic understanding of hardware and how it works will help you select and use the appropriate computer equipment. Managers today are faced with a variety of computers of different capabilities. A manager may be forced to use existing hardware because it is already in place or may have the option of acquiring new equipment. In either case, it is important to understand the capabilities of the different types of available computers.

THE COMPUTERS OF TODAY

How have we achieved our current wealth of computers? In the early days, the types of computers were limited. All computers were known as mainframes (which are described later in this chapter). At one time, eight different companies in the United States manufactured computers. Univac had the early lead in computing, but soon lost it to IBM. (Later Univac became a part of Sperry, which merged with another computer vendor, Burroughs, to form the UNISYS Corporation.)

As IBM became the dominant vendor in the United States and abroad, the computer industry was sometimes described as "IBM and the Seven Dwarfs." In the 1950s and early 1960s, companies such as Apple, Digital Equipment Corporation (DEC), and Compaq did not exist. RCA and General Electric manufactured mainframe computers, eventually taking huge write-offs as they left the business. Today minicomputer and mainframe vendors are reeling from dramatic changes in the cost/performance ratios of "commodity" processor chips versus systems based on proprietary circuit designs.

What trends in the technology have created today's computer industry? Why are there so many different types of computers, and what is each one designed to do?

The Rise of the Mainframe

Figure 8-1 presents an overview of the current computer environment. The first computers developed were mainframes, which are large general-purpose machines. In the early days of the computer industry, one could run only **batch** programs (the staff collects all data into a batch that is processed at one time) on mainframe computers. Many organizations have developed substantial applications on mainframe computers. Today this type of machine is likely to support a number of terminals and personal computers interacting with huge databases containing billions of characters of data. Mainframe computers are used extensively to process transactions and maintain vital data for access by various users. Examples of mainframe systems include order entry and processing at an electronics manufacturer, production planning and scheduling at Chrysler, and airline reservations at all the major air carriers. (We discuss the future of mainframes more in Chapter 13.)

Historically, IBM has dominated the mainframe market but experienced problems as users have shifted to other kinds of architectures. The challenge for today's mainframe manufacturers is to adopt new technology that will make these machines competitive on cost/performance measures. For example, one crude measure of performance is millions of instructions per second **(MIPS)** that a computer can execute. PCs and workstations cost less per MIP than mainframes.

Mainframe computers feature **proprietary hardware** (instruction sets that in general are unique to and controlled by the vendor). Intel and Motorola make millions of chips a year; the demand for mainframe computers is far less. The proprietary architectures of mainframe computers cannot take advantage of economies of scale in production, and this is why they have a worse cost/performance ratio than smaller computers built around commodity chips. Mainframe vendors are working to reduce the costs of their machines, for example, by designing multiprocessors using chips like the PowerPC.

Today many mainframe applications are called "legacy systems." These systems represent a heavy investment; they process critical transactions, and they are difficult to change. These mainframe systems are capable of processing a huge volume

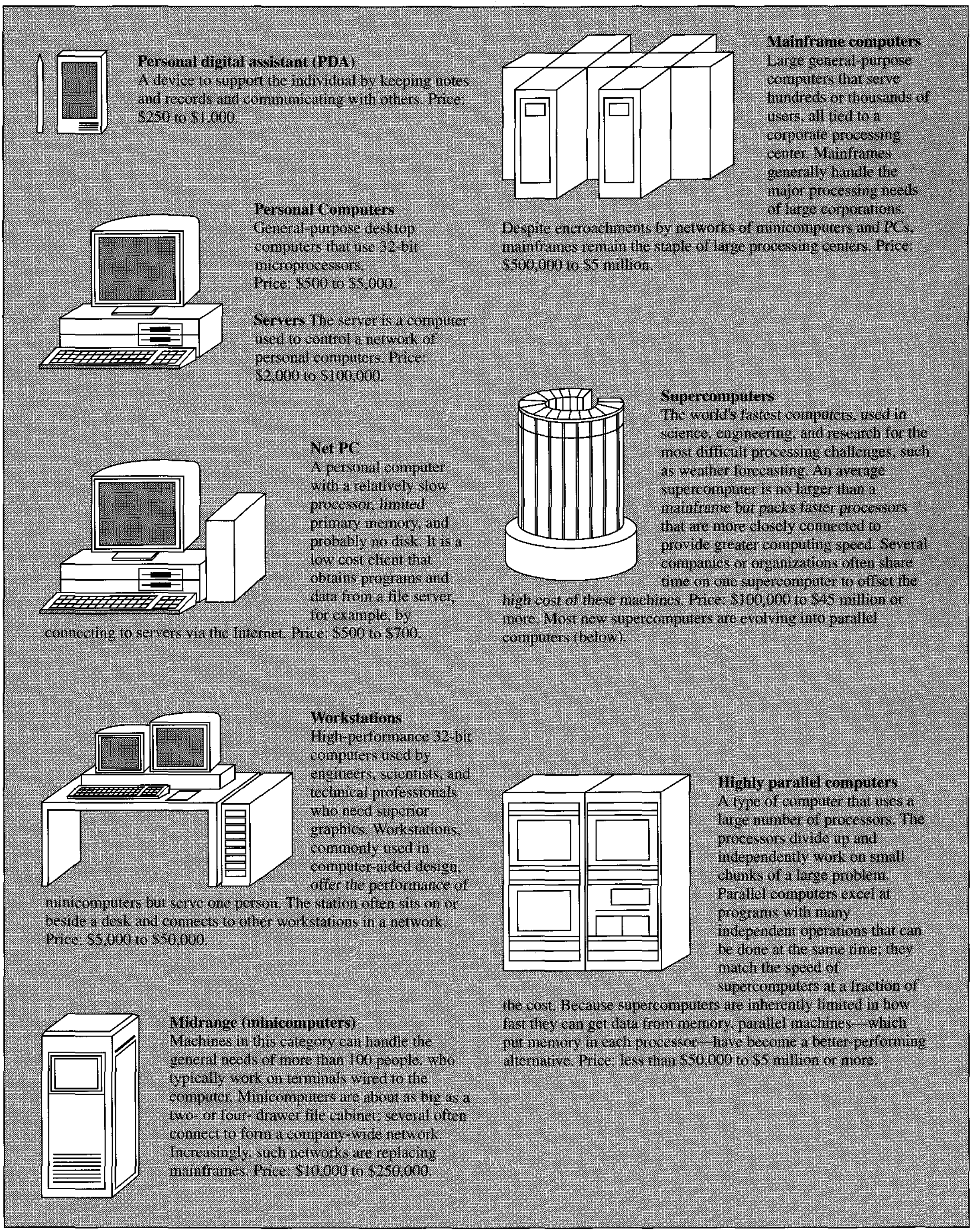


FIGURE 8-1
A guide to computers.

MANAGEMENT PROBLEM 8-1

Alice Roberts is Vice President of Administration for Kitchenware, Inc., a manufacturer of kitchen products. She has noticed a proliferation of computers in the company, both desktop and portable notebook computers. The office has a LAN with a connection to the Internet. The sales force uses its PCs on the road and communicates with the office using e-mail and occasionally faxing. All the computers represent about six different brands. Currently, there do not seem to be significant problems with compatibility. However, Roberts wonders if it would make sense to establish a single brand of desktop and another one for notebooks. Such a policy would let Kitchenware negotiate a special price with vendors and should eliminate any potential compatibility problems.

Several other managers she approached with the idea were skeptical. They argued that the field had advanced enough to provide compatibility. "We ought to let employees buy what they want as long as the computer staff tells them it will work on our network," responded a sales manager. "The sales reps have different needs—some want a really light machine to carry on planes, others will go with something heavier because they spend most of their time in cars and transporting it isn't a problem."

What advice can you offer Roberts in coming up with a purchase policy?

of transactions given very high speed data channels (defined below). It is difficult to configure smaller systems to handle 1500 or 2000 on-line transactions per second, something that a mainframe order entry system does routinely. Even though the firm might be able to buy hardware that has a better cost/performance ratio, it would have to spend a huge amount to develop new applications for this hardware.

IBM's strategy is to continue mainframe development and to keep these machines competitive. It updates the operating system regularly; the most recent edition features networking capabilities to help the mainframe become a giant server on a network, capable of hosting large electronic commerce applications. Over the past five years, mainframes have become smaller, faster, and cheaper as a result of using CMOS technology and the clustering of parallel processors to provide more computing power. IBM's S390 sixth generation (G6) processor runs at over 1500 million instructions per second (MIPS). This computer can have up to 12 processors, each operating at over 200 MIPS.

Organizations using mainframe computers generally process large amounts of data. The computers may access databases with billions of characters of data and control networks of hundreds or thousands of terminals. As a result, the computers need to be able to handle extensive telecommunications activities and input-output operations.

The mainframe usually has a data channel, which is as powerful as the CPU on some smaller computers. The **data channel** accepts instructions from the CPU, for

Breaking the Teraflops Speed Limit

The Department of Energy sponsors much of the research on supercomputers through its Accelerated Strategic Computing Initiative. The objective of the program is to triple computing performance every 18 months for a 10-year period. These powerful computers will be used to run weapons simulations as a part of compliance with the Comprehensive Weapons Test Ban Treaty. The laboratories involved estimate they will need 100 teraflops machines by 2005 due to the increasing complexity of the simulations. IBM has delivered part of a system that will perform at 3 teraflops, with a 2.5 terabyte memory, to the Lawrence Livermore National Laboratory. IBM is building its computing using off-the-shelf RS6000 chips.

The design of these machines faces hardware and software challenges. Very fast processors can be slowed by the time required to transfer data from memory to the processor. Programmers also have to be able to develop extremely complex simulations without having a lot of tools available for supercomputers. However, the implications are clear. Computers will continue to become faster, and many of the advances at the supercomputer level eventually filter down to the desktop.

example, to retrieve data from a **disk file.** The CPU goes on to another job while the data channel is busy. When the data channel finishes, it interrupts the CPU to let it know that data are available. The CPU then restarts the program that was interrupted if its priority is higher than other programs that are waiting to run. Control units on the mainframe serve to interface the computer, in this case the data channel, with different I/O and storage devices. This architecture has created mainframe computers that are extremely fast, and that can be used in database, transactions processing, and numerous other applications.

Powerful Supercomputers

Mainframe computers are not fast enough for some applications. The mainframe computer was originally developed for business use. It has features to enhance the processing of business data involving character manipulation and decimal arithmetic. Scientists and engineers have computationally intensive problems to solve, often involving numbers with many digits of significance. Examples include the simulation of airflow over an aircraft, weather forecasting simulations, analysis of geological data, and even predictions about the speed of a sailboat designed for the Americas Cup competition.

Companies such as Cray Research manufacture supercomputers; Cray dominates the market with over 200 of the top 500 computers installed. Supercomputers are among the fastest computers today, with speeds measured in hundreds of megaflops (a megaflop is the execution of 1 million floating-point instructions per second) to more than a gigaflop (1 billion floating-point instructions per second). Machines have achieved teraflop speeds, executing over 1 trillion instructions per second! Some experts argue that the future of high-speed computing is in massively parallel machines (described below) or by combining the power of a number of individual workstations connected with a network. Of the 20 fastest computers in the world, only one uses "vector technology," the original approach to supercomputing. The second fastest machine is a prototype massively parallel supercomputer built by Intel for Sandia National Laboratory in New Mexico. The computer is based on 9152 Intel Pentium P6 processors and has achieved a peak speed of over 1.3 trillion mathematical operations a second. As of this writing, the fastest supercomputer is "Pacific Blue" at Lawrence Livermore Laboratory in California. This computer, with 5800 processors and built by IBM, is capable of a peak performance of 3.88 teraflops.

Minis: The Beginning of the Revolution

The next type of computer to be developed was the mini. Companies such as DEC, now a part of Compaq, found that with integrated circuits they could build a highly cost-effective small computer with an 8- or 16-bit word length. Minis became very popular as stand-alone time-sharing computers and as machines dedicated to a department in a corporation.

Minicomputers evolved as manufacturers increased processing speeds and expanded word sizes to 32 bits. These computers can be classified as "midrange." IBM claims to have sold more than 200,000 of its midrange AS/400 systems. Companies use this midrange computer for a variety of processing tasks, some of which are similar to what a mainframe did a decade ago. A firm might use this computer for all its processing needs. A geographically dispersed company could have AS/400 computers at various geographic locations connected to a larger machine at headquarters. Third parties have developed thousands of applications for the AS/400 as well.

As an example of the trends in medium and larger computers, in 1995 IBM introduced models of the AS/400 built around its PowerPC chip. IBM, Apple, and Motorola developed this RISC chip to compete with Intel. Using a customized version of this chip lets IBM get away from a proprietary architecture and reduce the cost of the computer. However, because there are a huge number of applications for this popular computer, IBM had to maintain compatibility with its original architecture. The computer translates existing applications software the first time it is executed on the new machine without the need to change the original program.

The Personal Computer Has Changed Everything

Next came the PC or personal computer, which was first designed as an 8-bit computer. Apple introduced its famous PC in 1977. The original IBM PC, marketed in 1981, fetched 8 bits at a time from memory but performed computations on 16 bits at a time. Soon IBM introduced the AT, which fetches and processes 16 bits at a time. The next generation is the 32-bit PC or 386 (later the 486 as well) computer, which fetches and processes 32 bits at a time. The newest chip, the Pentium III, is capable of fetching and storing 64 bits at a time. The personal computer is used in thousands of ways today, and there are many thousands of programs available for it.

Figure 8-1 shows personal computers and workstations as separate categories. Workstations use high-performance 32-bit computers for engineering and scientific work. The workstation features superior **graphics** and is often used for design tasks. Powerful Pentium personal computers running graphical user interfaces (GUIs) fall into the workstation class as well. These PCs have the computational power and software capabilities to become the same kind of personal productivity tool for the manager that the engineering workstation is for the engineer.

The Server

In the client-server model of computing, a user's client PC makes requests of a **server** computer that has data and possibly programs on it. The server is responsible for the database and is likely to execute transactions to update and manage it. The server also has to extract data and provide it to the client. The user's client does various analyses of the data using its own processing power. At first, the server did not do much but let users download software and print reports in a local area network. However, as PC chips became more powerful, so have servers. They now challenge minicomputers and may soon go after the mainframe market. Intel is so optimistic about the server market that it is marketing complete boards for servers containing four Pentium chips. A vendor can use this board as the major component of a server. Vendors like Sun Microsystems sell powerful servers based on their own chips like Sun's SPARC chip. IBM is even calling its mainframes "enterprise servers."

A large grocery store used to have a $250,000 minicomputer. Now it runs its business on a multiprocessor server that costs $25,000 to $50,000. One Compaq server containing four Pentium processors has been clocked at 600 transactions per second with standard database software compared to 200 transactions per second for some midrange computers. Server makers envision computers with up to 32 Intel Pentium processors achieving the performance of today's high-end mainframes.

The Network PC versus the Under $1000 PC

Competitors of Microsoft, along with the Internet, stimulated the development of a new kind of PC called the Network PC. The idea behind the Net PC is that a person connected to the Internet does not need a powerful PC; this individual can work quite happily with a device that has a relatively slow CPU, limited memory, and perhaps no disk drive. Advocates of this approach think it should be possible to build the Net PC for well under $1000. Competitors to Microsoft envision the Net PC running some other operating system (control program) than Windows 98 or Windows NT, both Microsoft products.

The Net PC has so far failed to displace sales of full-featured personal computers. These devices do look attractive as replacements for dumb terminals (terminals with minimal logic that connect to minis and mainframes) or for providing network access for students at a more affordable price than a standard PC for most school districts. The dramatic reductions in the price of full-featured PCs bring their costs closer to those of a Net PC, making the case for the latter less clear.

It should be noted, however, that the cost of owning a PC goes well beyond its purchase price. The "total cost of ownership" for a PC in an organization has been estimated at two or three times the purchase price, primarily due to software and support requirements and the costs of networking PCs together. The Net PC, because it is simpler and takes most of its software from a server, should have a lower total cost of ownership than a full-featured PC.

The majority of PC sales today are for a class of machines costing less than $1000. It is not clear whether the Net PC will be attractive if one can buy a full-featured PC at these prices. How sensitive are consumers to a few hundred dollars if it buys a much more capable computer that can do meaningful work when not connected to the Internet?

Massively Parallel Computers

The highly parallel machine category in Figure 8-1 represents a number of approaches to computer design. The approaches have in common the idea of trying to avoid the bottleneck in conventional designs where all instructions and data have to be fetched from memory and brought to the CPU for processing. Some of these parallel computers have multiple processors that all execute the same instruction at once on the same data. Others execute multiple instructions on different data. Clearly, coordinating the execution of instructions and programming these machines are a challenge.

IBM has created a parallel supercomputer based on RISC technology in its very successful RS6000 workstation, which uses the PowerPC chip. The RISC-based SP1 connects as many as 64 chips and can run almost all the software that currently runs on its workstations. A number of experts in the field expect parallel computers to replace mainframes. As the physical limits of computation are reached, one way to gain increased performance is to compute in parallel.

A recent strategy followed by some users who need extremely high-speed computing is to connect clusters of high-end workstations with special software that lets them attack the same problem. The software assigns various parts of a complex computation to several workstations, generating considerable increases in processing power. It is possible for some applications that used to require a supercomputer to run on such a connected group of workstations.

A Personal Assistant

The PDA or personal digital assistant began as super calculators able to store a user's calendar and phone book. Today these devices often weigh less than a pound and some offer handwriting and voice recognition, fax and modem communications, and even a pager. PDAs are inexpensive enough that firms will develop dedicated applications for them. For example, a sales representative might use a small PDA that has information on contracts. A longshoreman uses a PDA that has a bar-code reader and scanner to record the location of containers. A rental-car company might have local maps and tour guides available in each city to be downloaded to your PDA. As wireless transmission technology expands and drops in price, PDAs will become more attractive.

MANAGEMENT PROBLEM 8-2

Ben Levine finished his MBA at a well-known business school last year and assumed a position as assistant to the president of Morgan Hill, a financial services company active in fund management. His first assignment was to find out how much the company was spending on information technology and to determine if the investment was providing a return.

To start, Levine looked at inventory records kept by the office services department and then conducted his own survey to identify computers, fax machines, and network components. He was surprised when the total annual expenditure was 25 percent of sales, and he found that IT was the firm's second largest expense after salaries and ahead of travel. Even more disturbing, he found a wide variety of computers in place, from mainframes to personal digital assistants. "It looks like we opened the catalog and ordered one or more of each machine in it," he remarked on reviewing the data.

How would you explain these findings? Do they necessarily mean that Morgan Hill has invested poorly? Why might there be so many different types of computers? How would you advise Levine to estimate the return the firm receives from its IT investment?

In Orange County, California, real estate agents now have the opportunity to use a PDA to remotely access, download, and store property information on a Sony Magic Link personal communicator. An agent can use it to communicate via fax, electronic mail and paging, or access a commercial on-line service. The agent can select listings using different parameters such as location and special needs of the client. The PDA will replace printed property listings, which were published every two weeks.

There are a variety of PDAs available with the market leader being the Palm Pilot from 3Com. There is even a cellular phone that accesses e-mail and provides some of the features of a digital assistant. PDAs' competitors are hand-held computers that feature small keyboards to facilitate data entry, a process that is clumsy at best on a PDA. The smaller PDAs use proprietary operating systems. Microsoft promotes Windows CE for slightly larger PDAs that are more computer-like than the hand-held models. Microsoft's long-term goal is to capture this market as well as the set-top cable controller market for Windows CE.

Conclusions

We can see why the task of developing the architecture for an organization's computing system is so difficult. If an organization is starting with no computing, one could conceive of buying a large midrange computer, a small mainframe, or a network of personal computers. The question of which option to choose may require a major study and considerable effort. The organization that already has a number of computers in place must decide how to manage and expand its systems as users develop new needs and ideas for technology.

Why So Many Types of Computers?

The text discusses several different types of computers, but you may be quite happy with a desktop or notebook PC. Why are there so many different kinds of machines, supercomputers, mainframes, minis, and PCs? This chapter discussed different computers in order of their development. In Chapter 13 we shall see that the most popular architecture today is called a client-server configuration. Why have companies not adopted this configuration and replaced their older configurations?

The major reason for the variety of computers is the applications users have programmed to run on them. There are many applications developed for mainframe computers. It would be very expensive to convert to a new architecture, given that the new system could handle the processing volume of the mainframe. As the industry develops new types of computers, mainframes, minis, and PCs, users will write custom applications for them. One large financial services firm recently reported having over 75,000 active COBOL programs comprising some 70 million lines of code, a significant investment in one language and system. As a result, there is a great reluctance to throw away existing applications to adopt the latest trend in computing. Instead, companies put new applications on the latest computing platform, create new interfaces for their old mainframe systems, and plan to reprogram applications sometime in the future. You should not be surprised to see a variety of almost all types of computers discussed in this chapter in a company, nor should you think a firm is necessarily behind the times because it still has applications that run on mainframe computers.

CHAPTER SUMMARY

1. Computer technology is marked by great changes. The early years were the era of the mainframe. They were followed by the development of the minicomputer and then the personal computer.
2. The mainframe computer is often criticized today, but it has a lot of features to recommend it. The most important is the large number of applications that currently run only on mainframes. The cost of redoing all of these systems is staggering! Mainframe technology is also well understood, and the machines have achieved a high degree of reliability. However, mainframes feature proprietary architectures that are very costly and tend to be associated with inflexible applications.
3. The minicomputer has evolved into a “midrange” system. These systems are blurring with file servers that provide data and sometimes programs for PCs in a network.
4. A few manufacturers make supercomputers. It appears that the supercomputer of the future is most likely to be a massively parallel machine or a group of computers on a network all working on the same problem.
5. The personal digital assistant is in its early phases. Improvements in wireless communications and the capabilities of these machines should increase their appeal.

6. The revolution in computer technology came about because of the chip and the ability to put millions of electronic components on a small chip of silicon or other material. An Intel Pentium II CPU on a chip has over seven million components and can execute well over a 100 million instructions a second, which is comparable to the speed of many mainframe computers.
7. Many of the features of larger computers are being incorporated into PC chips as these devices become more sophisticated.
8. Changes in the technology force changes in hardware and software architecture. The cost per MIP of a PC is much lower than for a mainframe. PC software is also easier to use and more appealing to the user than mainframe applications. These changes in the technology and the economics of computing have led to the client-server model in which data and some programs reside on servers, midrange computers, and/or mainframes while users work with PCs running programs to access and analyze the data provided by the various servers.
9. Computers are very fast, but secondary storage is not. It takes much longer to access data on a disk than in primary memory. However, it is not practical (or possible) to keep gigabyte (billions of bytes) or larger databases in primary memory.

IMPLICATIONS FOR MANAGEMENT

While starting your own business is risky and has a lot of challenges, at least you are not likely to be stuck with a 20-year-old hardware and software architecture. The reason you want to understand something about the variety of computers available is that you may encounter them. In fact, you may have to help develop an architecture for your employer, figuring out where you want to be and how to get there given the existing stock of equipment. While you might like to get rid of a particular computer, it is important to remember that there may be some applications that will only run on it. Airline reservations systems will use mainframe computers for processing for some time in the future. It is also unlikely that you have the resources or patience to throw away all your old applications and develop them again for a different kind of computer. You may save money on hardware, but at a tremendous cost in labor for systems development.

KEY WORDS

Batch
Data channel
Disk file
Graphics
Minicomputer
MIPS
Proprietary hardware
Server
Very large scale integration (VLSI)

RECOMMENDED READING

Barnes, L.; Shimberg, D.; and L. Lingner. *Client/Server and Beyond: Strategies for the 21st Century.* Englewood Cliffs, NJ: Prentice Hall, 1997. (An essential text for understanding client/server systems.)

Hord, M. *Understanding Parallel Supercomputing.* Los Alamitos, CA: IEEE Computer Society Press, 1998. (A book illustrating the evolution, concept, and basic architecture of parallel super computing technologies.)

IEEE Spectrum, January issues. (This publication features annual technology reviews and forecasts for a number of technologies. Monthly issues generally have some articles on computer hardware and software and networks.)

Shurkin, J. *Engines of the Mind : The Evolution of the Computer from Mainframes to Microprocessors.* New York: W. W. Norton & Company, 1996. (An entertaining book providing the history of the computer revolution.)

Sterling, T. "The Scientific Workstation of the Future May Be a Pile of PCs," Association for Computing Machinery. *Communications of the ACM;* New York; 39 no. 9, Sept. 1996. pp. 11–12. (An interesting article predicting the future of workstation computers.)

DISCUSSION QUESTIONS

1. Distinguish between computer hardware and software. Which most concerns a manager?
2. Why is the cost/performance ratio much better for a PC than for a mainframe?
3. What is the purpose of a control unit? Can the same control unit control more than one type of device?
4. Why can conversion from one computer to another be a problem?
5. Why is it difficult to convert programs from mainframes to client-server platforms?
6. What is the advantage of a data channel? How much logic must it contain?
7. What are the main limitations of a PDA?
8. What are the uses for a supercomputer?
9. Why are CD-ROMs for computers so popular? What is their main advantage?
10. What are the features of mainframe computers?
11. What features should a high-end server have?
12. What are the main characteristics of the client-server model?
13. Why is a computer manufacturer interested in compatibility within its own line of machines? Does a manufacturer want its computers to be compatible with the computers of other manufacturers? What are the advantages and disadvantages of such a strategy?
14. What applications seem best suited to the use of a touch screen?
15. What issues are involved in making a massively parallel computer work?
16. Why does a PC have several different buses?
17. What are the reasons for having secondary storage? Why not just add more primary memory?
18. What are the arguments for having data and servers in a central location?
19. How can networking computers reduce the amount of input and output activity that takes place?
20. Compare and contrast Net PCs with inexpensive personal computers?
21. What is the difference between an image of a page and that same page typed into a word processing program?
22. What is the advantage of a workstation over a larger computer?
23. What factors underlie the trend toward networks of personal computers (clients) connected to file servers?

CHAPTER 8 PROJECT

Simon Marshall Associates

Simon Marshall has a client who visited its offices and saw the personal computers installed there. The client owns a small manufacturing company that creates custom-machined parts for its customers. The company is able to do very high precision manufacturing and has been quite successful in its niche. The client asked Simon Marshall for advice. He had always avoided using a computer because he thought it would simply add to overhead and not save any money. Increasingly, however, his machines are controlled by computers, and his two engineers recommend using some technology in the office.

A representative from a systems integrator (a consulting firm that develops solutions for its customers) visited and suggested a number of possibilities, from a single PC in the office to a network in the firm. The client is confused and has asked Simon Marshall for help. Since they are new to computers as well, they have asked for your recommendations. How should their client proceed to evaluate the proposal from the systems integrator? What sounds like the most appropriate technology for him, at least to get started? Why?

CHAPTER 9

Software Is the Key

Outline

Focus on Change

Hardware alone is not enough to bring about major organizational changes. It takes software to do anything useful with a computer. As you read this chapter, think about earlier examples of companies that dramatically changed the way they do business. Many of the systems in these firms contain millions of lines of software code written by people in a painstaking, labor-intensive process. We need improvements in the way people produce software; some are sure to come through knowledge workers developing their own applications using desktop technology.

MANAGERIAL CONCERNS

Why do managers need to understand software? The choice of software to be used as a standard in the organization for developing applications is an important management decision. As you develop the firm's hardware and software architecture, what operating systems will you choose for the servers? What operating system do you want on user workstations? If you want to develop a new system, is it best suited for programming on the company's existing midrange computer using a higher-level business language or a fourth-generation language such as those discussed in Chapter 18? (A higher-level language has statements that are closer to a natural language like English than to the language the computer executes.) The proliferation of personal computers places the manager in the position of a direct hands-on user of computers. What software should the manager buy and use? How does one choose?

In this chapter, we explore computer **programs** and languages along with different types of operating systems and packaged programs. Table 9-1 shows that different hardware "generations" can be characterized by differences in computer software. (Remember, we defined software as the instructions that tell a computer what actions to take.) In this chapter, we discuss these different types of software. The software presented here is most often used by an information systems professional (with the exception of a special language like SPSS). Software that is

TABLE 9-1

SOFTWARE GENERATIONS

Generation		Software
First	1950–1958	Machine language
		Assembly language
Second	1958–1964	Assembly language
		Higher-level languages
		Batch operating systems
		Dedicated on-line systems
		Experimental time-sharing
Third	1964–1970	Preponderance of higher-level languages
		Expansion of packaged systems
		Operating system mandatory
		Mixed on-line and batch applications
		Virtual-memory time-sharing systems
Third-and-one-half	1970–1980	Expanded operating systems
		Virtual-memory batch systems
		Batch, on-line, and time-sharing mixed
		Database and communications packages
Fourth	1980 to present	More application programs
		Higher-higher level or "fourth-generation" languages
		Application generators
		Virtual-memory operating systems for PCs
		Object-oriented languages
		Open systems

likely to be of interest to a user with a personal computer is presented later in the text, particularly in Chapters 11, 18, and 20.

We generally divide software into two main types: systems software and applications software. Systems software manages the computer and/or provides a set of standard services to its users. The most well-known piece of systems software is the **operating system,** such as **Windows 98.** Database management systems, covered in Chapter 10, are another example of systems software.

A second type of systems software is a **programming environment.** An environment provides the programmer with a virtual workspace and access to various libraries. The programmer will use existing components of code to speed the development process.

Applications software solves an information processing problem in an organization. The programs constituting the systems we have seen so far are classified as applications software. Several computer languages discussed in this chapter are used to create applications software.

It is hard to overemphasize the importance of software. It is the key that unlocks the potential of the computer. Investors think so as well. Look at the most recent market values for Microsoft, a software company, and for IBM, a company that sells both hardware and software. As of this writing Microsoft's sales are a little over 18 percent of IBM's, but its market value is almost 2.5 *times* that of IBM's.

Programming Languages

Over the last 50 years, the trend in programming has been to make it easier to give instructions to a computer. The objectives of making programming easier are manyfold:

- To improve the efficiency of developing new technologies, especially to reduce the elapsed time required to go from an idea to a finished system.
- To make it easier to develop systems that are appealing to users.
- To encourage nonprofessional programmers, people like you, to develop applications themselves without having to rely on a programmer.
- To reduce the bottleneck of systems development, the large backlog of suggested applications that exist in most organizations.
- To reduce the number of errors resulting from a systems development effort.
- To take advantage of the tremendous increases in speed and cost reductions of hardware by using hardware less efficiently in order to improve the systems development process.

The first computer languages were **machine language,** the actual 0s and 1s the computer executes. Programming in machine language was never particularly enjoyable, and it certainly restricted programming to a small number of dedicated individuals. The first advance in computer software was the introduction of **assembly language,** a language which substituted **mnemonics** such as ADD, SUB, MULT for the machine language numbers that perform these instructions. Programmers

Programs Have Bugs

There is an old saying in the computer field that "no program is ever fully debugged." Errors sometimes appear in programs that have been running for a long time due to some untested conditions that caused the error to appear. Typically, the mistake is in some part of the program that was not tested. (It is very difficult and prohibitively expensive to test every possible combination of paths through a program.) If you use Microsoft Windows, you sometimes encounter a message that some action has caused a general protection fault, and you often have to terminate the application involved. In this case, the system recognized an error, and it tried to let you get around it by closing one application rather than restarting the computer.

A recent software problem in a cellular phone has caused a great deal of trouble for cellular companies and Motorola in Israel. The Alpha cellular phone, manufactured by Motorola, experienced a software problem in a program embedded in a ROM chip. The phone uses time division multiple access (TDMA) to switch its radio signal from one channel to another at frequent intervals. This strategy makes it possible for a number of phones to use the same cell at the same time. The software error caused the phone to lock onto one channel and stay there indefinitely, blocking other users in that cell from using it, until the offending phone was shut off or its batteries died. The problem resulted in inaudible voices, poor reception, calls being cut off, and times when the phones did not work.

The problem first appeared in Hong Kong and quickly spread to Israel. Cellular service is very popular in Israel and inexpensive, less than 3 cents a minute. Many customers in Israel leave their phones on all the time, and they use cellular phones eight times more than people in the U.S. Motorola recalled 150,000 of the phones from six countries and fixed the problem within six weeks, at a cost of $10 to $20 million. Several class action suits were filed against Motorola and a cellular phone company in Israel.

Bugs are a major problem; they can be very costly, and even dangerous in applications like air traffic control and medicine.

were also able to use variable names such as X, Y, and PAY, rather than try to remember exactly what each memory location contained.

Today assembly language is used only by systems professionals, generally in building systems software or special packages. There is no reason for a user to write assembler code. It is interesting to note that Lotus 1-2-3, a popular electronic spreadsheet program for PCs, was originally written in assembly language for speed of execution. Later versions were written in a higher-level language for ease of maintenance and enhancements.

The kinds of software you will be using are built up from the foundation provided by machine and assembly code. Higher-level languages are often translated into machine language to execute a program. As languages become higher in level, they have more overhead and compute inefficiently. Several organizations have experienced embarrassing performance problems using fourth-generation languages for applications they were not designed to process.

THE CONTRIBUTION OF HIGHER-LEVEL LANGUAGES

Higher-level languages make the computer easier to program and extend the use of computers to more individuals. The most significant of these languages appeared around 1957 and is called **FORTRAN** (FORmula TRANslation). This language is designed to facilitate the use of computers by scientists and engineers and is well suited to solving mathematically oriented problems on the computer. With FORTRAN, we can write a complex formula in one statement, for example,

$$X = (A + B)*(C - D)/E$$

An assembly-language program to accomplish this computation is shown in Table 9-2. The assembly-language version requires eight instructions, compared with a single line for the FORTRAN statement. The FORTRAN statement is at a higher level than the eight instructions required in assembly language. For many problem solvers, particularly nonprofessional programmers, a higher-level language eases the conceptualization of program structure. A number of other higher-level languages have been developed. BASIC is a language very similar to FORTRAN except that it was designed for time-sharing. You can use a variation called Visual Basic to develop applications for Windows 98 on a PC.

COBOL (*co*mmon *b*usiness-*o*riented *l*anguage) was developed to facilitate programming for business applications. An example of parts of a program is found in Table 9-3. For years commercial programs in the U.S. were written primarily in COBOL, creating approximately 30 billion plus lines of COBOL code worldwide. Organizations are seeking alternatives to this language in order to be more productive. COBOL is associated with unresponsive, mainframe computer systems, and a large number of firms are only maintaining or enhancing COBOL programs. They are often doing new development work with newer languages and frequently are using alternatives to mainframes. It is unlikely that either COBOL or mainframes will disappear quickly, but the use of COBOL is expected to steadily decline in the future.

TABLE 9-2

AN ASSEMBLY-LANGUAGE PROGRAM FOR THE FORTRAN STATEMENT X = (A+B)*(C–D)/E

Program		Comment
LDA	A	Load A into the A register
ADD	B	Add B to the A register
STA	T	Store the sum in a temporary location
LDA	C	Load C into the A register
SUB	D	Subtract D from the A register
DIV	E	Divide the results by E
MLT	T	Multiply the results by T
STA	X	Store the final result in X

TABLE 9-3

A COBOL PAYROLL PROGRAM SEGMENT

```
  IDENTIFICATION DIVISION.
  PROGRAM-ID. PAYROLL.
  AUTHOR, GORDON DAVIS.
*
* THIS PROGRAM READS HOURS-WORKED AND RATE-OF-PAY FOR EACH
* EMPLOYEE AND COMPUTES GROSS-PAY.
*
*
  ENVIRONMENT DIVISION.
  CONFIGURATION SECTION.
  SOURCE-COMPUTER, CYBER-74.
  OBJECT COMPUTER, CYBER-74.
  INPUT-OUTPUT SECTION.
  FILE-CONTROL.
     SELECT PAYROLL-FILE ASSIGN TO INPUT.
     SELECT PRINT-FILE ASSIGN TO OUTPUT.
*
*
  DATA DIVISION.
  FILE SELECTION.
  FC PAYROLL-FILE
       LABEL RECORD IS OMITTED.
  01 INPUT-RECORD              PICTURE X(80).
*
  FC PRINT-FILE
     LABEL RECORD OMITTED.
       01 PRINT-LINE           PICTURE X(132).
*
  WORKING-STORAGE SECTION
  77 OVERTIME-HOURS            PICTURE 99.
  77 REGULAR-HOURS             PICTURE 99.
  77 GROSS-PAY                 PICTURE 9999V99.
  77 REGULAR-PAY               PICTURE 9999V99.
  77 OVERTIME-PAY              PICTURE 9999V99.
  77 REGULAR-TOTAL             PICTURE 99999V99.
  77 OVERTIME-TOTAL            PICTURE 99999V99.
  77 GROSS-TOTAL               PICTURE 99999V99.
  77 MORE-CARDS                PICTURE XXX.
  01 PAYROLL-DATA.
       05 NAME                 PICTURE X(30).
       05 RATE-OF-PAY          PICTURE 99V999.
       05 HOUR-WORKED          PICTURE 999.
       05 FILLER               PICTURE X(422).
```

(continued)

TABLE 9-3—CONTINUED

```
00044     01 DATE-RECORD.
00045          05 DATE-IN               PICTURE X(8).
00046          05 FILLER                PICTURE X(72).
00047     01 COMPANY-HEADER.
00048          05 FILLER                PICTURE X(58)    VALUE SPACES.
00049          05 FILLER                PICTURE X(17)    VALUE.
00099   *
00100   *
00101     PROCEDURE DIVISION.
00102     MAINLINE-CONTROL.
00103        PERFORM INITIALIZATION.
00104        PERFORM READ-AND-CHECK UNTIL MORE-CARDS = 'NO'.
00105        PERFORM CLOSING.
00106        STOP RUN.
00107   *
00108     INITIALIZATION.
00109        OPEN INPUT PAYROLL-FILE.
00110        OPEN OUTPUT PRINT-FILE.
00111        MOVE 'YES' TO MORE-CARDS.
00112        READ PAYROLL-FILE INTO DATE-RECORD AT END STOP RUN.
00113        WRITE PRINT-LINE FROM COMPANY-HEADER AFTER ADVANCING
00114          2 LINES.
00115        MOVE DATE-IN TO DATE-OUT.
00116        WRITE PRINT LINE FROM WEEK-HEADER AFTER ADVANCING 2 LINES.
00117        WRITE PRINT-LINE FROM DETAIL-HEADER-1 AFTER ADVANCING
00118          2 LINES.
00119        WRITE PRINT-LINE FROM DETAIL-HEADER-2 AFTER ADVANCING
00120          1 LINES.
00121        MOVE SPACES TO PRINT-LINE WRITE PRINT-LINE.
00122        MOVE ZEROES TO REGULAR-TOTAL, OVERTIME-TOTAL, GROSS-TOTAL.
00123   *
00124     READ-AND-CHECK.
00125        READ PAYROLL-FILE INTO PAYROLL-DATA AT END
00126                                   MOVE 'NO' TO MORE-CARDS.
00127        IF MORE-CARDS = 'YES' PERFORM PROCESS-AND-PRINT.
00128   *
```

Many organizations, particularly small ones, use a language called report program generator (RPG). This language is suitable for business applications. RPG provides fixed program logic automatically, and programmers work from special RPG coding forms. The user defines the file, the output files, extra space for the compiler, input record formats, calculations, output, and any telecommunications interface. Because much of RPG is structured already, the programmer does not spend time with complex control logic. The language also makes it

MANAGEMENT PROBLEM 9-1

The American Society of Scientists is a large association of men and women who work in biology, chemistry, and physics. The society has a number of services for its members. It holds annual conferences on different topics all over the world and publishes six different newsletters and journals. In addition, it has insurance and credit card programs for its members.

For years the society separated its publishing computing from its membership services. The publishing applications run on a Unix time-sharing system using proprietary software packages for editing and formatting the publications. Membership services uses an outside service to process records, prepare mailing labels for journals, and perform accounting.

The head of the society wonders if this is the best way to handle technology. Costs have been going up about 10 percent a year across both publications and membership services. The society has asked you to help it evaluate alternatives. Could the publishing function be done better on desktop computers? Should the society move away from using an outside organization to handle member services and bring this activity in house, say on a LAN with multiple PCs?

easy to update files, and many versions support direct-access files with indices. The dominant language for development on IBM's popular AS400 midrange computer has been RPG.

The **C language** is extremely popular today. This powerful language was developed at Bell Laboratories and is used extensively on minicomputers, workstations, and personal computers for developing systems. C is not a language for the casual end user. Systems developers are particularly fond of C because it is very powerful and probably the most portable language around today. That is, software can be moved from one system to another with minimal effort because there are C compilers for most major computers. Table 9-4 is an example of a C program.

Object-oriented programming is a relatively new approach to developing software. The idea is to create objects that are self-contained modules of code. Designers encapsulate a set of data and all valid operations on that data together in an object. All of the objects in a class inherit the characteristics of that class. A class is an abstract concept for a group of related objects. For example, if a class is automobiles, the members of that class inherit the class properties of having four wheels, an engine, and doors. The programmer can write programs by putting together different modules in different orders. One attraction of object-oriented development is the presence of libraries of objects and procedures. If we could reuse code written in the past for a new application, there would be a dramatic improvement in productivity.

TABLE 9-4

A C PROGRAM TO COUNT WORDS AND CHARACTERS

```
#     include -<stdio.h>
/*
 *    Scan standard input and count words and total number
 *    of characters in words. A word is defined as any string of
 *    non-white space characters. Also print the average word
 *    length (to one decimal place).
 *
 *    DJB
*     /
main()
{
      int n:
      long c_cnt = 0, w_cnt = 0;

      while (n = get. word()) {
          c_cnt +=n;
          w_cnt++;
 }
 printf("word count %dspace char count: %d",
      w_cnt, c_cnt);
 if (w_cnt) printf("average word length: %.1f",
                  (float) c_cnt / w_cnt);
}
/*
 *    Get the next word by first scanning leading white space
 *    characters and then the non-white space characters that
 *    make up a word. Return the total number of characters
 *    scanned if a word is found, otherwise return 0 (on EOF).
 *    /
int get word()
{
      int c, c_cnt = 0;

      while (is white space(c = getchar()))
          ; /* ignore white space */
      if (c != EOF) {
          while ((c = getchar()) != EOF && !is white space (c))
            c_cnt++;
          return c_cnt + 1; /* plus 1 for missed first char */
      }
      else return 0;
}
/*
```

TABLE 9-4—CONTINUED

```
 *    Check if character is white space—that includes
 *    blanks, tabs, and new line characters. Returns 1
 *    if white space, otherwise returns 0.
 *    /
int is white space(c)
          int c;
 {
      if (c = ' ' || c = '' || c = '')
          return 1;
      else return 0;
}
```

There is an object-oriented version of C called C++. However, the creation of objects in C++ requires a highly skilled programmer. Another popular object-oriented language is Smalltalk, which is at a higher level than C++. Others are trying to develop graphical object-oriented languages. In the future it may be possible to develop a program by pointing at objects on the screen to combine them into a program!

A higher-level language will often be translated into machine language by a program called a **compiler.** It accepts a program called the source program and translates it into machine language called the **object program.** (See Figure 9-1 for a schematic of the compilation process.)

Another strategy is to create programs to be interpreted. The **interpreter** is a program that looks at each of your program's statements, decodes it, and performs the instruction. Interpreters make it easier to change a program and rerun it without recompilation, something useful when writing and debugging a program. BASIC is a good example of a language that develops programs using an interpreter. When finished, the user runs the debugged program through a BASIC compiler to produce object code. In general, a compiled program executes more quickly than an interpreted program.

One of the most important programs today for use on the Internet (see Chapter 12) is a version of C++ called **Java** that was developed by Sun Microsystems. Java is an interpreted program that programmers use to create "applets" (small programs) to be downloaded to client computers connected to the Internet. When you run a browser such as Netscape Navigator or Internet Explorer on your client PC, the capabilities of the PC to do local processing are not heavily used. The browser basically displays information on the screen, interpreting a format called hypertext markup language or HTML. Your PC is capable of much more processing, but how do you take advantage of its computational capabilities and protect yourself from downloading a rogue program? How does a developer write one program that will run on different kinds of PCs?

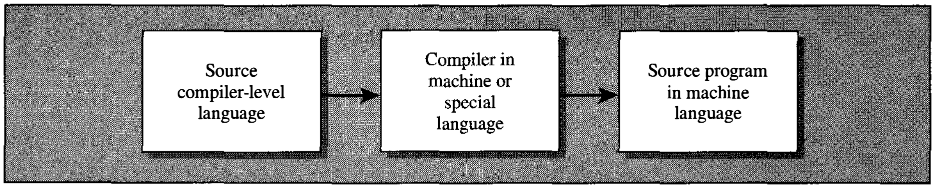


FIGURE 9-1
Compilation process.

Java in Action

One of Sun's objectives for Java was to break Microsoft's hold on personal computer software. Programmers could write code in Java that would run on multiple computers using different operating systems, not just Windows. This original strategy focused on the desktop; Sun tried to convince Web site developers that they could use Java to safely download programs that would execute on a PC. In this manner, a designer could produce an interactive application within a browser (given that the browser had a Java interpreter). For example, one could envision following a baseball game with icons on the screen following the motions of the real players. A user with an Internet connection could take a tour through a house for sale if a Web site had the appropriate software. Java brings animation to the Web.

For this strategy to succeed, everyone writing code needs to use the same Java language. Sun licensed Java but has been unable to control the language. Microsoft and Sun are involved in a legal dispute over Microsoft's version of the language, and Hewlett Packard has developed its own subset for use on different machines. Web developers have used other options for creating animation.

However, all is not lost for Sun. Programmers feel that Java is a language that allows them to create code twice as fast as other languages. It has features that make it easier to avoid and to find bugs; it is very good for creating reusable objects that reside on different computers on a network. IBM has five different types of server software, and Java's appeal is its ability to create software bridges among a variety of servers. IBM has over 2500 programmers working on Java.

Saab USA uses Java to help PC users at its 225 U.S. dealers pull together information about car service, ownership, finance, warranties, and other subjects. The system draws data from an IBM AS/400 computer at Saab's U.S. headquarters in Georgia and from an IBM System/390 mainframe at Saab's parts distributor, and even from older proprietary systems in the dealerships. Java also helps make information from internal systems available on the Web. Sprint PCS, a mobile-phone partnership, uses Java software to post reports to an internal Web site, making the information available to thousands of employees instead of just 200.

Despite the disputes among vendors, Java is alive and well!

Table 9-5 is an example of a Java applet and Figure 9-2 shows how Java runs on a client computer. Most of us are reluctant to download a program to run on our PCs without some kind of assurance that it will not damage our computer, for example, by introducing a virus. The figure shows how Java protects you from errant programs and how it runs on different PCs. First, the programmer writes code in

TABLE 9-5

A JAVA EXAMPLE

```
Code (A Personal Counter)
<SCRIPT LANGUAGE="JavaScript">
<!—

// Copyright (c) 1997 Mecklermedia Corporation.
// http://www.webreference.com/js/
// License is granted if and only if this entire
// copyright notice is included. By Tomer Shiran.

// name - name of the cookie
// value - value of the cookie
// [expires] - expiration date of the cookie (defaults to end of
  current session
// [path] - path for which the cookie is valid (defaults to path of
  calling document
// [domain] - domain for which the cookie is valid (defaults to domain
  of calling document
// [secure] - Boolean value indicating if the cookie transmission
  requires a secure transmission
// * an argument defaults when it is assigned null as a placeholder
// * a null placeholder is not required for trailing omitted arguments
function setCookie(name, value, expires, path, domain, secure) {
  var curCookie = name + "=" + escape(value) +
      ((expires) ? "; expires=" + expires.toGMTString() : "") +
      ((path) ? "; path=" + path : "") +
      ((domain) ? "; domain=" + domain : "") +
      ((secure) ? "; secure" : "");
  document.cookie = curCookie;
}

// name - name of the desired cookie
// * return string containing value of specified cookie or null if
  cookie does not exist
function getCookie (name) {
  var prefix = name + "=";
  var cookieStartIndex = document.cookie.indexOf(prefix);
  if (cookieStartIndex == -1)
    return null;
  var cookieEndIndex = document.cookie.indexOf(";", cookieStartIndex
  + prefix.length);
  if (cookieEndIndex == -1)
    cookieEndIndex = document.cookie.length;
  return unescape(document.cookie.substring(cookieStartIndex +
    prefix.length, cookieEndIndex));
}
```

(continued)

TABLE 9-5—CONTINUED

```
// name - name of the cookie
// [path] - path of the cookie (must be same as path used to create
  cookie)
// [domain] - domain of the cookie (must be same as domain used to
  create cookie)
// * path and domain default if assigned null or omitted if no
  explicit argument proceeds
function deleteCookie(name, path, domain) {
  if (getCookie(name)) {
    document.cookie = name + "=" +
    ((path) ? "; path=" + path : "") +
    ((domain) ? "; domain=" + domain : "") +
    "; expires=Thu, 01-Jan-70 00:00:01 GMT"
  };
}

// date - any instance of the Date object
// * hand all instances of the Date object to this function for
  "repairs"
function fixDate(date) {
  var base = new Date(0);
  var skew = base.getTime();
  if (skew > 0)
    date.setTime(date.getTime() - skew);
}

var now = new Date();
fixDate(now);
now.setTime(now.getTime() + 365 * 24 * 60 * 60 * 1000);
var visits = getCookie("counter");
if (!visits) {
  visits = 1;
  document.write(" By the way, this is your first time here.");
} else {
  visits = parseInt (visits) + 1;
  document.write(" By the way, you have been here " + visits +
    " times.");
}
setCookie("counter", visits, now);
// ->
</SCRIPT>
```

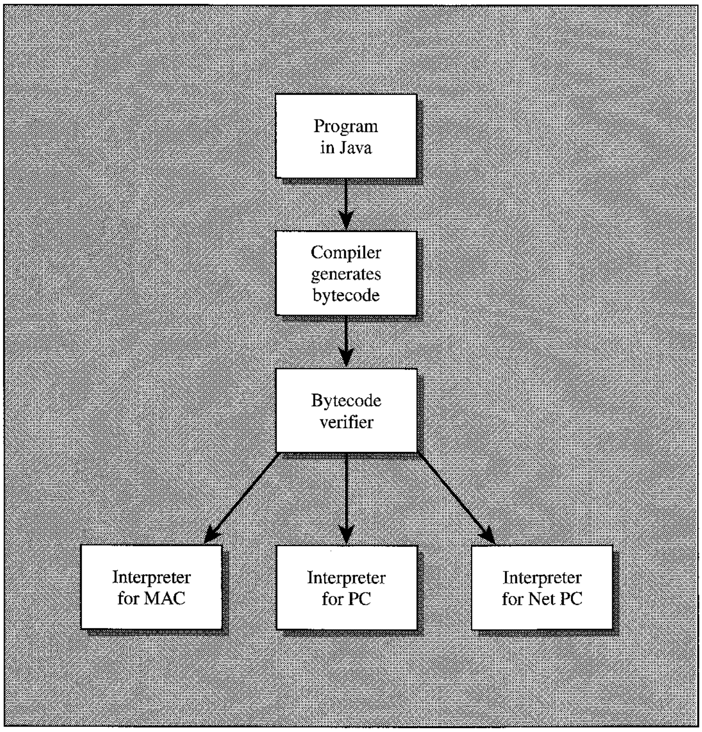


FIGURE 9-2
Java translation and execution.

Java. A compiler translates this code into something called **bytecode,** a representation of the Java program that is part way between source code and machine code. The bytecode verifier checks that the bytecode performs only legitimate operations. Each client computer that runs Java programs needs an interpreter. This interpreter is a program written in some language that is translated into the machine language of the client PC. The interpreter "interprets" the bytecode and does what it says. The interpreter also should check that the bytecode performs only legitimate operations on the client computer.

Using Java applets, the programmer enhances the capabilities of your Web browser. A client PC downloads Java applets and interprets them. An applet might produce animation on the screen; for example, a company can offer real-time simulation of a baseball game on the Internet. Alternatively, Java applets might process transactions on the Internet using some kind of digital cash. Using an interpreter instead of compiling into machine language makes it possible for Java to turn an Internet client into a more equal partner with a server, dramatically enhancing the usefulness of the World Wide Web.

Scripting languages are designed for "gluing" applications together. If adequate components exist, scripting languages let the programmer develop applications more quickly than conventional languages. They also let more people undertake casual programming without having to become professional programmers. TCL, Perl, Javascript, and Unix Shell scripts are examples of scripting languages; some consider Visual Basic as it has evolved to be a scripting language for tying together various components to build a graphical user interface. Unlike traditional languages, one would not develop complex algorithms in a scripting language. A two-line script in TCL creates a button control on the screen that displays a string and prints a short message when the user clicks on the button. To accomplish the same thing in C++ requires about 25 lines of code in three procedures. Like Java, scripting languages are interpreted, which means that they may suffer from slow execution. Scripting languages are not a replacement for other languages, but they can save time and labor when applicable.

An Example of a Special-Purpose Language

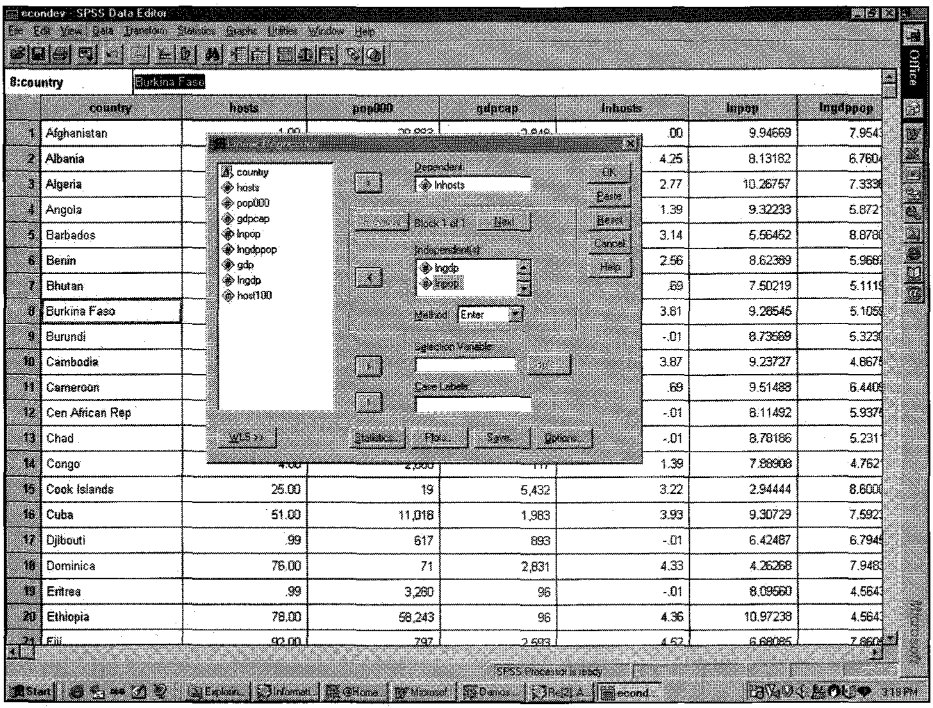
Special-purpose languages are designed with the same philosophy as higher-level languages: to extend the capabilities of the computer to users. Frequently, special-purpose languages are translated into a higher-level language that is compiled to produce machine language.

An excellent example of a special-purpose language is SPSS (statistical package for the social sciences). This comprehensive statistical system is designed to be used for statistical analysis. SPSS makes it possible to name variables for a particular study, save the variable names and data in a file, and create new variables from logical relationships among existing variables. The package features extensive data management facilities complemented by a number of statistical tests including preparing frequency distributions, testing for differences among populations, calculating measures of association, performing analysis of variance, and performing a series of multivariate procedures such as regression analysis and factor analysis.

Figure 9-3 shows the interface for the Windows version of SPSS (there are versions of SPSS that run on mainframes, minis, and PCs). The system allows you to input data by typing it into a spreadsheet program. You can identify each variable or column in the data matrix with a label such as Age, Sex, or Marital status. Then you can use the variables in various statistical procedures that range from a simple frequency distribution to more complex multivariate analyses such as regression analysis. Consider the number of program statements required in a language such as FORTRAN to perform this kind of statistical analysis.

Fourth-Generation Languages Ease Programming

A number of software vendors have developed languages that they advertise as belonging to the "fourth generation." Just as compiler-level languages are at a higher level than assembly language, **fourth-generation languages (4GLs)** are at a higher level than compiled languages. The purpose of these languages is to make it easier to program the computer. One does not have to construct as many detailed steps in writing a program. These languages are particularly appealing to users who need to access data on corporate computers.



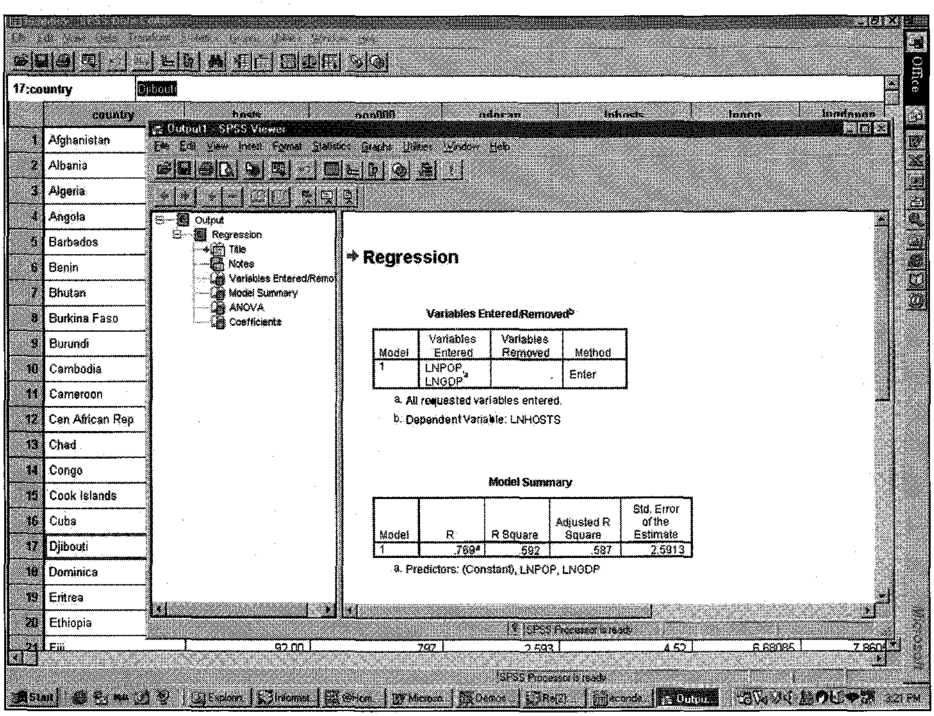


FIGURE 9-3
SPSS regression example.

The following is an example of a simple program written in **FOCUS,** one of the most popular fourth-generation languages:

```
TABLE FILE SALESDAT
PRINT NAME AND AMOUNT AND DATE
BY REGION BY SITE
IF AMOUNT GT 2000
ON REGION SKIP-LINE
END
```

This short program accesses a file named SALESDAT and produces a report that contains the region, site, name, amount, and sales if the sales are greater than 2000. The report is sorted by region and by site, with one blank line between regions. Generating a report like this would require many more statements in a language like COBOL. A fourth-generation language reduces the amount of detail in a program to improve productivity and makes it easier for users to think at a higher level. WebFocus is a product that lets users access a number of databases over an Intranet to retrieve information and generate reports. It is an adaptation of Focus as shown above to run on a system using Internet protocols.

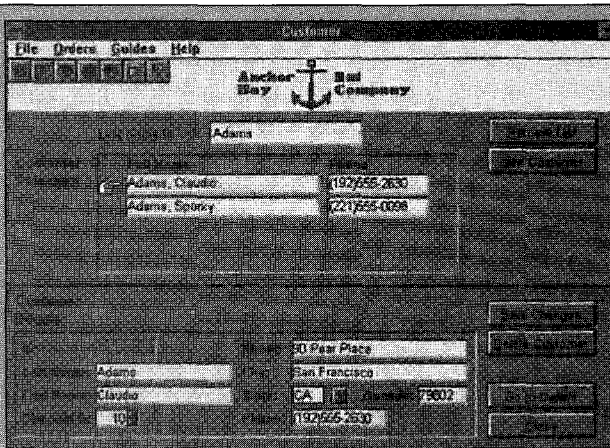
PowerBuilder is a popular 4GL for developing applications on a personal computer, and it is well suited to a client-server environment. A major brokerage firm used PowerBuilder to create an elaborate time recording and charge-back program for its internal systems development group. The use of this language made it possible to develop a large application in a relatively short period of time and resulted in a system with an appealing graphical user interface. Figure 9-4 is an example of PowerBuilder code. The latest version of PowerBuilder provides it with Web capabilities; it is designed now to facilitate the development of applications that run on Intranets and the Internet.

Package Programs Are Another Alternative

Package programs are software programs written by a vendor to be sold to multiple customers. Packages have been available since the first days of computers, but there has been an explosion in their sale and use.

One of the reasons for this proliferation is that the technology has matured. There are packages around today in the fourth or fifth (or more) version, improving with each version. The other reason packages are gaining in popularity is the requirement to sell personal computer packages. The market for personal computers is large, and a vendor knows that it is impossible to provide extensive training to customers who purchase the package. (PCs are often programmed in Visual BASIC, PowerBuilder, or C, but most users work primarily with powerful packages.) Therefore, the PC package has to be user friendly and well documented with an easy-to-use instruction guide. It is hoped that these positive features of packages for PCs will influence packages for all types of computers.

Although packages are certainly a type of software, we defer detailed discussion of them until Chapter 18, where we present packages as an alternative to the traditional way of developing applications.




```
•
•
•
//Call the user-defined window-level function wf_delcustorders ( )
//to check whether the customer to be deleted has any orders
//in the database. If so, disallow the customer delete operation.

integer li_returned orders
li_returned orders = wf_delcustorders (li_delid)

CHOOSE CASE li_returned_orders
    CASE IS > 0
        MessageBox("Delete Not Allowed", &
            "You can't delete a customer who has orders on file."+&
            ls_delname + "has" + String(li_returned_orders) +&
            "orders on file.", stopsign!)
    RETURN

    CASE IS < 0
        MessageBox("Delete Failure", &
            "Could not determine whether" + ls_delname +&
            " has any orders on file." +&
            " Please call the Anchor Bay support team.", &
            exclamation!)
    RETURN

END CHOOSE
•
•
•
```

FIGURE 9-4
A PowerBuilder application screen and some of the code that produced it.

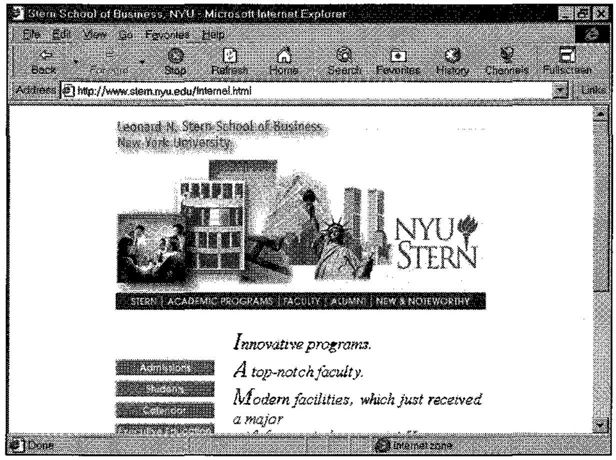


FIGURE 9-5
Stern School Intranet.

The Web Browser and Internet Standards

A Web browser like Netscape or Internet Explorer is a program that provides a client PC with a graphical interface to the Internet. With this program, you can obtain information from thousands of Web sites. Companies have created Intranets using Internet standards; these networks contain large amounts of company information that is easily available to employees. This browser software combined with the standards of the Internet creates a new way to develop applications. Figure 9-5 shows NYU's Stern School's Intranet; one of the applications is room scheduling. For some reason, a person always had to phone two places to reserve a room, and frequently it was double-booked anyway! The Intranet application makes it simple to use a browser to enter a room reservation request; notification comes within 24 hours via e-mail.

Figure 9-6 is a screen from Travelocity, a travel reservations system based on the American Airlines SABRE system. American has written programs to connect a Web server with its transactions processing reservations system, which runs on IBM mainframe computers. The software that makes the connection possible is sometimes called **middleware.** The server presents this transaction information to browser programs that run on client PCs. Travelocity is available to millions of people who have a Web browser and are connected to the Internet. We discuss the architecture of this system further in Chapter 13.

This combination of a Web browser and Internet standards makes it possible to create new applications such as those found on an Intranet, and to extend existing transactions processing systems to millions of users. The standards for HTML and the Internet mean that developers do not have to worry about providing a user interface program or building a proprietary network. As company applications become accessible to browser programs, more information appears on the Intranet, and as the Web continues to expand, you may find that the browser program is your primary user interface.

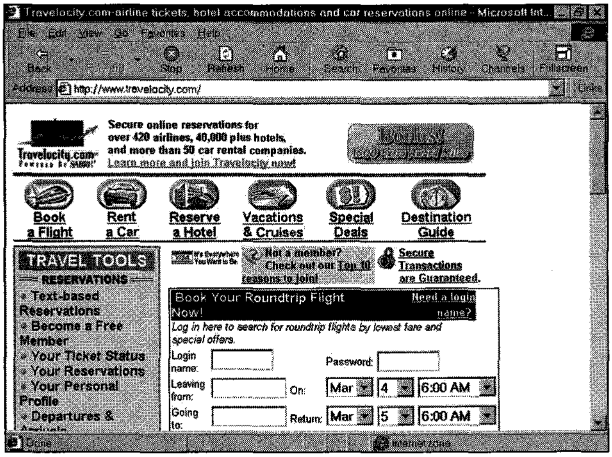


FIGURE 9-6
Travelocity web site.

The Operating System

In the first generation of computers, and for many second-generation installations, the operator of the system had a central role in controlling its use. The operator placed each new program, which had been punched on cards, in the card reader and loaded an assembler on tape. The assembler translated the object program and wrote it on tape; then a loading program loaded it and began execution. For production jobs to be run repeatedly, the object program would be saved on tape or on cards and loaded before execution. It would not be assembled each time it was used.

A skilled operator balanced jobs that needed many tape drives with jobs that needed few or no drives so that the large tape job could be set up while the other job computed. In the case of an inefficient operator, the computer might be idle for a large part of the day while tapes were loaded and unloaded. As this scenario indicates, operations were very inefficient. It became clear that the computer itself could be used to help make operations proceed more smoothly. The first operating systems came into widespread use during the late 1950s and early 1960s, with the earliest operating systems written by customers, not computer vendors.

It is important to note that operating systems are programs written by programmers. The functions in these programs are different from those in a typical applications program, for example, one that keeps track of inventory items. The operating system programs, as we shall see in this section, manage the resources of the computer. The operating system is concerned with providing your programs with the resources they need to run on the computer.

Early Systems

Batch Monitor The earliest operating systems were simple **batch monitors** (the terms **monitor, executive program,** and **operating system** are synonymous in this discussion) that read special control cards. These cards might include a job card containing information about the programmer and the job, for example, run-time estimate, lines to be printed, and cards to be punched. Control cards were provided to tell the operator to set up tapes or to prepare any special paper required for the printer.

The monitor, though simple, sequenced jobs so an entire stack or stream of jobs could be loaded at once. As disks became more common, compilers and work space were assigned to disks so that the operator did not have to mount the compiler, loader, and program object tapes. Operating systems and disk storage have drastically improved the efficiency of computer operations.

Multiprocessing During the second generation, at least one manufacturer offered a **multiprocessing** system—a computer system featuring more than one central processing unit. In reality, this system consisted of two complete computers. The smaller computer had an operating system and controlled both machines. The larger computer was a "slave" to the smaller machine. The small computer processed all input, and scheduled and printed all output, using disks as a temporary storage area. An operating system in the large computer indicated to the control machine that it needed service—for example, when it needed a new program to process—and the control computer answered its request. This approach freed the more powerful slave computer from I/O (input/output) and allowed it to concentrate on computations.

On-line Systems During the 1960s, the need became evident for on-line computer access for applications such as inventory control and reservations. The first **on-line systems** featured custom-designed operating system programs to control the computer resources. Applications programs in an on-line system express the logic of the application and are called by systems programs.

The **supervisor** in an on-line system establishes a series of **queues** and schedules service for them. First, the system assembles an incoming message in a communications buffer. This message may have to be converted into a different code and moved to an input queue in memory by an applications program. The operating system notes the addition of this message to the messages-to-be-processed queue.

When the central processing unit is available, the supervisor assigns it to process a queue, say, the one with our input message. An applications program called by the operating system might verify the correctness of the message (correct format and the like), after which the message is placed in a working queue.

The supervisor calls an applications program to interpret the message, during which time the message may be moved along several different working queues. The supervisor calls different applications programs to process the message further and determine a response. Finally, a program assembles an output message in another queue for transmission to the terminal. The supervisor schedules the CPU to send the output message. This example is considered a **multithreaded** operation. There are a number of tasks associated with each message, and the operating system assigns a CPU to each task as it is ready for service.

MANAGEMENT PROBLEM 9-2

Michael Lo is vice president of manufacturing for Lorimar Industries, a company that manufacturers several lines of electronics circuit boards. He has been working with Wendy Pfeffer from Information Services to develop a plan for the next generation of production management system. They have read a great deal about SAP's R/3, an integrated suite of "enterprise" programs designed to handle processing for all aspects of the firm's business, from manufacturing to financials. Another contender is Oracle, which offers a number of applications for the enterprise. Of course, Lorimar can always develop new software itself with its internal staff.

Lo is concerned about the implementation requirements for SAP; most firms have to use extensive outside consulting help to install the program. He also feels installing SAP would require redesigning of existing procedures. "I think Oracle may be more flexible, but it will require more programming on our part and more customization," Lo suggested. However, Pfeffer is not encouraging the company to develop its own software. "These packages work now; if we develop one from scratch, it will take a long time. I think it makes some sense to change our procedures in order to have a system sooner rather than later," she said.

What advice can you offer Lorimar in making its decision about its next generation software?

The demands on such an on-line system are extensive. A great deal of bookkeeping is required to enforce and monitor queue disciplines. I/O operations also involve telecommunications activities. There must be adequate fallback and recovery facilities to prevent and handle system failures. For example, messages may be in process in one of a number of queues when the system fails. Recovery programs must try to restore processing and prevent data files from being corrupted.

The Birth of Time-Sharing As computer systems became more heavily loaded during the 1950s and early 1960s, the debugging of programs became a frustrating and time-consuming process. A programmer might be allowed only one test run a day or one run every several days. Programmers found their schedules and lives controlled by machine availability.

There is a clear mismatch between the speed with which humans think (and mechanically enter input or review output) and the internal speeds of computers. Could we make computer users feel as though they have exclusive use of their own machine by rapidly switching the computer from one user to another? One programmer's "think time" would be used by the computer for serving other programmers. Each user would share the time of the computer, especially the CPU and memory. This special case of an on-line system provides the user with computational capability and the ability to write and execute programs.

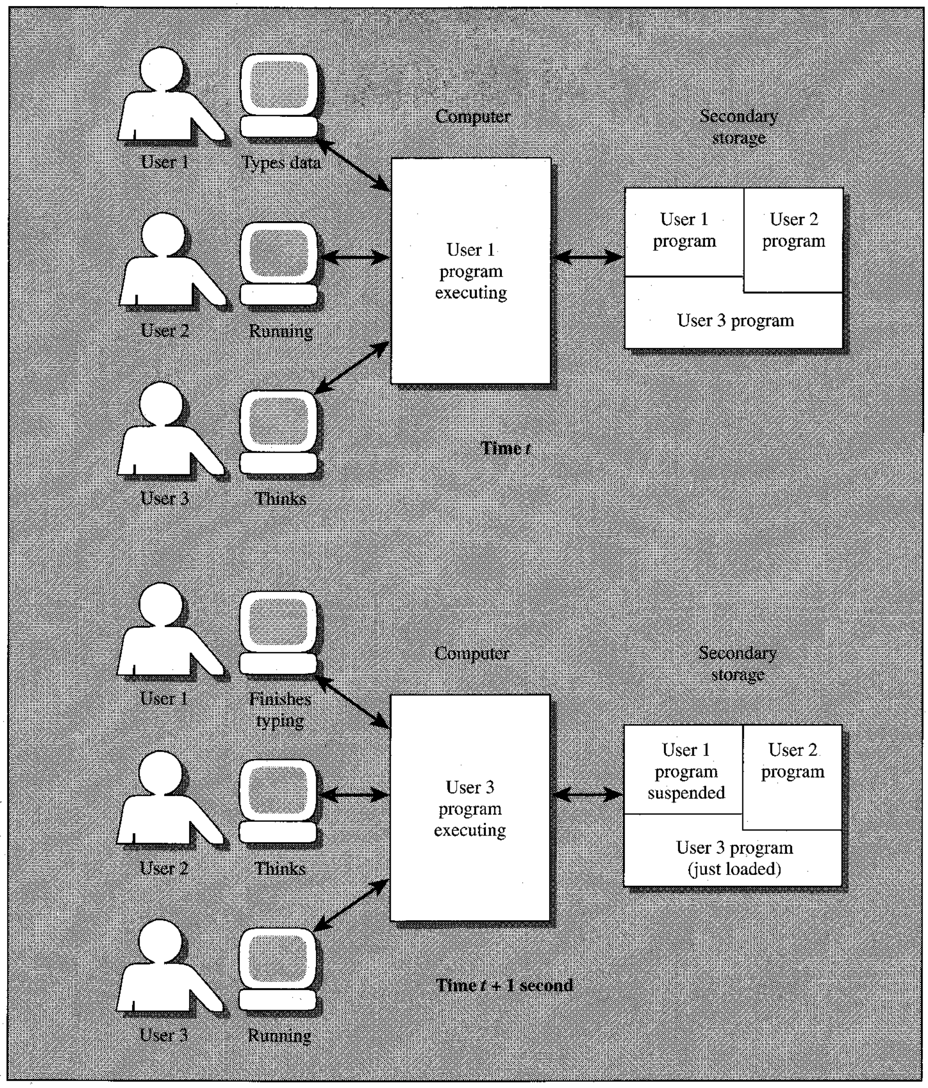


FIGURE 9-7
Early time-sharing processing.

The operation of early time-sharing systems is illustrated in Figure 9-7. In this representation, only one program is executing at a time because there is only one CPU. A program executes for a short time until it is interrupted and "swapped" out of memory onto a secondary-storage device.

Another user's program is swapped into primary memory, and execution begins where it stopped when the program was previously swapped out of primary memory. In a simple round robin scheme, each user is given a maximum time slice in sequence. A program may be swapped out of primary memory even though it has used less than its time slice if it needs to send output or receive input, since these activities are handled by a data channel.

The Next Steps

By the early 1960s, most university and job-shop computer centers used batch monitors, and the commercial time-sharing industry was becoming established. Many business users also used operating systems for their equipment. When the next generation of computers was announced in 1964, manufacturers had clearly embraced the idea of an operating system. The IBM 360 line could not function without the operating system. An operating system manages the resources of the computer; for example, it handles all input-output through **interrupts.** In fact, there are special instructions that can be performed by the computer only when it is in "supervisory state" under the control of the operating system. These privileged instructions are unavailable to programmers, whose jobs run in "problem state." The operating systems also require a certain amount of memory for permanent resident routines. Other parts of the operating systems are stored on disk and brought into memory as needed.

Multiprogramming In our discussion of hardware, we mentioned the development of data channels to take some of the I/O burden from the central processing unit. There was still an imbalance between CPU and I/O, however, even with channels. The batch operating systems used in 1964 utilized multiprogramming, a process very similar to the program-swapping techniques developed for time-sharing. In **multiprogramming,** we have more than one program in a semiactive state in memory at one time. Multiprogramming switches the CPU to another program when it can no longer process the one it is working on because the program must wait for something, for example, the printer. The operating system saves the status of the "stalled" program and looks for another program to work on. The data channel interrupts the CPU to notify it that the printing has been completed, so the stalled program is ready to run again. The operating system decides whether to continue its current program or to return to the stalled one based on priorities assigned by the user.

The presence of one or more programs in a semiactive state in memory with the CPU assigned to one after another is a key feature of many modern operating systems. Multiprogramming works because the operating system manages the programs that are running on the computer at one time. Multiprogramming time-sharing and an on-line system do the same thing. In fact, if you use Windows 98 on your PC, you launch multiple programs into memory at one time. When you cycle among these applications, you are assigning the CPU to a different program or application. This technique makes better use of the CPU and other resources of the computer.

Time-Sharing Time-sharing users often run out of memory. Programmers would like to have limitless memory, or a **virtual memory** several times larger than physical memory. In virtual memory, as shown in Figure 9-8, a program and

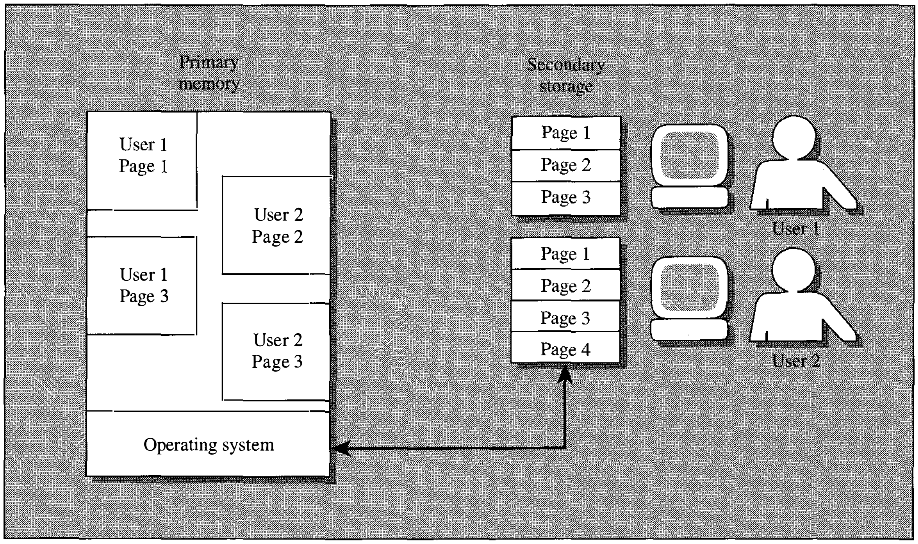


FIGURE 9-8
Paging.

its data are broken into pages. Only those pages needed in primary memory at any one time are loaded. Other pages are kept on secondary-storage devices. In a demand **paging** scheme, a program executes in memory until it needs a page that is not in primary memory. A request for the page generates a page fault, and the supervisor locates and loads the needed page from secondary storage. In loading the page, the supervisor may replace an inactive page belonging to another program in primary memory. This entire process is transparent to the programmer, who sees a virtual memory as large as the total number of pages allowed, not the physical size of the computer's primary memory.

Evolutionary Advances

The 1970s brought improvements and modifications to operating systems. The major advance took virtual memory out of the exclusive domain of time-sharing and included it in batch systems. Many packages are available to help reduce the problems of developing on-line systems. There are packages to handle inquiries and telecommunications tasks. These packages can be combined with database management systems, which are discussed in Chapter 11. For mainframes, the dominant operating system has been IBM's MVS (multiple virtual systems), replaced by a new version called OS/390. This newest mainframe operating system is designed to turn the mainframe into a large server and to promote its role in client-server architectures. Midrange computers are likely to feature Unix or Windows NT, described in the next section.

One useful view of an operating system is as a resource manager. The operating system consists of a series of managers, and each manager must accomplish the following: monitor resources, enforce policies on resource allocation (who, what, and how much), allocate the resource, and reclaim the resource. There are four major resource categories:

1. The **memory manager** keeps track of what parts of memory are in use and by whom and what parts are available. In multiprogramming, this manager decides which process obtains what amount of memory at what point in time.
2. The **process manager** keeps track of the status of processes. It includes a job schedule that chooses among jobs submitted and decides which one will be processed. (It assigns resources as does a CPU.)
3. The **device manager** monitors input-output resources—anything connected to the computer through a data channel or bus. It tries to schedule and allocate these resources efficiently.
4. The **information manager** controls the file system and its directories. Information must be protected, and this manager allocates and reclaims resources, for example, by opening and closing files.

Operating Systems for Personal Computers

Our discussion has traced the development of operating systems, and the examples were drawn primarily from large systems. Personal computers also have operating systems, though originally they had fewer features than their mainframe counterparts. The functions of PC operating systems are similar to those of any operating system: to manage the computer's resources.

The highest level in the operating system is the command level, seen by users of the system. The lowest level is BIOS (basic input-output system), part of which is actually in read-only memory. All input and output uses the BIOS routines, so there is no need for each application to write codes to control the lowest level of input and output to the diskettes, printer, or display. The operating system provides a number of commands for the user through its graphical user interface.

Chips with 32-bit processors and 32-bit memory buses are designed with hardware support for virtual memory. Chips like the Intel Pentium family require an advanced operating system to take advantage of their power. Many of the features of modern mainframe operating systems are found in supervisory programs for the powerful chips of today, including virtual memory and the ability for the user to have several different active programs in memory simultaneously.

There are three major operating systems competing for users of certain minis, PCs, and workstations. Windows 98 offers the user a graphical user interface (GUI). Using a mouse, the user can "click" on a graphical icon on the screen to load a program such as a word processor or spreadsheet, then place this program in a "window" on the screen marked with a border. The user can simultaneously load other programs in other windows and switch among them using the mouse.

It should be pointed out that the windowing interface was first an integral part of the Apple Macintosh system. Newer versions of Windows have finally begun to give the PC some of the same ease-of-use features found in the original Macintosh. [To be completely fair, the whole idea of windows came from Xerox's Palo Alto Research Center (PARC), but Xerox never commercialized its invention.]

Of course, as an operating system offers more features, it requires more hardware to run it, both in terms of primary memory and the amount of disk space required to store operating system modules. To run Windows 98 you need at least 32 Mbytes of main memory.

The next major contender in the operating systems contest is **Unix.** This system offers multitasking, a graphical interface (if you add one to it), and high portability. There are versions of Unix that operate on mainframes, minis, and PCs. Unix is written in C, which was originally developed for the purpose of writing an operating system. Most of the major vendors of engineering workstations, including Hewlett-Packard and Sun Microsystems, base their systems on Unix. It is also probably the most frequently used time-sharing system on minicomputers. Even IBM, which for years would support only its own proprietary operating systems, now offers a version of Unix called AIX.

Unix is available from several different vendors; each version is different enough that a program written in one version may have to be modified to run on another vendor's version. At first, AT&T was the dominant force in defining Unix since Bell Labs developed it. However, AT&T spun off Unix and formed a company called Unix Systems Laboratories. Novell bought this company for $320 million in 1993. But in 1995, in order to concentrate on its core networking business, new management at Novell sold Unix to Santa Cruise Operation, Inc. (SCO), a major Unix vendor. In addition to SCO, vendors selling Unix include Sun, Hewlett-Packard, and IBM. Sun recently released a new version of its Solaris (Unix) operating system, which has 12 to 13 million lines of code compared to NT's 35 million lines. It is possible that the presence of so many versions along with the threat posed by Windows NT, discussed below, will force these vendors to come together for a common Unix.

Windows NT is an operating system from Microsoft intended for servers and "power users." Windows NT also illustrates the migration of features from larger computers to smaller ones. For example, Windows NT supports symmetric multiprocessing, something that in the past was associated only with mainframe operating systems. Windows NT takes advantage of multiple, identical processors. Remember that processes can be broken down into different threads (see the earlier discussion of on-line processing). Windows NT assigns these threads, based on their priority, to the available processors in a multiprocessor system. Manufacturers of various RISC-based technology, such as DEC, are adapting Windows NT for their machines. Companies spend over $50 billion a year on multiuser software, twice what is spent on PC programs. Much of Microsoft's future depends on being able to capture the server market, and NT is the operating system that is crucial to implementing this strategy. Windows 98 will merge with Windows NT at some time in the future so Microsoft will only have to support one operating system.

Linux: A Free Unix? A graduate student in Norway developed an operating system much like Unix. He posted the code on the Internet and invited different people to expand and extend the system. The result is Linux, which is available for free or for a modest charge. The system is very modular and a person can install just what is needed. Linux has been used to turn old PCs (486s) into Web servers. Several computer vendors are supporting versions of Linux for their computers. Some view it as a way to challenge Microsoft's operating systems while providing an inexpensive alternative to the "Wintel" combination of hardware and software.

One thing is clear: Users want to have systems that are as portable as possible. **Portability** means that an operating system will run across a number of different computers. We are rapidly approaching the point, at least for minis and workstations, where hardware is like any other commodity. The user will not care, and very likely will not know, what hardware is executing his or her programs. The one thing the user will see is the operating system and program interface. These interfaces need to be as common as possible across all types of hardware.

Who will win? It is very hard to predict what will happen in the operating systems wars. Windows 98 sales have been strong. (Windows 3.1 ran on an estimated 100 million computers when Windows 95 was introduced in August of 1995.) Unix has a solid base of support and is unlikely to disappear. A key question is whether its use will continue to expand. Many experts think that Windows NT will emerge as the winner since Microsoft is such a powerful software vendor. It clearly would like to see Windows NT become the dominant operating system on servers, midrange computers, and desktops.

CHAPTER SUMMARY

1. Software is the key to the utilization of computers. As hardware becomes less expensive and more powerful, we shall continue to see the need to develop software programs for new computer applications.
2. Programming can be a time-consuming and tedious task. However, in the span of four decades, software development has advanced tremendously and computer languages are becoming easier to use.
3. In a short period of time we moved from machine language to graphical user interfaces and extremely powerful packages for PCs. Each stage depends on the ones that preceded it.
4. *A key task of management is to determine what development approach and language are appropriate in a given situation.* For most organizations today, the first choice is to buy a package program rather than develop a custom system.
5. Because there is so much software in existence, we should expect to find widely varying standards of quality and functionality. You may encounter a mainframe system that was written 10 years ago and changed through minor enhancements. It is unfair to compare this system with the newest software for Windows 98!
6. No organization can afford to redo all of its software at one time. There may be very good business reasons for continuing to use a 10-year-old system, even though its interface and even its functions are outdated. As a manager, you will have to decide how to allocate scarce resources among maintenance, enhancements, and entirely new systems.

7. Operating systems are extremely important components of a computer. Large mainframes from IBM use OS/390 and run many legacy COBOL applications. Midrange computers tend to run Unix, and Windows 98 (or its predecessor) is dominant for PCs. Windows NT is positioned as an operating system for servers, though a number of companies are using Windows NT on clients as well.
8. There is still much to be done to remove the software bottleneck that exists in developing applications. In later chapters we discuss some strategies to reduce the cycle time for developing applications.

IMPLICATIONS FOR MANAGEMENT

Hardware, at least at the level of the PC, is a commodity item. You should be more concerned with the kind of software you can run than the brand of PC you are using to run it. To get something done on a computer, you have to use software. Either you create the application, or you buy it in the form of a software package. For much of what you want to do, it is too costly to use a professional designer or programmer, so you will work with PC software like a spreadsheet and database management system to solve your problems. Since the beginning of the industry, the trend in software has been to make it more accessible and easier to use. Graphical user interfaces have helped a great deal so that a manager can do a lot by "pointing and clicking." One of the hard decisions you will face is whether to use some kind of software yourself to solve a problem or to turn the problem over to IS professionals.

KEY WORDS

Assembly language
Batch monitor
Bytecode
C language
COBOL
Compiler
Device manager
Executive program
FOCUS
FORTRAN
Fourth-generation language (4GL)
Higher-level language
Information manager
Interpreter
Interrupt
Java
Linux
Machine language

Memory manager
Middleware
Mnemonic
Monitor
Multiprocessing
Multiprogramming
Multithreaded
Object-oriented
Object program
On-line system
Operating system
Packages
Paging
Portability
Process manager
Programming environment
Programs
Queues
Scripting languages
Special-purpose language
Supervisor
Unix
Virtual memory
Windows 98
Windows NT

RECOMMENDED READING

Appleby, D.; and J. Vandekopple. *Programming Languages: Paradigm and Practice,* 2nd ed. New York: McGraw-Hill, 1997. (A good book for understanding concepts, theories, and applications for high-level programming languages.)

Fichman, R.; and C. Kemerer. "Adoption of Software Engineering Process Innovations: The Case of Object Orientation." *Sloan Management Review,* 32, no. 2 (Winter 1993), pp. 7–22. (A good introduction to object-oriented programming and some thoughts on how likely it is to succeed in becoming the dominant programming methodology.)

Ghezzi, C.; and M. Jazayeri. *Programming Language Concepts.* New York: John Wiley & Sons, 1997. (A comprehensive reference for all kinds of programming languages.)

Gookin, D. *C for Dummies* (2 volume set). Foster City, CA: IDG Books Worldwide, 1997. (An excellent tutorial for beginners explaining basics of programming techniques from the ground up.)

Silberschatz, A.; and P. Galvin. *Operating System Concepts.* 5th ed. Reading, MA: Addison-Wesley, 1997. (This popular book offers both a theoretical and a practical foundation for understanding operating systems with numerous examples.)

Tanenbaum, A.; and A. Woodhull. *Operating Systems: Design and Implementation,* 2nd ed. Englewood Cliffs, NJ: Prentice Hall, 1996. (A fine introduction to basic concepts and working principles of operating systems.)

DISCUSSION QUESTIONS

1. What motivated the development of assembly language? What trend did this inaugurate?
2. For what purpose is assembly language used today?
3. Why is programming such a time-consuming task?
4. Under what circumstances, if any, should managers write programs?
5. What are the advantages of standardized subsets of languages such as FORTRAN and COBOL, that is, a set of statements that are compatible across all compilers?
6. Develop a checklist of the factors to consider in evaluating a packaged program.
7. What is the major appeal of packaged programs for user departments? What is the major disadvantage of these packages for the information services department?
8. How does Java differ from more conventional languages?
9. What are the advantages to breaking up programs into small pieces or modules?
10. Why does a manager care what operating systems are used on computers in the organization? Why should he or she prefer one system to another?
11. What was the motivation behind the development of operating systems?
12. How have time-sharing techniques influenced the development of operating systems?
13. Why are standards like HTML so important for a browser?
14. How does virtual memory contribute to the development of programs?
15. When can problems occur with virtual memory? Under what conditions should we expect performance of a virtual memory system to be best? Worst?
16. What is the advantage of a simple programming language such as Visual Basic?
17. What factors influence the choice of a programming language for an application? Why should an organization have standards for languages?
18. Why do some programmers prefer to write a program from scratch rather than modify a program written by someone else?
19. How should programs be tested? What types of data should be used and who should generate the data?
20. What kind of applications will make use of languages like PowerBuilder?
21. Why do users want "open systems"?
22. How is program testing complicated by a client-server environment?
23. How might a browser like Netscape or Internet Explorer become the standard "desktop" for a client computer?
24. What are the major advantages of special-purpose languages? How do they extend computer use to more individuals?
25. Can an entire application be developed with a fourth-generation language?
26. What hardware and software characteristics are responsible for the overall performance of a computer system?
27. How can the quality of software be evaluated? What standards or measures can you suggest?
28. Software program goals include minimizing the number of statements, the use of main memory, the number of runs to debug, and execution time, as well as maximizing output clarity and program clarity. Which of these goals are incompatible? Which ones should be emphasized by management?
29. Why is it so difficult to replace COBOL applications?
30. Does the extensive use of packages make it more difficult or less difficult to change computer manufacturers? On what factors does the answer to this question depend?
31. What problems do you anticipate in connecting an Internet server to an existing transactions processing system like SABRE?

32. What advantages does multitasking offer in a PC server?
33. What kind of software does a server for a local area network need to have?
34. What are the differences between a mainframe operating system and a personal computer operating system?

CHAPTER 9 PROJECT

Simon Marshall Associates

Simon Marshall is running Windows 98 on the PCs in its office. John Marshall has read articles about "operating system wars" and wonders if his firm is keeping up with what is happening. "Windows NT, Unix—they're all a bit confusing to me. We've begun to develop some Windows skills—now at least we can paste spreadsheet graphs into our written reports. I also want to get into groupware, as we do a lot of projects together. I know that I will need a network, but I wonder if I should go to a new operating system before thinking about a network. It's all so confusing."

What advice can you give John about groupware, networks, and a possible switch to a new operating system?

CHAPTER 10

Database Management

Outline

Focus on Change

By giving a supplier access to your production and inventory database, you may be able to eliminate your raw materials inventory and have the supplier manage it. The supplier becomes part of your corporation, changing the way both of you do business. As you read this chapter, think about the kinds of databases necessary to create new relationships with customers and suppliers. By saving your experiences in resolving customer problems in a database, you can provide better customer service because your representatives can search the database to help customers who report new problems. This database now contains "knowledge," that is, information and intelligence about typical customer problems with your products. Systems that change the relationship between you and your customers often rely on database technology.

•

A typical organization has a large number of files, many of which may be stored on a computer device. We call these data machine readable because you can use a computer to process them. Paper files, on the other hand, are much less accessible. Companies frequently refer to related files as a part of a database. This term may be used generically, or it may refer to a specific system or database management software. Examples of database systems for personal computers include Paradox and Access. Databases for midrange systems include Oracle and Sybase, and IBM's mainframe database is called DB2.

FILE ELEMENTS

Computers store data in a **file,** which can be defined simply as a collection of data. A computer file is organized in a particular way with a well-defined structure for the information in the file. A computer file consists of a collection of **records,** each of which is made up of **fields.** The various fields consist of groups of characters, as described below.

Data

The smallest unit of storage is the byte, which consists of 8 bits. This byte can represent numbers, characters, or parts of an image. The unit of interest in processing business data is the **character,** for example, the number 9 or the letter A. (We generally do not work directly with characters but rather with groups of characters that have some intrinsic meaning, such as Smith or 599. These groupings of characters are called fields, and we identify them with a name. Smith is an employee's surname and 599 is Smith's department number.)

Groups of fields are combined to form a logical record, such as the one shown in Figure 10-1. This logical record contains all the data of interest about some entity. In this example, it has all the data in the file about an individual employee.

A **key** to a record is a specific field of interest that will be used as a basis for storing and retrieving data. Many files are organized on a key: The last name is the primary key for a telephone book; that is, the telephone book is arranged in

Example:	Smith, D. J.	599	031875	250	C	G	
Field	Name	Department	Birth date	Salary	Occupation code	Last job code	

FIGURE 10-1
A logical fixed-length record.

alphabetical order based on telephone subscribers' last names. A secondary key, in the case of the telephone book, is the person's first name or initial. The telephone book, then, is arranged in sequence on the primary key (last name), and within the primary key it is arranged in order by the secondary key (first name). Fields designated as keys are also used as a basis for retrieving information from a file. For example, an inventory part number may be the key for retrieving information from an inventory file about the quantity of the part on hand.

Direct-Access Files

There are two major types of files: sequential and direct access. Sequential files were the first type of secondary storage. All records are kept in some sequence such as numerical order by Social Security numbers. Most of us will encounter sequential access files only in special circumstances. Records in this type of file are located one after another according to a given sequence. For example, the record with payroll number 1 is followed by the record with number 2, etc. With a sequential file, you cannot find a specific record, such as the person with payroll number 127, unless you read the entire file until you locate a record with payroll number 127. On the average, if there are n records in the file, you will read $n/2$ records to find the one you are seeking.

A direct-access file uses a physical medium and programming, which facilitate the storage and retrieval of specific records. These files are at the heart of database management systems and most of today's file storage technology. The reservations data in an airline's reservations system are stored on direct-access files.

Storage Media

The most common device for storing direct-access files is the magnetic disk (see Figure 10-2). One type of disk consists of a series of platters mounted on a spindle. The top and bottom of each platter (except for the very top and bottom ones) are coated with a magnetic material like that on a music cassette tape. Read and write heads are fitted between the platters. They float on a cushion of air created by the rotation of the disk and do not actually touch the surface of the platter. By moving the heads in and out, we can access any spot on the rotating disk. Holding the head in one place traces a track on the disk as the platter rotates under the read-write head. The maximum

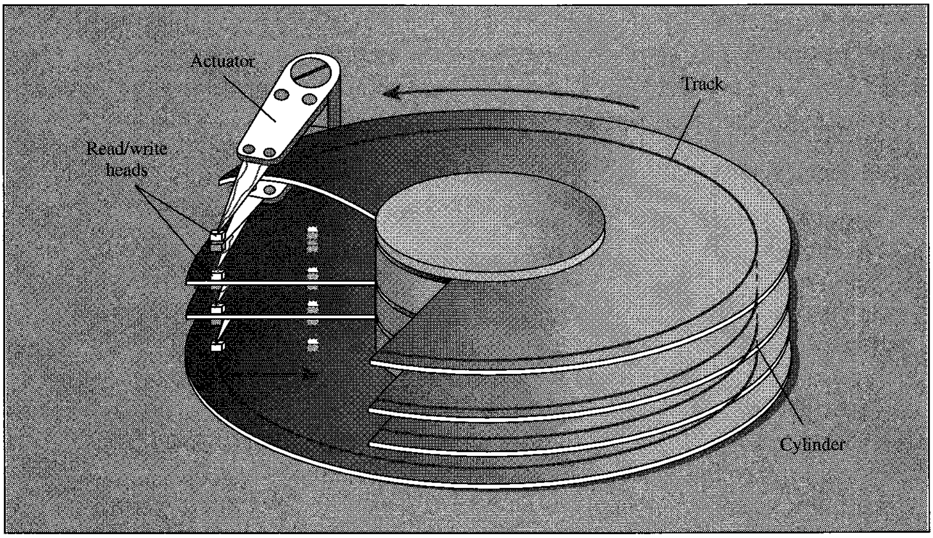


FIGURE 10-2
Magnetic disk.

block size or physical record size for a disk file is limited by the physical capacity of each track. Looking down from the top of the disk, the tracks on each surface form a cylinder. When using a disk file sequentially, we write on a given track of the first platter, then on the same track of the second platter, and so on. This strategy minimizes the access time because the heads make the minimum possible movement.

The total access time to read or write is made up of two components: seek time and rotational-delay time. Seek time is the time needed to move the read-write heads from one position to another. Rotational delay occurs because the data we want may not be directly under the read-write heads, even though they are located over the correct track. We have to wait for the disk to revolve to the beginning of the desired data. The total time for seek and rotational delay adds to the average access time for the disk, usually 10–20 milliseconds.

Seagate advertises one of the fastest PC disk drives available. The disk rotates at 10,000 revolutions per minute, which gives an average latency of less than 3 milliseconds. The disk is available with a storage capacity of 4.5 or 9.1 Gbytes, and transfers data at rates up to 16.8 million bytes per second. The average seek time is 8 milliseconds, and the company claims a mean time between failure of 1 million hours. IBM is selling a disk drive using giant magnetoresistive heads, read-write heads the size of a pin. This 3.5-inch drive holds 16.8 billion bytes of data.

Each track on the disk has an **address.** Usually, manufacturer-supplied software lets us specify a file and record size, and then retrieve a specific record. The records are numbered 1 through *n,* where *n* is the number of records in the file. Thus, we can treat a file as consisting of a group of separately numbered records without concern for the physical track address where the record is stored. The software associates the track address with a logical record and finds the desired record for us. The diskette drive for a personal computer is similar to that for a hard disk except that the diskette has only two sides. The read-write head actually touches the floppy disk when accessing the file.

Finding Data on the File

In a sequential file, finding the data you want is not too difficult, though it may be time-consuming. Each record is in a sequence, so you simply read the file until you get to the location of the record of interest. (This is the reason why sequential files are associated with batch processing and usually with magnetic tape. You update the file at one point in time and make all the changes, reading the file just once and creating a new version.)

The major advantage of the direct-access file is, as its name implies, that you can locate any record in the file in roughly the same short (milliseconds) period. For example, when you call an airline, they want to access the inventory of seats for the flight you want to take on the date you want to fly without having you or the agent wait on the phone.

If we request a record number, the file management software will supply it for us; then we must associate the logical record number with the information desired. For example, in an inventory application, how do we know where information on inventory part number 1432 is located? What logical record contains data on part 1432? One solution is to begin at the first record on the file and read each record until we find part 1432, but this is simply scanning the file sequentially. Another solution to our problem is to create an index like the index to a book. The computer looks up the logical address for part 1432 in the index and then retrieves that record from the disk.

Key	Index entry	Record address
1432	1432–312	312
4293	4293–137	137

We search the index in primary memory (which is several orders of magnitude faster than searching the disk itself) looking for the key. The index entry tells us at what record that key is located. See Figure 10-3.

More Complex Access

So far in the discussion of direct-access files, we have talked about how to locate a unique primary key such as an inventory part number. (This key is unique because there is only one part with a given number.) More complex structures are also possible with direct-access files. For example, we can ask questions about how many parts are needed for a particular assembly and obtain a response. Consider an inventory example in which it is desired to keep track of which parts belong in what assembly. This situation is depicted in Table 10-1(a). We wish to define a file structure to answer questions such as what parts in inventory are used to build assembly number 103. To find all parts used in assembly 103, it is possible to read each record and see if the assembly field is equal to 103. In Table 10-1(a) we read record 1, which is used in assembly 103. Then we read records 2 and 3 without

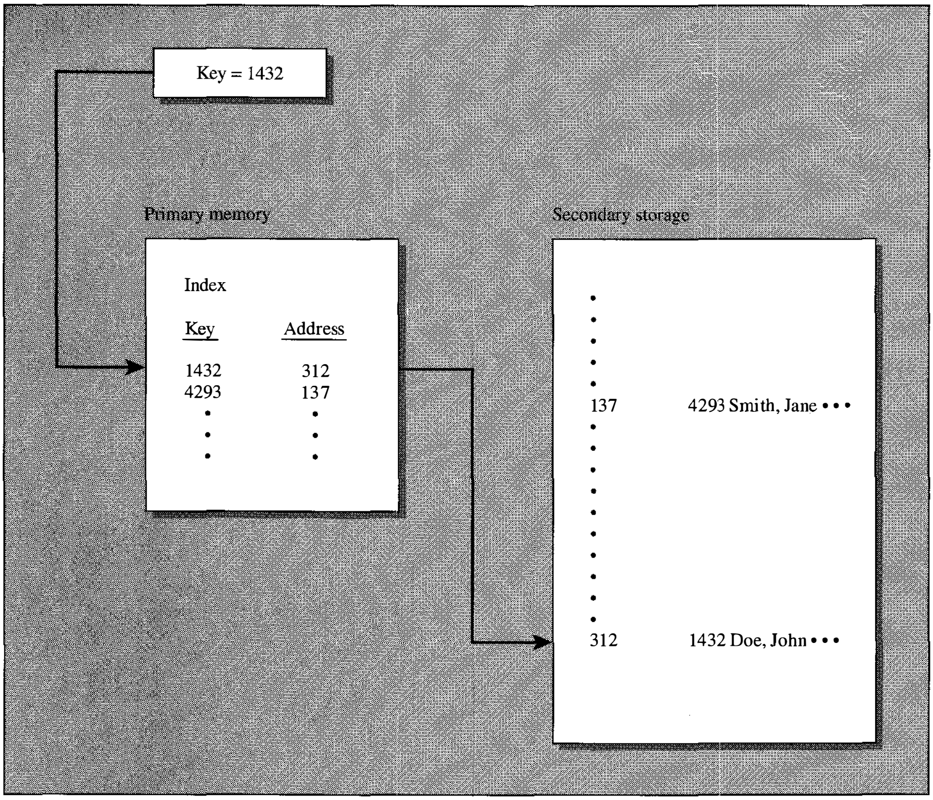


FIGURE 10-3
Index lookup.

TABLE 10-1(A)

FILE EXAMPLE

Record	Part no.	Assembly	On hand	Vendor
1	4326	103	27	ACME
2	6742	607	51	JOHNSON
3	8137	12	100	DAWES
4	3218	103	13	FRAZIER
5	3762	607	43	ARMOR

finding assembly 103. We find it again at record 4, and so on. Clearly, this process is not very efficient as there could be 100 records between each occurrence of assembly 103.

To avoid this excess read time, we use a **pointer**—a piece of data whose value points to another record. In this case it points to the next record where assembly 103 is found. The inclusion of pointers in the file is shown in Table 10-1(b). The pointer

TABLE 10-1(B)

FILE EXAMPLE

Record	Part no.	Assembly	On hand	Vendor	Pointer
1	4326	103	27	ACME	4
2	6742	607	51	JOHNSON	5
3	8137	12	100	DAWES	13
4	3218	103	13	FRAZIER	42
5	3762	607	43	ARMOR	106

TABLE 10-1(C)

INDEX TO ASSEMBLIES

Assembly	Record
12	3
25	212
103	1
104	62
607	2

in record 1 points to the next occurrence of assembly 103 in record 4. Now, when looking for assembly 103, we retrieve record 1 and examine the pointer field. It tells us that the next occurrence of assembly 103 is at record 4. We follow the chain of pointers through the file to answer the retrieval question of what parts belong in assembly 103. This type of file structure is known as a **linked list** or a **chained file.**

How do we find the record of the first part in assembly 103? We could read the file sequentially, but there might be 500 or 600 records before the first part in assembly 103 is located. This problem is easily solved using an index like the one in Table 10-1(c). This index simply points to the first part contained in assembly 103. First we retrieve this record and then we follow the chain of pointers in each record through the file.

While you will probably never work with a direct-access data file at this level of detail, the discussion of pointers running through a file is very important in Chapter 12, when we discuss hypertext, which is a way of linking text entries in files stored on different computers around the world. In this case, a highlighted word has a pointer to further information about that term, possibly stored on a computer thousands of miles away!

ENTER DATABASE MANAGEMENT SOFTWARE

Creating complex files using the techniques described above and many others is a tedious and error-prone process. In the 1960s, software vendors developed products called **database management systems (DBMSs).** These examples of systems software automate many of the tasks associated with using direct-access

Name	Address	Zip code	City	Department number
Smith	16 Main	92116	New York	302
Jones	37 Spencer	07901	Chicago	161
Morris	19 Old Way	83924	New York	302
Able	86 Fulton	10006	Denver	927
Charles	19 Hunter	11126	Chicago	161

Name	Profession	Income
Johnson	Bartender	15,000
Martin	Programmer	14,000
Jones	Systems Analyst	18,000
Carson	Manager	17,000
Smith	Systems Analyst	19,000

Join:	Name,	Address,	Zip code,	Profession,	Income
	Jones	37 Spencer,	07901,	Systems Analyst,	18,000

Project:	City,	Department
	New York	302
	Chicago	161
	Denver	927

FIGURE 10-4
A relational database.

files. As with other types of software originally developed for large computers, a large number of sophisticated DBMSs for personal computers exist today.

A DBMS has to provide:

- A method for defining the contents of the database.
- A way to describe relationships among data elements and records.
- A mechanism to set up the database in the first place.
- Ways to manipulate the data including:
    Updating (adding, modifying, and/or deleting information).
    Using complex criteria to retrieve selected data.

Benefits of the Relational Model

The *relational model* is the dominant structure for vendors writing DBMSs. The underlying concept of a **relational file** system is very simple: Data are organized in two-dimensional tables such as the one in Figure 10-4. Such tables are easy for a user to develop and understand. One virtue of this type of structure is that it can be described mathematically, a most difficult task for other types of data structures. The name of the model is derived from the fact that each table represents a **relation.**

Because different users see different sets of data and different relationships among them, it is necessary to extract subsets of the table columns for some users and to join tables together to form larger tables for others. The mathematics provides the basis for extracting some columns from the tables and for joining various columns.

Relational database management systems have many advantages. Most DBMSs for personal computers are based on the relational model because it is relatively easy for users to understand. This section presents an example of a relational database and shows how it would be processed by a personal computer DBMS. We also discuss some of the key issues in the design of relational databases.

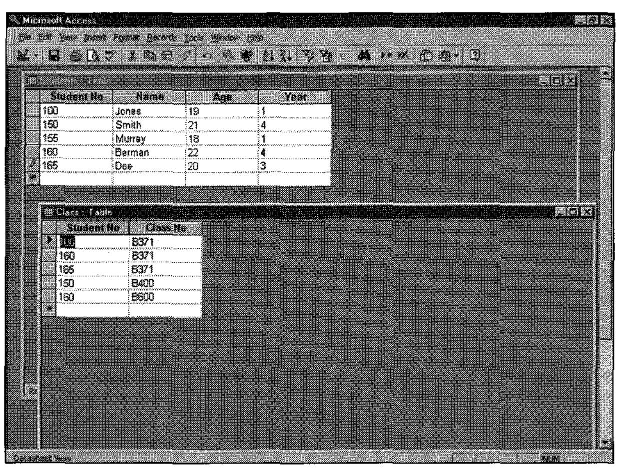
An Example

Figure 10-5 shows the results of creating two relations using a DBMS called Access, a part of Microsoft Office, and entering data in them. The first relation is Student; the key is student number, and the other fields are name, age, and year in school. The second relation is Class, and its key is also student number; the relation relates student number to class number.

Figure 10-6 shows how Access can be used to inquire about all students who are in year 1. The user fills out a table describing the inquiry and indicates each desired field for the answer, then indicates the criteria for selection. In this case, the criterion is that year = 1. The DBMS places the answer on an output screen.

One of the most frequently used relational operations is the **join,** in which two relations are joined on some key. Figure 10-7 shows how the DBMS would be

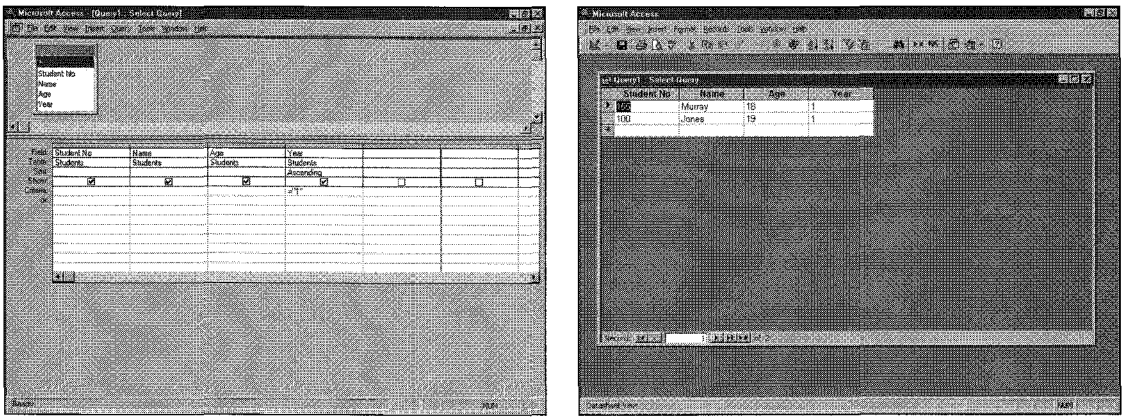
FIGURE 10-5
Setting up two relations.



used to join the Student and Class relations. Note the line the user drew between student number in each relation. That line tells Access the common field on which the two relations are to be joined.

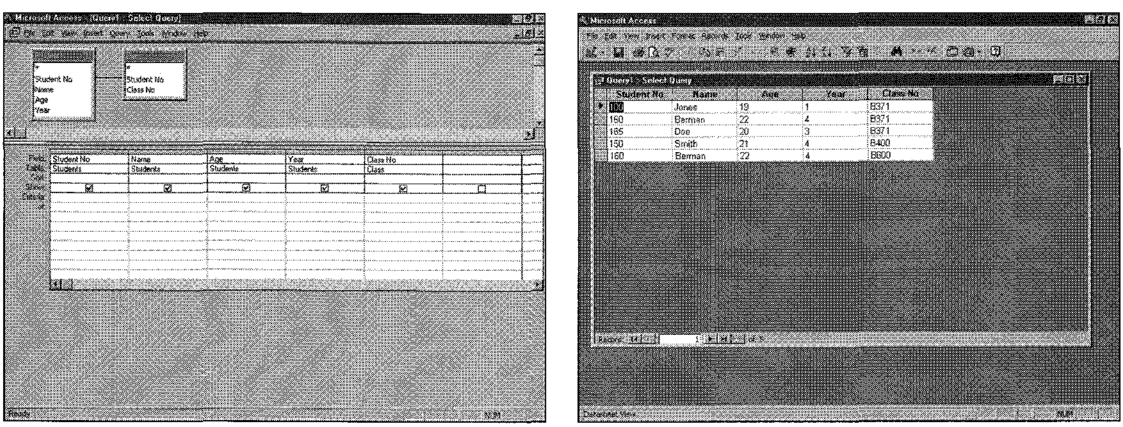
Figure 10-7(a) shows the query form, and the results of the join are shown in Figure 10-7(b). We now have a list of each student assigned to his or her classes. Note that Murray does not appear in the join because there was no record for Murray in the Class relation. Similarly, student 160 is listed as taking two classes, so Berman appears twice in the joined relation.

FIGURE 10-6
Inquiry about students in Year 1.



(a) (b)

FIGURE 10-7
Joining two relations. (a) Query form. (b) Results of the join.



(a) (b)

Normalization

One of the major tasks in designing a relational database is **normalization.** The process of normalization ensures that there will not be any problems in updating the database and that operations on the various relations will not lead to inconsistent and incorrect data.

Kent (1983) presents a set of guidelines to make normalization more intuitive and easier to understand than the mathematical rules for normalization. During the normalization process, the designer first looks to be sure that the relations are in first normal form (discussed below). Next, he or she checks for second normal form and finally for third. (There are also fourth and fifth normal forms, but we leave them for more advanced courses on databases.)

First normal form requires that all occurrences of a record type contain the same number of fields. As a result, a record cannot contain a repeating group. We could not have one relation that listed facts about a class and have a repeating set of fields for each student in the class. To represent such a problem using the relational data model, we would need more than one relation. The first would be a relation for the class and the second a relation for students.

Second and third normal forms require the examination of the relationship between key fields and other fields in the record. To conform to second and third normal forms, each field that is not a key must give us information about the entire key and nothing but the key. (Each higher number form assumes that the relations satisfy lower number forms. For example, second normal form assumes that the relation is in first normal form, and so on.)

Suppose that one has a relationship as follows:

Part Warehouse Quantity Address

If Part and Warehouse form a composite key, this relationship is not in second normal form. Note that the warehouse address would be repeated in each record that stores information about a part in the warehouse. If the address changes, every record of a part in that warehouse would have to be updated. The update would require a great deal of processing and could result in an error if one address were overlooked. What would happen if there were no parts in the warehouse? It is possible that the database would lose track of the warehouse because there would be no record having its address.

The relation can be made to conform to second normal form by splitting it into two relations:

1.) Part Warehouse Quantity 2.)Warehouse Address

Part Warehouse can be the combined key for the first relation, and Warehouse can be the key for the second. Now the warehouse address appears only once in the database and can easily be changed. We succeeded in normalizing the relation so that it is in second normal form.

Third normal form requires that a nonkey field not be a fact about another nonkey field. Kent offers the following example:

Employee Department Location

The key to this relation is Employee. If each department is located in only one place, the location field is a fact about the department in addition to being a fact about the employee. This design leads to the same problems as with the warehouse example: The location is repeated in each record of an employee assigned to that department. Because of this redundancy, the data might become inconsistent and a department with no employees might disappear from the database.

The solution here is similar to the one above: split the relation into two relations:

1.) Employee Department 2.) Department Location

where Employee is the key for the first relation and Department is the key for the second.

In general, normalization creates a database in which there is minimum redundancy of data, and risks of damaging the database through updating are minimized. Because the relational model is the dominant data model, it is important to understand the normalization process. There are many different relational database management systems available, each with its own set of commands. A single query language would be of great value, especially when one needs to retrieve data from different systems. Structured Query Language (SQL) has become such a standard.

IBM developed SQL a number of years ago. The language was first proposed as a retrieval language for users, but it is difficult to use; consequently, few users are likely to master it. It is important to note that SQL is the query language for IBM's mainframe relational database management package, DB2. There is an ANSI standard for SQL, and this language has been adopted by the major DBMS vendors as one way to interact with their systems. SQL also offers a mechanism for universal database access. For example, suppose the DBMS you are using translates the query language you enter into SQL commands. It could then retrieve data on a different system, so long as they both used the same SQL dialect.

The basic structure of an SQL expression has three parts:

1. The **select clause** lists the attributes desired in answer to the query.
2. The **from clause** is a list of relations or tables that the query language processor should consult in filling the request.
3. The **where clause** describes the attributes desired in the answer.

As an example, consider the following SQL expressions taken from Korth and Silberschatz (1986):

```
select branch-name
from deposit
```

This is an SQL expression to obtain a list of all branch names from a bank table (branch-name) containing data about branches and customers. One might find all customers having an account in the Midtown branch with the following expression:

```
select customer-name
from deposit
where branch-name="Midtown"
```

SQL expressions can become complicated as we qualify retrieval requests:

```
(select customer-name
 from deposit
 where branch-name="Midtown")
 intersect
 (select customer-name
 from borrow
 where branch-name="Midtown")
```

This query produces a table of all customers who have both a loan (from the borrow table) and an account in the Midtown branch.

There has been a proliferation of database management systems for all types of computers, with SQL appearing to be one common feature. Various vendors design their DBMS packages to translate queries using the package's interface into SQL commands to query a remote database. Why would a user be interested in such a feature?

Suppose you are working with Access, a PC database system, and want to access data located on an IBM mainframe in a DB2 database. You would like to enter Access queries and not have to learn about DB2. Using an SQL interface, Access could access the data you want on the mainframe. Of course, Access must translate your queries into SQL and forward them to the DB2 for processing. You would have to know the names of the fields and the relations in the DB2 database.

The use of SQL as an intermediary and a standard in accessing a large number of different types of database systems should be of great help to users and to systems analysts. Although you may never formulate a query in SQL, you are likely to find it processing queries developed in other languages.

Object-Oriented Databases

Relational database systems are extremely popular in business; they excel at representing typical business data such as orders, sales, financial results, and so on. However, there are applications that require a database to store very complex objects, such as computer-aided design systems. Think of all of the possible objects on a parts diagram for a subassembly of an automobile. It is hard to imagine how this information would be stored in a relational system. However, if the database is designed to store objects instead of relations, then a solution is easier to envision. Each object has an identity number that the database uses to store and retrieve it. Our discussion of systems design includes a description of object-oriented design. The characteristics of an object-orientation also apply to an **object-oriented database.** An object is a member of a class of similar objects, and it inherits the general characteristics of objects in its class.

In the computer-aided design example, it is likely that most storage and retrieval requests will be associated with a single object on a particular drawing. It is unlikely a designer would ask to see all bolts used in a design at one time. He or she is much more likely to ask to see a specific bolt as a component of an assembly. However, in a business application, a user might ask questions that require a system to process a number of rows in a relational table. An object-oriented database could be quite slow handling this kind of request. Thus, the designer has to consider carefully the nature of the application in selecting a database management system.

DATABASES IN SYSTEMS DESIGN

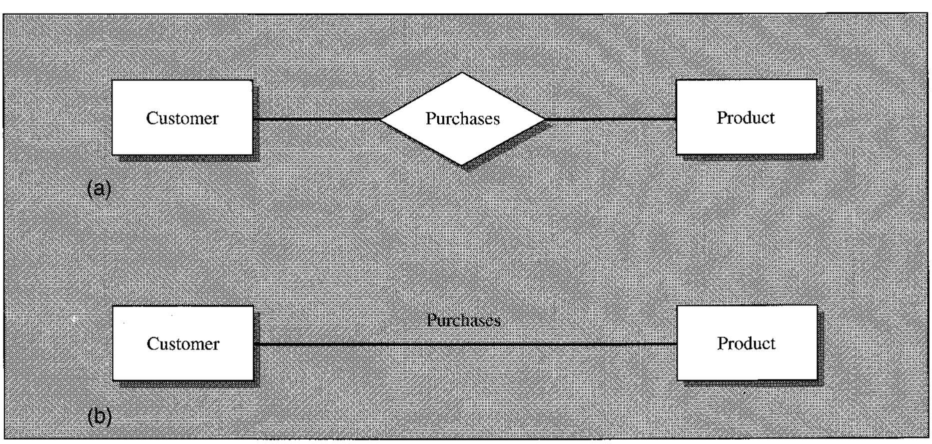
It should be apparent at this point that one of the major design tasks in building an information system is determining the contents and structure of a database. The type of retrieval and reporting required by users and the availability of input determine what data to store. However, it is a very complex task to specify these data, group them into records, and establish data structures for a system.

Data Modeling

A data model is useful for a number of reasons. First, it helps us understand the relationships among different components in a systems design. Data models show users more clearly how a system will function.

The most common type of data model is the **entity-relationship (ER) diagram.** The ER diagram is easy for a user to follow and serves as an excellent communications vehicle. The ER diagram consists of object types and relationships. In Figure 10-8(a) we see an example of two objects linked by a relationship: A customer purchases a product. The two entities here are "customer" and "product;" the relationship is "purchases." Entities are represented by rectangles and relationships by diamonds. Some analysts like to use a simple, straight line between entities and label the line with the relationship, as shown in Figure 10-8(b), though certain more complex relationships cannot be modeled in this manner.

FIGURE 10-8
(a) An entity relationship (ER) diagram. (b) An alternative ER diagram.



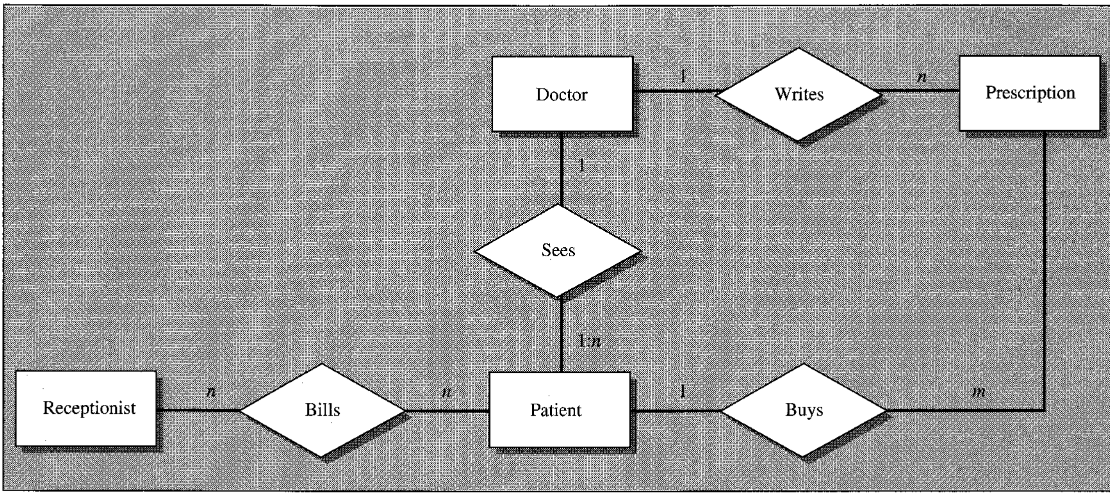


FIGURE 10-9
Doctor-patient ER diagram.

Entities also have attributes, which are the fields we would include in a file record. A product has a product number, size, description, price, cost, and so on. The ER diagram, then, can be used to show relationships, while the conventional listing of the file contents contains the attributes of entities.

Figure 10-9 shows another example of an ER diagram. Here the figure shows that a doctor sees a patient. The doctor writes a prescription, and the receptionist bills the patient. The numbers on the ER diagram describe the nature of the relationship. There is one doctor who writes from 1 to n prescriptions. In this practice, one doctor sees many (n) patients. The receptionist sends n bills to many (n) patients. Many patients buy one or more prescriptions. We can have 1:1, 1:n, n:1, and m:n (many-to-many) relationships among entities.

Another way to show the nature of relationships is to use arrows. A single arrow stands for a "one" relationship, and a double arrow represents a "many" relationship. For users, the added information provided by describing the nature of the relationship is probably not worth the added confusion; these data are primarily useful to the designers of the system.

Figure 10-10 is a data model for a student applying to college. A student completes an application, and the admissions staff make decisions about many applications. The staff notifies candidates by sending out a letter. The round circles in the E-R diagram are attributes of an entity. The application entity has three attributes: an identification number, the decision (accept, reject, postpone), and a date.

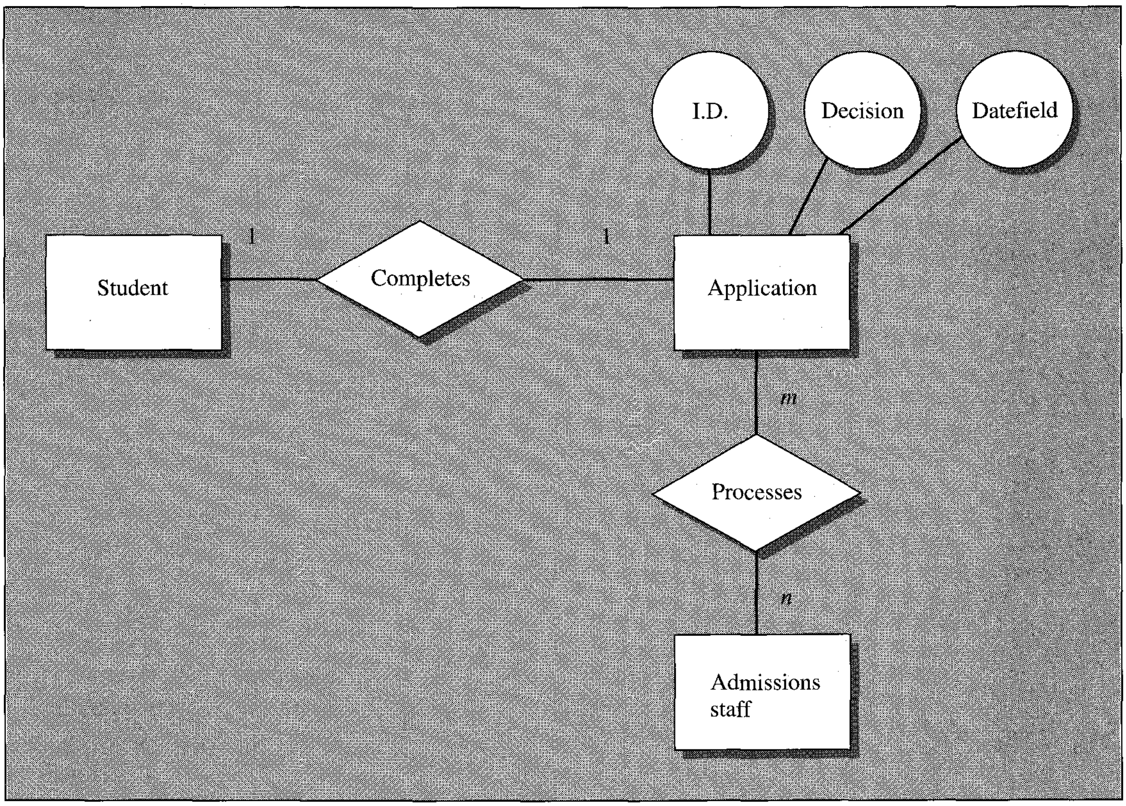


FIGURE 10-10
College application ER diagram.

In another example, Figure 10-11 shows the relationship of a student with his or her adviser. The adviser counsels many students, and these *n* students enroll in *m* different classes—an *n:m* relationship. Each student has a gender, year, and age, and there are many different majors from which the student can choose.

Figure 10-11 presents an entire simple database. However, there can be other views for different individuals. A professor might care only about a class list, not about a student's major or adviser. The department chairperson wants to know something about majors in the department.

Sometimes these differences are called **logical views** of the data. It is very likely that different users will have different logical views of data. A key task when designing the database is to integrate these many potential views and create a physical database capable of supporting different logical views with adequate performance.

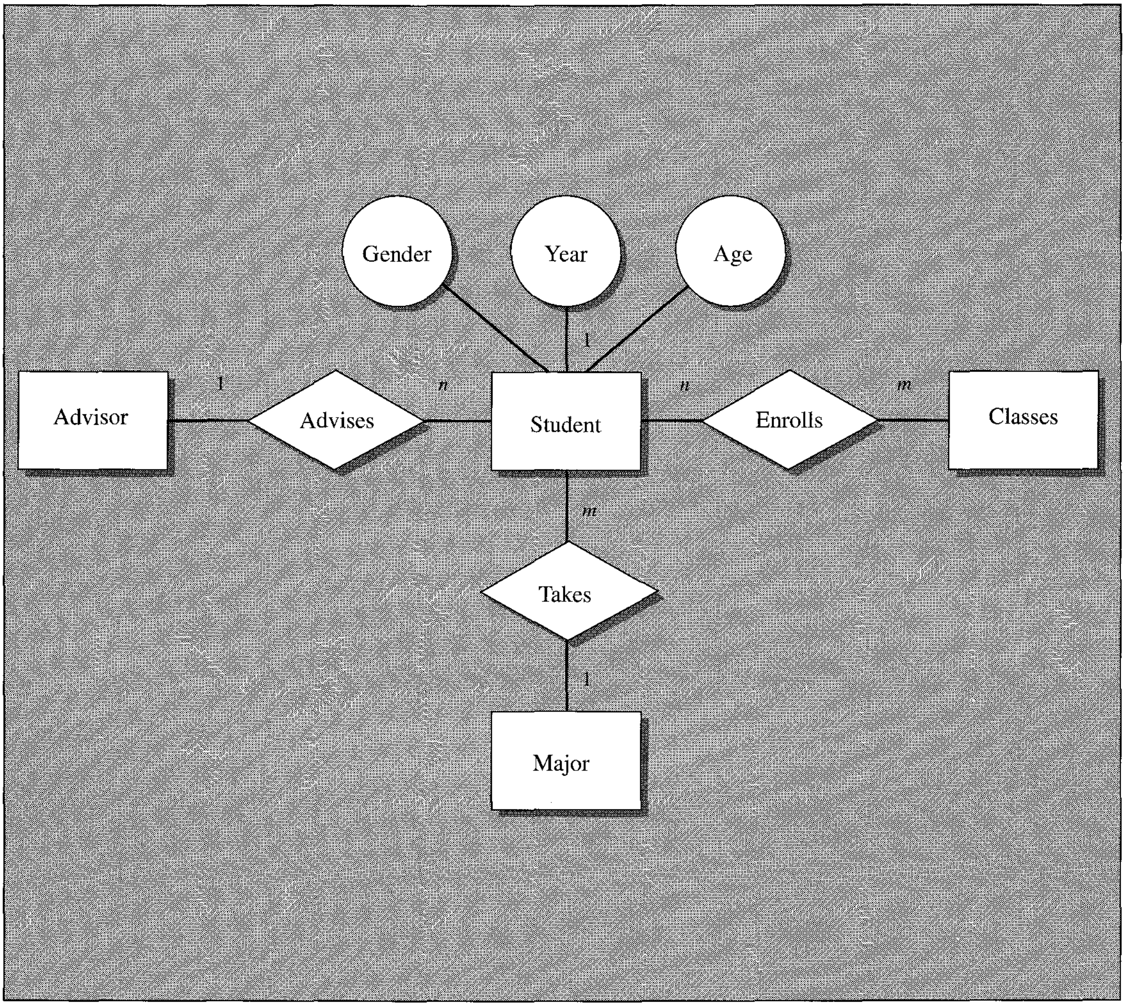


FIGURE 10-11
Student-adviser ER diagram.

The Role of the Database Administrator

Many organizations using database software have created a new position known as the **database administrator (DBA).** This individual is responsible for working with systems analysts and programmers to define the physical and logical views of the data to be manipulated by computers.

DBMSs in Building Systems

Database management systems are very popular packages for personal computers. These packages feature friendly interfaces that make it easy for users to define the

What Is 64 Bits Worth?

Oracle sells one of the most popular relational database management systems. The company has developed a 64-bit version of its system; that is, the software will take advantage of processor chips that fetch and perform operations on 64 bits at a time. This DBMS will run on the DEC's Alpha chip, one of the fastest chips currently available. The two companies claim that a 64-bit database on an Alpha gives serious competition to mainframe databases.

The 64-bit version allows much more of a database to be processed in main memory at high speeds. With 64-bit processing, it takes fewer operations to move data from secondary storage into main memory.

Of course, not everyone will sell their mainframes and rush to the new system. It is costly and time-consuming to convert applications. There are many applications on the typical mainframe, so all of them would have to be converted before one could eliminate it. Also, the cost savings are debatable. Forrester Research estimates that it costs three times more to support a 5000-user network of computers than it does to support an equal number of users on a mainframe.

Certainly at the level of the processor and DBMS, 64-bit technology has to be a threat to mainframe vendors over the long term.

structure of relations and enter data. Using the system, it is possible to update data, process transactions, make queries, and generate reports.

Most of the PC DBMS packages also have development tools or languages, and users have developed many applications using a DBMS. A programmer, for example, can use Access to create an order-entry system for a small firm. Using the development language, the programmer can set up a system so that users do not have to know anything at all about the database system. Instead, users see menus from which they choose options. The DBMS processes the menus and manages the application.

There are a number of database management packages for different types of computers from mainframes to PCs. Particularly for smaller systems, a modern DBMS can sometimes serve as the only systems-building tool needed to develop an application.

Oracle: An Enterprise DBMS

The Oracle Corporation is the leading vendor of databases at the enterprise or entire firm level, claiming to have a 50 percent market share for server database systems. Today the company positions its primary database system called Oracle *n*, where *n* is the most recent version, as a database for network computing for the enterprise.

Oracle's view of hardware and software architecture is what they call "server centric." They mean that most of the heavy processing takes place on the server, with the client having limited logic. One of the arguments in favor of this architecture is control and the ability to respond to change. If databases are distributed across a number of clients, it is easy for data to be in conflict and difficult to ensure that changes reach each machine. Keeping a database centrally on one or more servers reduces the problems of data management.

Oracle offers an extended relational data model and uses SQL for queries. The first relational database systems supported only alphabetic and numeric data types. Today there are many types of data including images, documents, audio, and video, to name a few. Rather than have a separate system for each, Oracle has extended its DBMS to support a variety of data types.

In Part IV on systems analysis and design, we will discuss object-oriented design. Briefly, "business objects" represent common entities found in the business such as an invoice, order, product, and so on. In object-oriented design, an object contains data about an entity and the procedures needed to modify those data. The relational model stores data in rows, not according to an object definition. Oracle has the ability to essentially map data from a relational database so that it looks as if one is working with an object that encapsulates its data.

Oracle's latest version of its DBMS will support tens of thousands of users, according to the company. It also can process huge amounts of data, tens of terabytes or more, to support the kind of highly detailed, disaggregated data that companies like to analyze. The company also provides support for using Java in combination with its DBMS to develop applications. In addition to offering its DBMS as a product, Oracle has used it to develop a number of applications packages consisting of 35 integrated software modules for tasks such as financial management, supply chain management, manufacturing, human resources, and sales force automation.

Distributed Databases

Organizations are building more distributed databases in which different parts of the database are located on different computers in a network. The movement toward client-server computing and the implementation of groupware will accentuate this trend. This type of database raises a number of issues for the organization, including the following:

- Will data be replicated across computers, or will there be only one copy?
- If data are replicated, how frequently must different versions be updated to reflect changes? (At times there will be different values for the same data if all copies of a file are not updated at once.)
- How will updates to the database be coordinated so that its integrity is maintained?
- Who "owns" distributed data, and who has access to it?
- Distributed databases offer users easier access to data at the cost of overall higher complexity of the system.

The Data Warehouse

Businesses collect a tremendous amount of transactions data as part of their routine operations. Marketing departments and others would like to analyze these data

Billions, Even Trillions of Bytes of Data

Bank of America regularly creates a database that consolidates 35 million records processed by separate computers handling checking, savings, and other routine transactions. The consolidated database has 800 billion characters of data. How does the bank use this information? Every day about 100,000 customers call the bank to check a balance, challenge a charge on a credit card, or ask about interest rates. The bank decided to try to sell them something when they call.

The way to accomplish this cross selling was to tailor the product to each customer's needs. For example, if you have been accidentally bouncing checks, maybe you would pay for overdraft protection. The consolidated database provides bank employees with incredible insights into customer behavior and preferences. Some companies call these applications "data warehouses" for obvious reasons.

Burlington Coat Factory depends on a 1.5 trillion byte database that runs on a cluster of eight superminicomputers from Sequent computer systems. Company managers use the warehouse to determine a variety of information, for example, what styles are selling best, how are different stores performing, where to open the next store and so on.

These data warehouses are good candidates for parallel computing—multiple processors working in parallel are powerful and cheap enough to perform analyses on billions of bytes of data. John Alden Life Insurance company has a warehouse with four years of detailed medical claims with extensive cross indexing, comprising some 150 billion bytes of data. The company figures that asking a question to compare hospital networks in Illinois and New Jersey on hip replacements would tie up a mainframe all night. A 24-processor IBM SP2 does this job in the "tens of minutes."

The computer can scan for information users request, or it can look for interesting relationships and patterns, a process called data mining. This kind of technology provides you with the ability to understand your customers and the nature of your business far better than in the past.

to understand their business better. For example, you might ask to see a display of sales by region, for the current period, compared to the same time last year. After seeing this display, you may want to see the analysis by product group, then product group for the last six months, and finally the same data by sales team. Instead of the two dimensions associated with the relational model, you are asking for a **multidimensional** analysis.

To accommodate this kind of analysis, sometimes called OLAP for on-line analytical processing, firms offer multidimensional databases for data warehousing. You must define the various dimensions of your business so the system can provide summaries based on those dimensions. The idea is to let you ask questions involving a number of factors without having to be familiar with the underlying organization of the data. See Figure 10-12 for an example of how a multidimensional view differs from a relational table. One strategy for creating the "data cube" associated with a multidimensional database is to create a "fact cube" through an *n*-way crossing of all the dimensions specified when defining the

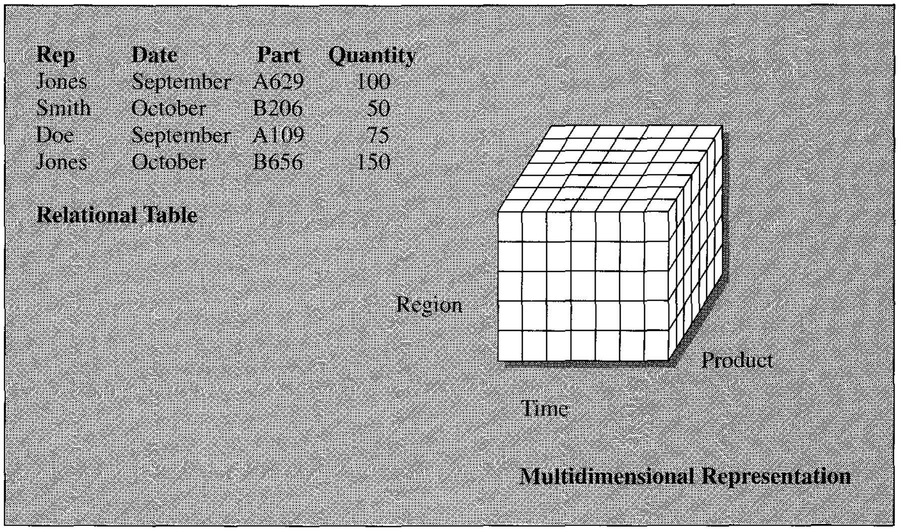


FIGURE 10-12
Multidimensional databases.

NASD Data Warehouse

A data warehouse at the National Association of Securities Dealers (NASD) helps to keep trading activity on the level. There are some 550,000 registered traders buying and selling an average of 700 million shares a day on the NASDAQ Exchange. The NASD is building a regulatory data warehouse that will hold 1.4 terabytes in total and will grow by 4 Gbytes per day. Officials will use reports from the warehouse that are produced within 30 minutes of the close of the market. In one year, NASDAQ monitors found 26,000 possible trading problems that led to an investigation.

The data warehouse runs on a 16-processor system using Oracle7. Programs manipulate transactional data from the market reporting system and load it into the warehouse. The system employs data-mining tools to apply pattem recognition to the data in a search for suspicious activity and trading trends. The NASD creates smaller datasets on Sun SPARC servers so that analysts can investigate in more detail information on late trade reporting, member profiles, and other topics. Over the next few years, the number of users of the warehouse is expected to grow from 25 to over 500.

database. It is likely the multidimensional database will store only valid entries to save space. For example, not all products might be sold in all regions, leaving empty locations in the cube.

One objective of a **data warehouse** is to help you understand your business better. This kind of technology, then, helps create a "learning organization," an organization that is able to better understand its market, customers, and itself.

MANAGEMENT PROBLEM 10-1

L.K. Acton is a mail-order sales firm that began by selling outdoor clothing and accessories. Since its founding, it has steadily expanded into a range of clothing, as well as camping, hiking, and skiing equipment. The company accepts orders through the mail, by toll-free phone, and over the Internet. It has always maintained a transactions history and kept a database of past customers for use in mailing seasonal catalogs. The president of Acton, Mary Hutchinson, is considering the vast amount of information the firm has on the purchasing patterns of its customers. She is wondering about establishing a data warehouse that would contain customer name, address and a history of purchases, credit card used, and other information.

Hutchinson has spoken with her IS staff and is confident that the technology exists to create the warehouse without too much difficulty. She believes Acton could use the information for its own marketing purposes and possibly sell it to other firms interested in contacting customers. Her vice-president of marketing, however, is opposed to the idea of selling information. He would like to use it himself but feels that customers might be angered if Acton sold information about them. Hutchinson is asking for your advice. Does it make sense for Acton to set up a data warehouse? How should the company use it if it does? Should it sell customer information?

Data Mining

One of the reasons for building a data warehouse is to undertake **data mining.** The idea is to look for interesting and important patterns in a huge database. A company like MCI wants to learn about its customers, to serve them better, and to avoid losing them to competitors. One strategy is to look through marketing data on 140 million households characterized by as many as 10,000 attributes. These variables include income, lifestyle, and past calling habits. However, it is hard to know which attributes are the most significant. MCI uses a supercomputer to compute a set of 22 detailed (secret) statistical profiles of its customers. MCI can target different profiles with custom promotions, develop plans for selling new services and packages, and enter into joint marketing programs with other firms that are geared to customers that fit a certain profile. Data mining is also being used by NBA basketball teams to analyze the thousands of bytes of statistics that each game generates and by the Treasury Department to look for evidence of financial crimes through an analysis of money transfers.

Data mining is associated with **knowledge discovery** systems, applications that try to make sense out of data. Databases are an important component of these systems as they contain large amounts of data that may provide a decision maker with knowledge. Programs for data mining and knowledge discovery help sift through all these data and offer ideas to the decision maker. They are another type of decision support system, which we discuss further in Chapter 21.

Virtual Databases

It has been estimated that about 90 percent of the data in the world is not in relational databases; it is scattered across Internet Web sites, legacy applications, and nonrelational databases. Virtual database technology makes external data sources a part of your corporate, relational database system. With virtual database software, you can make queries of data that are scattered over a variety of locations and stored in different ways.

To find a job for a marketing manager position in a company at a certain location where the company's sales are growing at 25 percent a year would require an extensive search of Internet job directories. A virtual database allows the user to make one query. The database consolidates job listings from many sources and develops indexes for job title, category, and other attributes of the listings. The programmer accesses the virtual database using standard SQL commands while the end user might work with a query form on the Web.

There are currently a number of virtual database applications on high-traffic Web sites such as Yahoo! and the Wall Street Journal Online. It is also possible to combine external data with a company's internal data warehouse to expand the range of data-mining and knowledge discovery programs. Virtual database technology is also very useful for electronic commerce. Junglee Corporation, a subsidiary of Amazon.com, uses a virtual database to integrate data from multiple merchants to give shoppers comparison data. One example is a virtual database that combines the contents of Amazon.com and Powell's Books with the *New York Times Book Review;* the result is a unified, relational schema with two tables: books and reviews. Junglee has also applied this technology for classified employment ads, real estate, and apartment listings.

Virtual database technology extends databases beyond the confines of the organization; it provides consistency in accessing data that originate in many different places and that is stored in different ways. The result is an extremely powerful technology for accessing the tremendous amount of data that exists in automated databases.

Changing Database Markets

Sales of database management systems have been declining after a long period of growth. One problem has been the rise of the Internet, which is slowing the growth of the market for the traditional DBMS. Companies are implementing new applications on the Internet to provide employees and customers access to data that they already store in a DBMS, probably on a midrange or mainframe computer. Frequently data on the Internet involve multimedia objects. This trend creates another problem for relational database vendors as customers seek object-oriented databases, which are particularly useful for multimedia data.

The major vendors offer hybrid databases that combine relational and object-oriented features, though these have had mixed success compared to completely object-oriented databases. (To learn more about object-oriented design, please see Chapter 15.) DBMS sales are also affected by the movement toward packaged software, particularly enterprise software from Baan, SAP, and PeopleSoft. These applications have built-in database capabilities and appeal to customers who do not want to do their own systems development and programming.

A Lot of Data about You

Acxiom is a company in Arkansas that maintains a huge amount of data about all of us. Twenty-four hours a day the company gathers and sorts information on 196 million Americans. The data come from credit card transactions, magazine subscriptions, telephone numbers, real estate records, car registrations, and fishing licenses, to name a few sources.

The company typically does not provide information on individuals. Rather it identifies thousands or millions of people at a time who fit a particular profile. For example, a company purchasing a list of names and addresses might ask for individuals within a certain age range or weight who drive certain makes of cars and use certain credit cards. For a bank wanting to send solicitations for a credit card, Acxiom might look at financial information and classify people into groups as most likely to least likely to respond to the mailing.

For the most part, this kind of business is unregulated. However, legislators introduced some 8500 privacy bills in state legislatures last year. In addition to companies like Acxiom, there are Web sites that sell reports containing personal data, some of which comes from credit reports. The technology makes it possible to gather and process huge volumes of information about individuals. We have to decide to what extent this information should be available and balance that against our right to privacy.

MANAGEMENT PROBLEM 10-2

Marilyn Atkins is vice president of the human resources department for Multinational Manufacturing, Inc. (MM). Her firm employs nearly 100,000 people around the world. Filling vacancies when they arise is a constant problem. Preference is given to existing employees, although it is very difficult to know when an existing employee has the skills needed for an opening so that he or she can be notified to apply for.

Marilyn talked to representatives of MM's information services department, and they indicated that a relational database management system might help her. Currently there is a personnel system that is updated once each month. It consists of sequential files kept on a disk and contains data on employees, including records with name, education, skill, salary, and similar data. Other records reflect job history—the positions the employee has held in the firm.

The new database system extracts data from sequential files like the ones used in the personnel system and then builds relations, which are available for inquiry through a query language that is part of the package.

Can you help Marilyn define relations and formulate a few sample inquiries to extract the kind of information she needs from the existing personnel system using the new database manager?

CHAPTER SUMMARY

1. Organizations keep a tremendous amount of material in machine-readable form stored as files on a computer. This trend will continue as firms move away from the use of paper for records.
2. Data in files are stored in records. The most common form is a fixed length record consisting of fields. Each field contains a group of characters that represent a value for the field, for example, a social security number.
3. Direct access files are stored on disks with average access times in the range of 8 to 15 milliseconds.
4. A pointer is a number, stored in a field, which directs a program to another record. Pointers are also used to allow a user to follow a logical connection among a variety of computer systems on a network.
5. The database management system automates the tasks of setting up a database. It facilitates defining records and relationships among them, and it handles the updating and retrieval of data from the database.
6. The relational model in which data are stored in tables or relations is the dominant type of DBMS today.
7. Normalization is an important part of the design of a relational database.
8. A key part of the systems analysis and design process is defining data requirements. Entity-relationship models are one way to describe data and relationships.
9. SQL is an intermediate language that may serve as a bridge among different DBMSs.
10. You can use one of a number of PC DBMS to develop quite sophisticated applications for yourself and others to use.
11. Data warehouses facilitate on-line analytical processing, an analysis that helps management better understand its business and contributes to becoming a learning organization.

IMPLICATIONS FOR MANAGEMENT

The ability to store and retrieve vast amounts of data is one of the things that makes a computer so useful in business. While it will probably never happen, one great dream in the industry is to replace paper with data stored in machine readable form on a computer. Database technology is what lets American Airlines keep track of millions of reservations. This same technology lets a credit card firm custom tailor promotions to customers who have a history of purchasing a particular product. A university database keeps track of your progress in school, recording the courses you have taken, the number of credits earned, and your grades. You can also use a DBMS on a PC to develop useful applications in your own work. Database is a key technology. You will encounter it in all the functional areas of business including marketing, accounting, manufacturing, and personnel. Databases, in combination with communications networks, are responsible for much of the appeal of the Internet and World Wide Web, discussed in Chapter 12.

KEY WORDS

Address
Chained file
Character
Database administrator (DBA)
Database management systems (DBMS)
Data mining
Data warehouse
Entity-relationship (ER) diagram
Field
File
From clause
Join
Key
Knowledge discovery
Linked list
Logical view
Multidimensional database
Normalization
Object-oriented database
On-line analytical processing (OLAP)
Pointer
Record
Relation
Relational file
Select clause
Structured query language (SQL)
Where clause

RECOMMENDED READING

Embley, D. *Object Database Development: Concepts and Principles.* New York: Addison-Wesley, 1997. (A detailed introduction to object-oriented database technologies.)

Hernandez, M. *Database Design for Mere Mortals: A Hands-On Guide to Relational Database Design.* New York: Addison-Wesley, 1997. (A very practical reference explaining the core concepts of design theory without technical jargon.)

Kent, W. "A Simple Guide to Five Normal Forms in Relational Database Theory," *Communications of the ACM.* 26, no. 2 (February 1983), pp. 120–125. (A clear article on normalization.)

Mattison, R. *Database Management Systems Handbook.* 2nd ed. New York: McGraw-Hill, 1997. (This handbook provides an excellent coverage on database technology, design, and architecture, including object-oriented databases.)

Parent, C.; and S. Spaccapietra. "Issues and Approaches of Database Integration," *Communications of the ACM.* 41, no. 5 (May 1998), pp. 166–178. (An excellent paper exploring the issue of integrating different databases.)

Post, G. *Database Management Systems: Designing and Building Business Applications.* New York: McGraw-Hill, 1998. (A useful manual for database modeling and design with numerous business applications.)

Silberschatz, A.; Korth, H.; and S. Sudershan. *Database System Concepts.* 3rd ed. New York: McGraw Hill, 1998. (A complete database textbook that covers everything from the basic to the complex and provides theoretical underpinnings and practical implications.)

DISCUSSION QUESTIONS

1. Why do users have different logical views of their data requirements?
2. Why is direct access so much more flexible than sequential access?
3. How does a DBMS tend to make data and programs more independent? Can programs and data ever be totally independent?
4. What is OLAP? How does it contribute to the organization?
5. Why do most organizations use a DBMS for specific applications rather than attempt to define a comprehensive database for all applications?
6. How does a DBMS make it easier to alter the structure of a database?
7. Does a DBMS completely isolate the user from the underlying structure of the data?
8. Why does a relational database need to be normalized?
9. Why might you want a DBMS on your PC that could also communicate with a larger computer database?
10. What complications are added to a DBMS when distributed processing is involved?
11. What kind of security and controls are needed in a DBMS?
12. In an on-line environment, a common problem is to lock out access to a record while it is updated. Why do you think this is necessary?
13. Recovery from a computer failure or other interruption of a system is a major consideration for organizations. What problems do you see in recovering from such a failure when using a DBMS?
14. How should one back up a database used for on-line processing?
15. How can accessing data in relational tables be speeded over a straight sequential search?
16. What evaluation criteria would you recommend be applied to a decision of what database management system to acquire?
17. Why is there a need for a database administrator in an organization using a DBMS?
18. How can the systems analyst use the facilities of a DBMS during the design process for a new system?
19. To what extent is performance (in terms of speed of access) a major consideration in database design?
20. In the schema of Figure 10-11, how would an adviser query the system to determine the major for a given student? How would the query language access the database?
21. Under what conditions is it better to program a retrieval option into a system, as opposed to providing a user with a general-purpose query language?
22. Are there any conditions under which it would be desirable to duplicate data in a database? If so, what are they?
23. Think of an application like student registration, and design a relational database for the registrar.
24. Under what conditions might an organization want to have more than one vendor's DBMS? What problems do you foresee if there are multiple database systems?
25. Why has the relational model come to dominate the DBMS market for personal computers?

26. What major trends in technology make database management systems feasible? What do they contribute to information technology, themselves?
27. What considerations apply to the decision of whether a DBMS is on a server or on client computers?
28. Does using a DBMS from a particular vendor mean that the organization is tied to that vendor for the foreseeable future?

CHAPTER 10 PROJECT

Database Assignment, Part I

In addition to a spreadsheet package, a database management system offers a lot of assistance for a firm like Simon Marshall. The first application Mary thought was appropriate for the database package was tracking the inventory of stock the firm has in safekeeping for customers.

She explained, "A lot of our clients don't want to leave their stocks with a brokerage firm. The brokers sometimes loan the stocks and do other things with them that make our clients nervous. We can't store stocks here, so we have a safekeeping agreement with the bank. Our records aren't too good, and I think putting them on the computer would help us be more disciplined about keeping track of this information."

The problem below involves using a database to solve the inventory problem for Simon Marshall.

Inventory

Simon Marshall keeps an inventory of securities for certain customers. Currently, the securities are actually kept by a bank, but Simon Marshall has been concerned about its ability to audit the securities maintained in the bank's vault.

Simon Marshall has asked you to develop a simple inventory system to keep track of its holdings with the bank.

The following are the fields in the relation and the data for input:

Name	Stock	No. shares	Date
John Doe	ATT	100	9/9/95
Mary Roe	GM	200	10/14/89
Karl Anderson	RM	150	11/21/96
Sam Smith	IBM	200	1/1/97
Sally Jones	NAB	150	6/6/90
Howard Cannon	EXX	90	1/19/92
Roger Roberts	BSL	175	7/8/96
Karyn Hanson	ATT	125	9/1/94
Terry Bradley	GM	85	1/15/95
Margaret Smith	NJT	100	9/4/91

You have been asked to:

- Set up a relation in a DBMS to maintain these data. Be sure to enter the date as a date field.
- Input the data above.
- List the relation after you have entered the data.
- Retrieve and list all investors who have more than 125 shares of stock in safekeeping.
- List all investors who put stock into safekeeping after February 1, 1990.
- List all investors who put more than 100 shares into safekeeping in 1990.

Database Assignment, Part II

Over time, John and Mary, principals of Simon Marshall, would like to keep each customer's portfolio on the computer. "We recognize that it will take a long time to get everything on the machine, but once we have done it, we can price out the portfolio in an instant and give really good information to our clients," Mary commented one day.

You are assigned to set up a prototype for the portfolio application. The basic design strategy is to have two relations, one containing information about the security in the Company relation and the other containing the contents of a portfolio in the Portfolio relation.

Using two relations gets around a number of updating and data redundancy problems that are the reasons for normalizing a relational database. Since a portfolio is likely to contain multiple positions in a given stock, it is wasteful to carry all the data about that stock with each position. (Multiple positions exist each time the stock is bought because each purchase will probably be made at a different price. For tax and accounting purposes, each purchase must be recorded separately.) By joining the relation containing stock data with the relation containing the portfolio, we can compute the current value of the portfolio. Such an exercise is part of your assignment.

Portfolio Status

Simon Marshall has asked you to help design a simple system to keep track of a stock portfolio using a database management system on a PC. You will need two relations, one to hold information about each company and the other to keep data about an individual's holdings. (It would be redundant to keep all of the data about a stock with each position a user might have in that stock.)

The first relation, Company, contains the name of the firm, its location, line of business, and the current price of its stock. The second relation, Portfolio, contains the name of the firm, a lot number to identify each stock purchase, the number of shares bought of that lot, and the total purchase price of the lot.

1. Print all of the records of each relation.
2. Using the Portfolio relation, print a report of only GM shares.

3. Use the Company relation and sort the firms into sequence by location. Display and print the results. Do the same to sort the relation into order by type of business.
4. Join the two relations together.
5. Print a report using the DBMS report-creation option to show net position on each stock and for the entire portfolio.

Company Relation

Company	State	Business	Share price
AT&T	New Jersey	Communications	22.78
GM	Detroit	Manufacturing	52.45
IBM	New York	Electronics	178.54
TWA	Kansas	Airline	45.80

Portfolio Relation

Company	Number	Shares	Purchase price
AT&T	12345	50	1,200.00
AT&T	54321	100	2,100.00
IBM	88888	60	10,100.00
IBM	44444	100	18,000.00
TWA	11111	50	3,000.00
GM	12121	75	3,750.00
GM	34343	150	8,000.00
GM	56565	100	5,000.00

CHAPTER 11

Communications

Outline

Communications between Computers

- Codes
- Transmission Modes
- Direction of Transmission
- How Are Signals Represented?
- Speed of Transmission
- What Is a Protocol?
- Summary

Networks

- Network Configurations
- Local Area Networks
- TCP/IP: A Network Protocol
- Going Wireless
- Voice Considerations

The Advantages of Networks for Business

- What Are the Alternatives for Wide Area Communications?
- Why Develop Private Networks?
- Worries about Network Security

The Contribution of Communications

- Electronic Mail as a Communications Tool
- Electronic Data Interchange

Beyond the Model T
Building an Electronic Market
Transforming Organizations and the Economy

Focus on Change

The communications industry is responsible for some of the most extensive technological changes affecting organizations. Extensive deregulation through the Telecommunications Act of 1996 has led to alliances and mergers among the major communications firms. Long distance carriers are buying cable companies to give them access to local subscribers. The local phone companies are trying to enter the long distance business. These changes provide alternative sources for service and lower communications costs. Communications technology makes it possible to share data within the company and with external organizations. It facilitates coordination and helps management define new organizational structures as it removes constraints on the time and place for work and makes possible the creation of new structures that cut across traditional lines on the organization chart. As you read about the companies in this chapter, think about how communications technology is changing the nature of work and relationships with customers.

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Early computers processed data in batches with intervals of days or months between runs. Devices were soon developed to transmit data on punched cards from one location to another over telephone lines, marking the beginning of the communication of data through an existing telecommunications **network.** The operation took place off-line, and the computers involved were not directly connected to the telephone lines. In addition to card punches that could send and receive, there were devices for sending the contents of files on magnetic tapes from one location to another.

In the early 1960s, the first on-line systems were developed. These computers, used for airline reservations, served many terminals connected through various types of communications lines. (A few years earlier, the first such on-line systems had been developed for defense applications.) At about the same time, terminals were attached to computers used for time-sharing. The major difference between on-line and time-sharing systems is that the former are dedicated to a single application. For example, an airline reservation agent can only make a reservation or inquire about the status of various flights. The agent cannot write a program from the terminal. With time-sharing, the user of the terminal usually does have the ability to write programs.

The use of on-line systems has expanded rapidly. Today most new systems have some portion that is on-line, such as data entry, update, and/or inquiry. At the same time, there has been an expansion in the number of alternatives available for establishing communications among computer devices. Users can choose from dial-up phone service all the way to private networks using satellites for transmission.

In this chapter we cover the fundamentals of data communications. First we look at a basic model of communications between computing devices. The basics provide the foundation for understanding networks. Organizations are rapidly building and interconnecting networks of computers and other devices. The chapter discusses how a firm can obtain network services from common carriers or from building a private network. We also discuss some of the software required for communications-intensive applications. Several applications that depend on telecommunications, such as e-mail and electric data interchange (EDI), illustrate how this technology contributes to the organization.

The need for standards in the communications industry has been apparent for many years. How could you place a direct dialed call to someone in a European or Asian country if the various telephone companies involved in the call had not agreed on standards? There are a number of groups, both domestic and international, that work on developing standards for new types of communications. While standards are important in a variety of endeavors, they are mandatory for successful telecommunications.

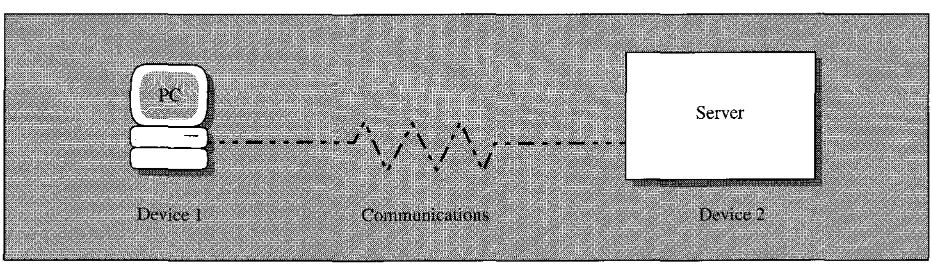
COMMUNICATIONS BETWEEN COMPUTERS

Figure 11-1 is a diagram of high-level data communications between two computer devices. We shall expand this basic schematic further. The most familiar type of communications is probably the case in which device 1 is a PC and device 2 is a **server** of some type. The transmission line may be nothing more complex than a pair of twisted wires from the terminal leading to a central computer that offers time-sharing services. Figure 11-1 describes the process.

Codes

The data sent over the line are represented as some type of **code**; that is, the sending and receiving ends of the communications lines have to agree on how to represent symbols such as the letters a, b, c, etc. The most frequent code for interchanging data is called **ASCII** (American Standard Code for Information Interchange), which is a 7-bit code (there is an eighth bit for error checking) and thus has 128 symbols. A code used with earlier computers was BCD (binary coded decimal), a 6-bit code. Finally, there is a code that is primarily used by IBM mainframes known as EBCDIC (extended binary coded decimal interchange code), which is an 8-bit code.

FIGURE 11-1
High-level data communications.



All codes, then, use sequences of 0's and 1's to represent different symbols. As an example, the ASCII code for H is 1001000. On the sending end, an H is translated into 1001000 for transmission. On the receiving end, the string of bits is translated back into an H. (It should be noted that computers are designed to represent data in memory in coded form. However, there is no required relationship between the internal coding and the codes used for transmission between computers.)

Codes often feature extra bits or characters that are used to control transmission and to detect errors. A simple transmission scheme that sends one letter at a time might include a start bit and a stop bit to delimit the beginning and end of the character for the receiving station. A basic error-detection scheme is parity checking: The sending device checks that there is an odd number of bits in each character; if there is an even number, the sending station makes the parity bit a 1, creating an odd number. Under this odd-parity scheme, the receiving device also counts the bits. If there is an even number, at least one bit has been lost in transmission. The parity scheme is rather simple. There are far more elaborate error-detecting and even error-correcting codes available.

Transmission Modes

There are a number of options for transmitting data over communications lines. The most frequently used approaches are the following:

- *Character mode.* In **character mode,** data are transmitted as single characters as they are typed on a terminal. This technique is very simple and does not require complicated hardware or software.
- *Block mode.* In **block mode,** data are placed temporarily in a hardware memory on the sending device. The block is surrounded by appropriate characters indicating the start and end of transmission. The data are then transmitted as a single block, usually with some type of error-checking sequence at the end of the block. If there are errors, the two **nodes** arrange for a retransmission of the data.
- *Asynchronous mode.* **Asynchronous transmission** is associated with character mode operations, since the characters are sent when entered. A single bit is added to the front of each character, and one or more bits are added at the end. These extra bits alert the receiving device to the existence of the character and delimit it.
- *Synchronous mode.* Block transmission features blocks of equal length, one following another. In synchronous mode, there is no need for the start and stop bits that are associated with each character in asynchronous transmission, saving considerable overhead when in the block mode. The beginning of each block is identified, and the sending and receiving devices must be synchronized. This synchronization is maintained by a clocking signal, and this synchronization is in force whether any data are being sent or not.

Direction of Transmission

There are several ways to send data over lines. In **simplex transmission,** the data are sent in one direction only, but this approach is rare. Using **half duplex transmission,** data travel in two directions but not at the same time. With **full duplex**

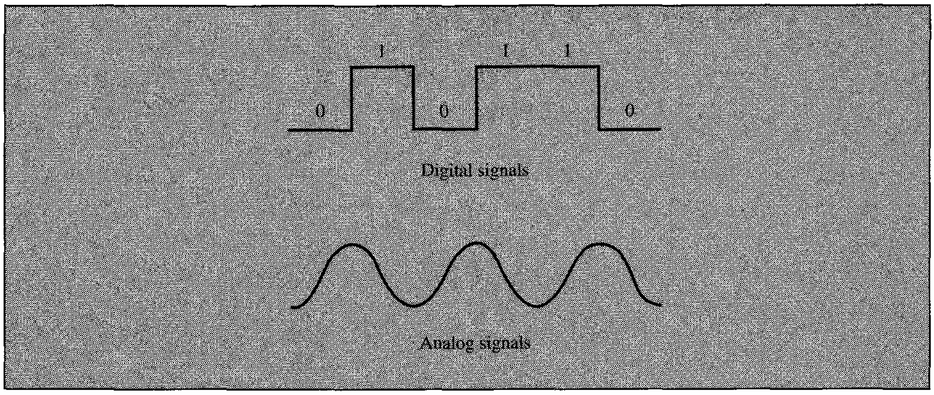


FIGURE 11-2
Digital and analog signals.

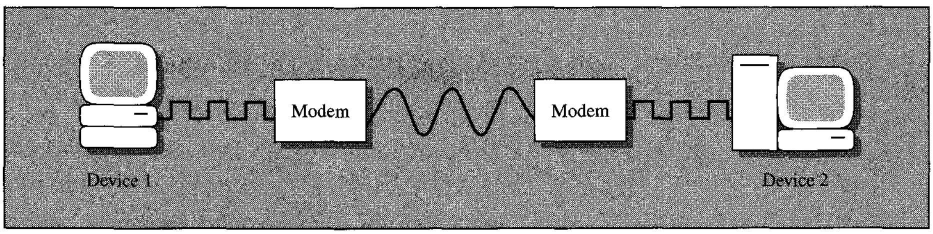


FIGURE 11-3
Modulation and demodulation.

transmission, data are transmitted simultaneously in both directions. Note that this approach generally requires two lines since the same data path cannot carry signals in two directions at the same time.

How Are Signals Represented?

There are two basic ways to represent signals: analog and digital. These signals are shown in Figure 11-2.

Analog Signals **Analog signals** are used because the first data transmission took place over voice telephone lines, originally developed to carry analog signals. Because computer devices communicate in digital form, the digital signal must be converted to an analog signal (**modulated**) for transmission and then changed to digits (**demodulated**) at the receiving end. As shown in Figure 11-3, a device called a **modem** converts the digital code into an analog signal.

Figure 11-4 shows one approach to this modulation task. In the figure, we see encoding done using amplitude modulation. The analog signal is continuous and has the form of a sine wave. By using different **amplitudes** (heights of the sine

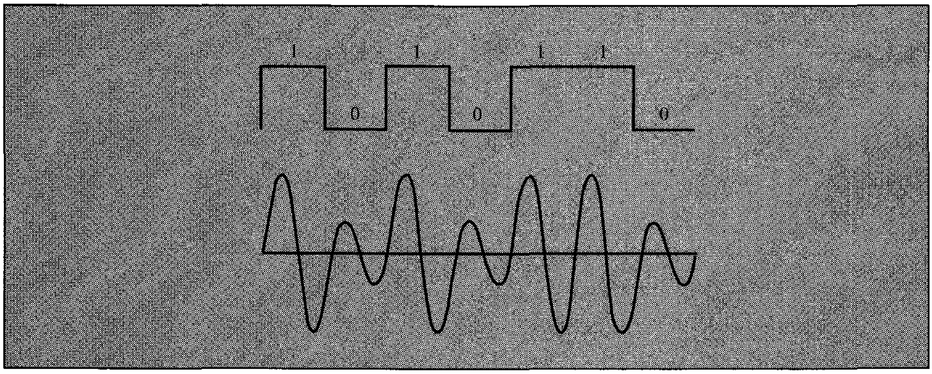


FIGURE 11-4
Amplitude modulation.

wave) to represent a 0 and a 1, the digital data can be encoded for transmission over analog lines. The modem is the device that accomplishes this modulation. It is possible to modulate a signal using the amplitude of the sine wave as described above, varying the **frequency** of the wave or changing the phase of the sine wave to encode a 0 or a 1. Your personal computer probably has a modem that operates at up to 56 Kbits per second over a dial-up phone line. Using this modem, you can connect to a variety of computers, though it is unlikely you will actually communicate at the modem's maximum speed due to the limitations of the local line to your telephone.

Digital Signals Because of the explosion in data transmission over the past two decades, and for greater efficiency, telephone companies and private communications carriers have developed digital transmission networks. If the entire circuit from end-to-end is digital, there is no need for a modem. The only requirement is some kind of a line interface device to connect the sending or receiving unit with the transmission line.

Thus, even with digital transmission, we still need to convert analog signals to digital form. A communications carrier might provide a digital link between telephone central offices, while the "local loop" to a home or office goes on an analog copper circuit. There is also great interest in digitizing some analog signals so information, such as video-conferencing, multimedia, and home video, can be compressed and sent over relatively low-speed lines. The analog signals from a video camera can be digitized and then compressed so the large number of bits required will "fit" on a line. **Compression** involves using some type of algorithm to take out redundant information by coding it. A compression algorithm might look for a pattern in an image that is all dark. It would substitute a code for the number of black elements rather than transmitting all the black bytes. At the receiving end, equipment would generate the black elements that were not transmitted.

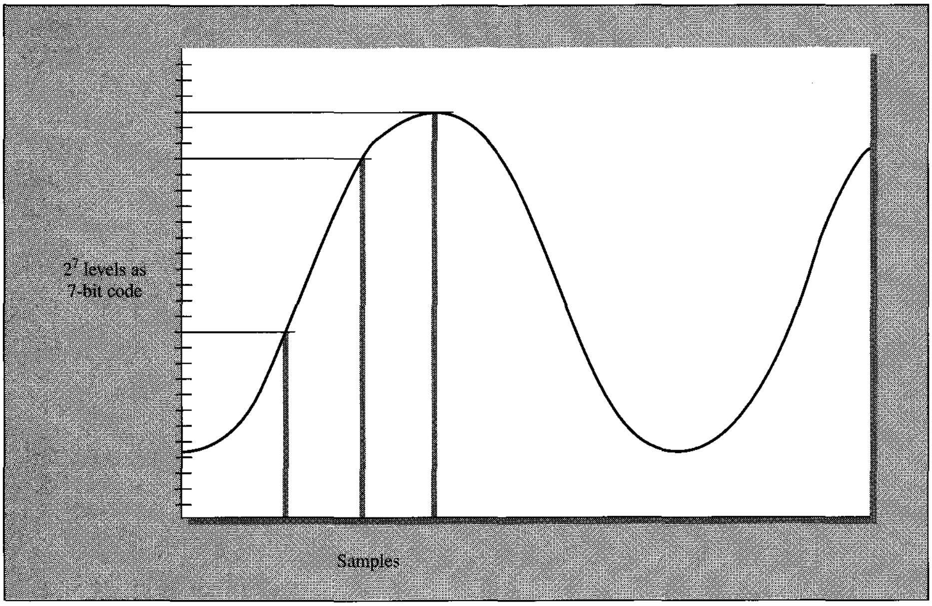


FIGURE 11-5
Analog-to-digital transformation using pulse code modulation.

Figure 11-5 shows how it is possible to digitize an *analog wave using* **pulse code modulation (PCM).** The Y axis on the waveform is divided into a series of intervals. If we are using a 7-bit code, we would make 2^7 or 128 intervals. One unique 7-bit pattern is assigned to each interval. If we view the Y axis as a window through which the wave passes over time, at a particular instant or sampling point, we would note the interval the wave touches at our window. Then we would send the 7-bit pattern that has been assigned to that interval as a digital representation of the wave. We would take another measurement at the beginning of the next sampling interval. Thus, the digital signal consists of a series of 7-bit characters, each of which encodes part of the waveform. To provide an adequate representation of the wave, we might sample 8000 times per second. With this interval, we generate 7 bits × 8000 samples/second = 56,000 bits/second as the amount of data sent over the line. It should be clear now why analog data, like full-motion video, require very high capacity lines (the higher the capacity or speed, the higher the **bandwidth** of the line).

Speed of Transmission

Transmission can occur at different speeds. The communications specialist uses a measure of speed called a **baud,** which is the number of times per second that the signal changes. For our purposes, it is easier to think in terms of bits per second or characters (**bytes**) per second. Subvoice-grade lines transmit 45 to 150 bits/second,

TABLE 11-1

TRANSMISSION SPEEDS

For home		For a network	
PC Modem	56 Kbps	Voice grade	56 Kbps
ISDN	64 or 128 Kbps	T1 line	1.544 Mbps
ADSL	44 Kbps to 8 Mbps	T3 line	45 Mbps
Cable modem	384 Kbps to 4 Mbps	DS3 line	45 Mbps
DirecPC Satellite	400 Kbps	OC3 connection	155 Mbps
Wireless	Up to 4 Mbps home, 1,555 Mbps business	OC12 connection	622 Mbps
		OC48 connection	2.45 Gbps

bps = bits per second, K = thousand, M = million, G = billon

whereas **voice-grade** lines transmit a maximum at 56 Kbit/second only if you are using a modem that can compress the data. Digital transmission is popular because it is very reliable, offers high speeds, and eliminates the need for modems. Table 11-1 describes communications alternatives and speeds for home and for networks, which are discussed in the next section.*

What Is a Protocol?

Transmission involves **protocols,** which are sets of rules and procedures to control the flow of data between points. Both the sending and receiving stations need to follow the same procedures. For example, if blocks are being sent, both stations must agree that the transmission is to be in block mode. A protocol can also increase the efficiency of transmission by reducing the amount of data that must be sent for control purposes.

We must control the following:

- Setting up a session
- Establishing a path from nodes 1 to *n*
- Linking devices together
- The hardware sending and interpreting the data

Protocols are also used to handle the following:

- Detection and correction of errors
- Formatting
- Line control
- Message sequencing

*In this text, Kbits/second, Mbits/second, and Gbits/second equal 1000 bits/second, 1 million bits/second, and 1 billion bits/second, respectively.

The International Standards Organization (ISO) has suggested a layered architecture to facilitate communications among different types of equipment. The seven logical layers are as follows (the numbering follows the ISO designation of levels):

7. *Application.* The window through which applications gain access to the services provided by the model.
6. *Presentation.* Services here are concerned with data transformation, formatting, and syntax.
5. *Session.* A set of rules to set up and terminate data streams between network nodes.
4. *Transport.* These rules guarantee that the transfer of information occurs correctly after a route is established throughout the network.
3. *Network.* Rules for arranging a logical connection between a source and destination on the network based on available data paths in the network.
2. *Data link.* Rules that describe how a device accesses the medium in the physical layer and identifies data formats, procedures to correct transmission errors, and so on.
1. *Physical.* The lowest level in the model consists of a set of rules to specify the electrical and physical connection between devices.

The highest levels should remain similar for different equipment, whereas lower levels depend more on the devices and manufacturers involved.

Summary

A device sends out a code, such as ASCII letters, to some type of interface, which sends the message over a transmission line. For analog transmission, the interface is a modem, which transmits either characters or blocks of data. At the receiving end, the interface unit must reconvert the code into the appropriate code for processing the transmitted data (see Figure 11-6).

NETWORKS

A network connects a variety of computers and other devices. Table 11-2 describes the networks discussed in this chapter.

The largest computer network is the Internet, which we shall discuss in some detail in the next chapter. The largest general-purpose network in the world is the public **switched network** used to carry most voice traffic around the world. Here, one simply dials a number and establishes a point-to-point connection only when it is needed. You probably use this network if you connect to a university computer using a personal computer with a modem. In addition to telephone, there are special private network services also providing switched connections. Such a network covers a huge distance and would be considered a **wide area network (WAN).** Some organizations want a network that is local to a given area, and they might configure it using private lines. This kind of network is known as a **metropolitan area network (MAN).**

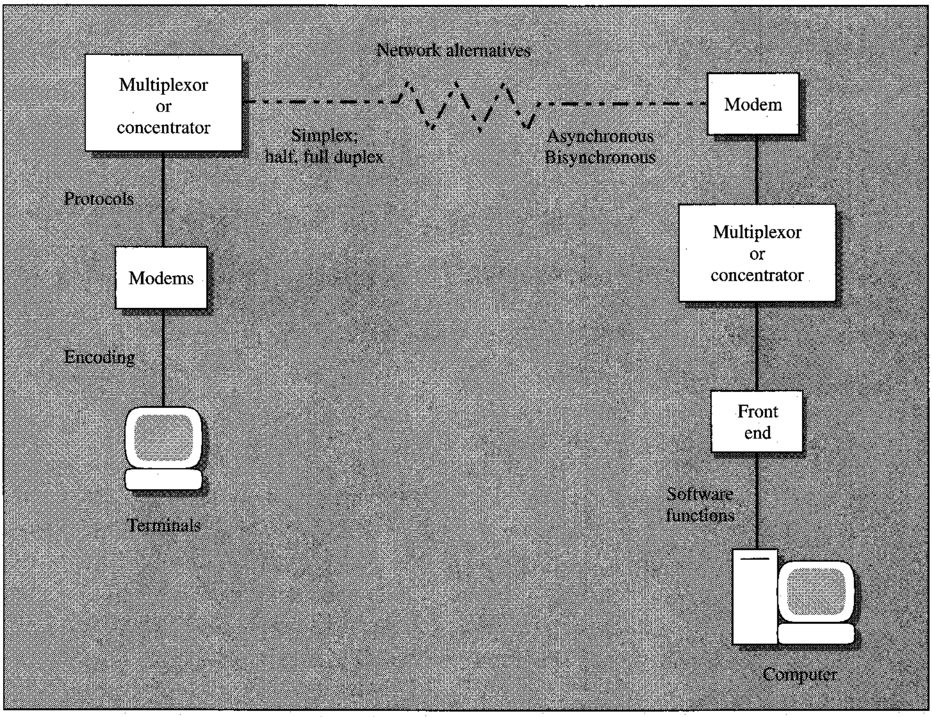


FIGURE 11-6
Some communications options.

TABLE 11-2

TYPES OF NETWORKS AND EXAMPLES

Type of network	Example
Network of networks	The Internet
Public switched network	Voice telephony
Wide area network (WAN)	The phone system
Metropolitan area network (MAN)	A campus network
Local area network (LAN)	PC network within a building

In place of a switched network, you could make a simple direct connection between a computer and a terminal using twisted-pair cables running directly between the two devices. You can generally wire directly for a mile or two before the loss of signal (**attenuation**) becomes too great and modems are needed.

One way to reduce line costs is to have several terminals connected to a device called a **multiplexer.** The multiplexer combines the signals from various low-speed terminals and sends them over a higher-speed line. In time division multiplexing, the device samples separate incoming signals and combines them on the output line. At the receiving end, the signals must be demultiplexed. With a multiplexer, the speed of the output line must equal the sum of the speeds of the input lines.

A **concentrator** is a hardware device that collects messages from terminals and stores them if necessary. The concentrator sends the messages over a higher-speed line to the computer. Unlike the multiplexer, however, it can temporarily store the data, so the capacity of the high-speed line does not have to equal the sum of the capacities of the low-speed lines it serves.

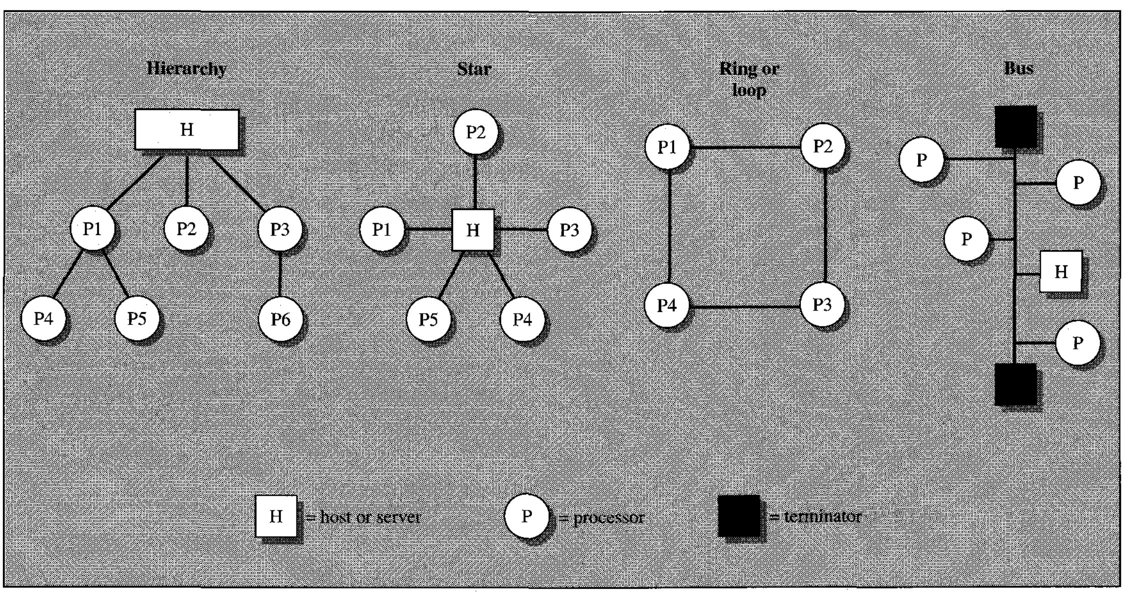
There are also network devices called **bridges** and **routers,** which we discuss later in the chapter along with local area networks.

Network Configurations

Given the various communications options, you can configure a network of computers and terminal devices in any number of ways. Figure 11-7 presents some popular options. In a hierarchical scheme, one computer controls a series of subordinate computers. An example of this approach might be a central computer controlling local grocery store computers, which in turn control point-of-sale terminals at checkout stands. The star connection is similar, but here a single **host** or server can communicate with each remote processor. The local computers communicate with each other through the central system.

In a ring or loop scheme, all processors can communicate with their immediate neighbors. This pattern can be extended to allow communications from any

FIGURE 11-7
Examples of computer-to-computer connections.



processor to any other processor. The bus typology features a communications bus connecting individual computers. Computers put messages containing the address of their destination on the bus for delivery.

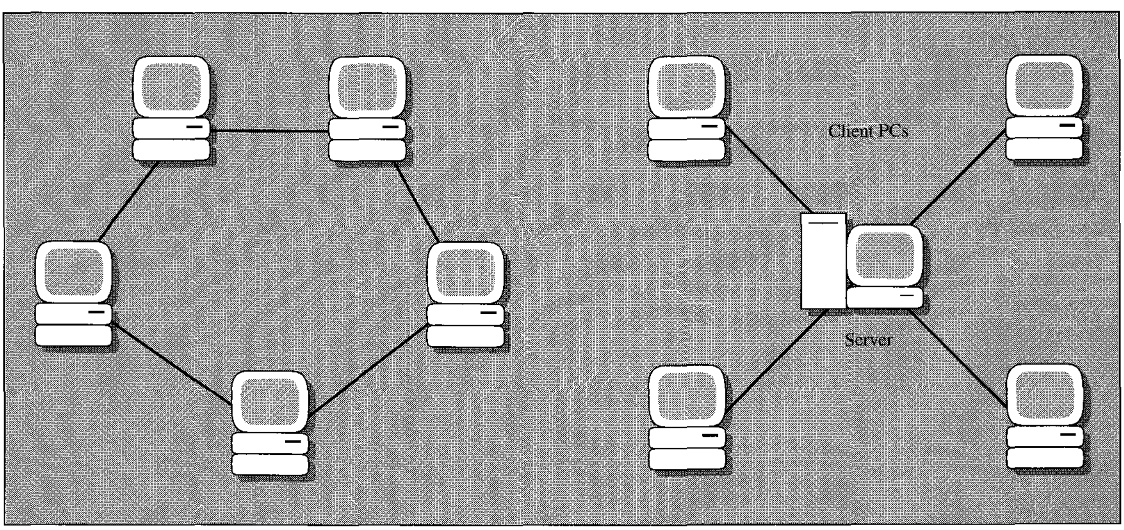
Local Area Networks

The first people to buy personal computers used them as stand-alone devices. In so doing, they bought freedom and independence from the professional information services staff. Soon, however, users found it advantageous to share devices such as laser printers. The most common way to share devices, data, and programs is through a **local area network (LAN).** The local area network is an approach for connecting various devices that need to communicate with each other and that are grouped closely together, as in a single building.

There are two major architectures for LANs (see Figure 11-8). The first is a peer-to-peer network in which all PCs are connected to each other. Data on the network are passed from one PC to the next. As a user, you must devote some of the resources of your workstation to accepting and passing data on the network. Each computer on the LAN incurs this type of overhead. Peer-to-peer LANs are relatively inexpensive and represent an attractive alternative for a small network. This kind of network is sometimes called a "zero-slot LAN" because there is no need for a circuit card, taking up a slot in the computer, to connect to the network.

The second type of LAN is more popular and employs a file server. The server is a computer that responds to requests from its clients or user PCs. A client might request that a job be printed on a single laser printer that serves a LAN with 10 PCs. The server puts the client's print job in a queue and prints it when

FIGURE 11-8
(a) Peer-to-peer LAN. (b) Client-server LAN.



the printer is free. If the client asks for a software program or data, the server provides it. The LAN is generally installed for a group of users who need to share something—a database, computer equipment, and/or software. This LAN is more complex than the peer-to-peer network and is usually more expensive. It does free the client workstation from performing any LAN functions for other users.

A wiring hub is frequently used to configure a network in a building. All the computers on the floor of the building where my office is located are connected by copper wires to a wiring closet on the floor. This closet contains a hub and the lines from individual computers plug into the hub. The hubs on various floors are connected with file servers using fiber-optic lines.

Ethernet The most popular local area network protocol today is Ethernet. In contrast to the peer-to-peer LAN, a computer connected to an Ethernet LAN must have a **network interface card (NIC),** usually called an Ethernet card. Such a card is standard equipment on Dell's Optiplex series of computers, which are marketed to organizations. Ethernet cards are also available for the PCMCIA slots of notebook computers, so that you can plug your portable computer into a LAN.

At a low level, the LAN must transmit data over the network. How is transmission coordinated so every workstation does not try to send data at the same time and thus block the data from other PCs? One solution to this contentious problem is called carrier sense-multiple access with collision detection (**CSMA/CD**). The transmitting station checks whether a channel is clear by listening for a carrier sig-

MANAGEMENT PROBLEM 11-1

Global Manufacturing is considering a new technology application. The company wants to process orders in a central location and then assign production to different plants. Each plant will operate its own production scheduling and control system. Data on work in process and completed assemblies will be transmitted back to the central location that processes orders.

Global now has minicomputers at each plant that perform routine applications such as payroll and accounting. The production scheduling and control systems will be a package program running on a new computer dedicated to this application. Global has a high-level systems design for data transmission from the central computer to the plants and for the plant data to be transmitted back to central planning.

The systems staff at Global has retained you as a consultant to help them with further analysis. What kind of computer configuration seems most appropriate? What kind of transmission network do they need? What data should they collect? Prepare a plan showing the information Global must develop in order to establish this telecommunications system. Should Global use a private network or can it accomplish its objectives through the Internet?

nal. If the net is busy, the station waits until it is clear and then sends a message while listening for collisions with other stations that might have started to send at the same time. If a collision is detected, the station stops sending and waits a random time interval before starting to send again. **Ethernet** is the best example of a CSMA/CD protocol.

The fastest version of Ethernet, called **gigabit Ethernet,** promises speeds from 200 Mbits/second to the full 1 Gbits/second. Networks use gigabit Ethernet to connect switches or to link to high-speed servers. This technology is for the backbone of a network and not for communications with the computer on a desktop! There are now an estimated 100 million Ethernet ports worldwide, so this technology is rapidly becoming a standard.

As you might expect, LANs grew in organizations without a lot of planning. Different departments and even different floors in buildings have their own LANs. Sometimes these LANs use different standards: One might use Appletalk and serve Macintosh computers while another features an IBM PC standard called **token ring architecture.** Sooner or later, users on these networks want to be connected to each other. The solution is to use a bridge or a router. A bridge has very little logic; it connects similar networks. A router contains logic and serves as the interface between two or more networks and possibly a wide area network. Routers have enough logic to select the best path between two **nodes** on a network. A **multiprotocol router** is able to process messages from networks that follow different protocols. A bridge or a router can be used to connect hubs on different floors of a building or in remote locations. And hubs are continuously becoming "smarter." An organization might route all the wires from the local wiring hub to an intelligent hub. This smart hub contains bridges and routers, and is controlled by software, since the hub itself is a computer.

TCP/IP: A Network Protocol

One of the best known protocols is **Transmission Control Protocol (TCP)/ Internet Protocol (IP)** developed by a Department of Defense research project to connect various kinds of networks, discussed in the next section, to form an Internet. (The Internet, itself, is discussed in the next chapter.) The Defense Department was faced with a variety of military computers and networks all produced by different contractors, generally the lowest bidder! It had two objectives: first to create a protocol to allow all its networks to be interconnected, and second to create a network (of networks) able to carry on if some component or subnetwork could not operate due to failure or destruction.

The IP part of the protocol is responsible for moving packets of data from node to node in a network. IP forwards each packet based on a four-byte destination number or IP address. (A computer connected to the Internet must have an IP address.) Gateways and servers move data among departments and around the world. IP operates on these computers. TCP is responsible for verifying the correct delivery of data from a client computer to a server and must see that data are not lost someplace on a network. TCP adds support to detect errors or missing data and to generate a retransmission until all the data have been correctly received.

Because the Internet is a packet-switched network, when you connect to an Internet service provider (ISP), the communications software must use the TCP/IP protocol. Yet another protocol for use over serial communications lines like the telephone is PPP or **point-to-point protocol.** This protocol actually transmits a variety of network protocols over a number of different types of lines.

Going Wireless

Setting up a network with cables and wires is not always desirable or feasible. Wireless technology uses some kind of broadcast to eliminate the need for cabling. Wireless modems are available for local area network applications; they are generally limited to short distances within a building.

The most obvious wireless option for wide area communications is the cellular phone network. Cellular digital packet data (CDPD) uses cellular frequencies to transfer digital data as a packet. This technology is in use today and is adequate for messages. The bandwidth is too low, however, for transmitting graphics and video. Another option is to use a system of low-orbit satellites like Iridium or Teledesic. These two systems employ large numbers of satellites (66 or more) in a low orbit. The sending station sends data to a **satellite** that forwards it through other satellites until it reaches the receiving station. The advantage of a low orbit

Harvesting by Satellite

The idyllic view of the American farmer using a tractor and plow to produce a bountiful harvest is not quite complete. Farmers on the leading edge use Geographical Position System (GPS) satellite navigation to map and analyze fields, telling the farmers where to apply the proper amounts of seeds, fertilizer, and herbicides.

One equipment dealer indicated that he had sold 14 combines in a year, and 11 of them were equipped with GPS receivers. He is also retrofitting older combines as the technology spreads, though only about 5 percent of American farmers now use it. GPS units and their associated computer monitors start at about $6500.

In the past farmers managed their business on a per-field basis; now they can micromanage. One Illinois farmer found that parts of his fields did not need any fertilizer at all after monitoring the soil. Less fertilizer lowers costs and reduces pollution from the runoff of water from the fields. A typical application is to use geographic fixes from the GPS and a computerized counter to record how much grain is being harvested each second from each meter of the field. Then the farmer downloads this information into a personal computer, which produces a contour map that shows variations of, say, more than 60 bushels an acre. Cross-referencing this information to other variables, like characteristics of the soil, allows the farmer to analyze why some land is less productive. The farmer combines these data with GPS navigational fixes to precisely apply herbicides or fertilizer only where it is really needed.

Innovators constantly take advantage of new opportunities provided by technology. In this instance, equipment manufacturers are combining a navigational system first developed for the U.S. Navy with information technology to improve productivity in agriculture.

is reduced power consumption, allowing for a smaller handset than the traditional satellite phone. Iridium has relatively low bandwidth, but Teledesic with its 288 satellites can handle up to transmission speeds of 155 megabit/second. For more details, see Varshney (1999).

A retailer might want to use a wireless terminal to keep track of inventory. A trucking firm could use a wireless system to send messages to its trucks and determine where they are at any time. K Mart stores use wireless technology to provide up-to-date information on the sales floor. A clerk carries a terminal that looks like a laser gun. The terminal connects with backroom computers using low-power radio frequencies. When the clerk scans an item on the shelf with the laser gun, he or she can read on the gun's display screen whether the item is on order and when it is expected to arrive. K Mart claims this system has doubled inventory turns per year.

United Parcel Service began a systems modernization program in 1986 to allow it to compete with Federal Express in the overnight-delivery market. By 1991, UPS invested $1.5 billion to develop its technological infrastructure. The effort included a global data network for $50 million, a $100-million data center in New Jersey, electronic tablets for drivers ($350 million), and $150 million for a cellular network. The company now has nearly 2000 IS employees, 5 mainframes, 300 minis, and about 33,000 PCs. There are also 1500 LANs and 69,000 hand-held computers. The company has planned to spend another $3 billion on technology to expand the capabilities of its systems.

UPS has equipped its trucks with terminals that send data over the cellular phone system. This approach allows it to track deliveries for all air and some ground parcels during the day. In the past, that information was collected in batch mode and used to update centralized computers at night. The data were not available for inquiry until the next day.

When drivers collect a package, they capture delivery information, including a signature, using a hand-held pen-based computer. This computer fits into an adapter in the truck containing a cellular modem which sends data to a switch in a cellular network. The switch places the data from the truck on the UPS private network known as UPSnet to be sent to the UPS mainframe database in New Jersey.

American Airlines is also joining the ranks of companies using wireless technology for communications. Wireless notebook and subnotebook computers allow passenger agents to roam airports, providing passengers with faster check-in. The system provided by McCaw Cellular Communications, an AT&T subsidiary, provides access to the SABRE database of passenger reservations. The agent is able to offer many of the same services as agents behind counters using fixed terminals. American sees the system expanding to personnel on the tarmac using devices to report maintenance and departure times.

Using one of several wireless networks that offer services in major cities, you can send e-mail messages from your notebook computer without having a phone nearby. A columnist for a computer magazine recently described how she used her notebook computer on an airline flight to compose and store a variety of e-mail messages. On leaving the plane, she had her computer broadcast the messages to a wireless network for delivery.

Finally, Hewlett-Packard developed a wireless mobile unit that lets doctors receive a patient's vital signs for remote diagnosis. The unit is capable of receiving electrocardiograms as well as other vital signs. The system features a $25,000 dispatch system that is linked to medical monitors and five palmtop computers. During testing, the system is credited with saving the life of one patient when information about his irregular heartbeat was sent to his doctor in her car. She returned to the hospital while the nurse prepared the patient for treatment, saving a great deal of time.

Voice Considerations

The designing of a communications network must consider both voice and data transmissions. We measure data transmission in terms of bits per second, whereas voice is usually measured in terms of duration of conversation. The communications systems designer uses statistics on call volumes to determine what capacity the network must have for voice transmission. These calculations are added to the requirements for data transmission to arrive at an overall specification for the network. There have been a number of innovations in voice communications—the most significant one in the last decade is cellular phones, both analog and more recently, digital.

Originally portable phones worked in a large area, and the number of phones was limited by the frequencies available for this service. A cellular network divides its coverage area into a series of small cells, and each cell has an antenna for receiving and sending data in each cell. Because the cells are small, cellular phones transmit at low power and their signals do not travel far beyond the local cell. As a result, the system can reuse frequencies in different cells, greatly multiplying the capacity of the system. Computers monitor the location of callers based on signal strength from their phones and "hand off" a call to a new cell when the caller moves into that cell. Personal communications systems (PCS) feature digital transmission using a different frequency from cell phones, but the principles are the same. The growth in cellular phones has been dramatic. There are reports of individuals dropping their "land line" phone and using cellular communications exclusively. Developing countries are installing cellular systems because the cost of installation is much less than for a phone system connected by cables.

The second recent innovation in voice communications is the use of the Internet for long-distance service. Individuals can purchase software that allows two people to use an Internet connection to communicate via voice. Companies can purchase devices that act as a gateway for a number of phones; one such gateway supports 120 ports and transmits the calls over the Internet using Voice over Internet Protocol (VoIP). The advantage of Internet telephony is lower cost; one only pays for an Internet connection, not time and distance charges for each call. The disadvantage is that the quality of communications is not as good as with traditional phone service.

THE ADVANTAGES OF NETWORKS FOR BUSINESS

There are a large number of sources for communications services. As examples, we have discussed the public switched network, in which telephone lines on the

Volvo to Use Network to Increase Market Share

Volvo in Greensboro, N.C. is building a global network to support truck manufacturing. AT&T is the contractor for a 200-node frame relay network to connect truck dealerships. A separate net links more than 30 warehouses and remote sites for other Volvo auto and marine products. One objective of the project is to have all data available everywhere so that an engineer in Sweden can query U.S. databases. With the help of the network and other IT projects, Volvo plans to boost its tractor-trailer sales from third place internationally to first or second.

The network will help employees around the world share databases of information on standard modules for trucks that can vary in design for each country. Volvo talked with several different companies and chose AT&T because of its experience and reputation. However, the company also uses network services from Sprint and Global One. Increased competition in communications has helped Volvo use communications and database technology as a part of its strategy for increasing its market share.

local level connect with AT&T, Sprint, or MCI-Worldcom. We can also pay to lease a line or pay according to the time a line is in use. The actual communications path may be through land lines, microwave links, satellites, or some combination of the three. A firm may develop a private network and/or use services offered by common carriers.

What Are the Alternatives for Wide Area Communications?

A type of network known as **packet switching** is now a standard for transmitting digital data. A circuit-switched network establishes a connection between every pair of points that wants to transmit data, just as the telephone network does. There is considerable overhead in making the connection between the two parties. In packet switching, the network does not make connections for individuals. It routes bunches of data called packets. Network hardware and software break data into packets with each packet having an address. Each node on the network looks at the address and determines the best path for sending it on toward its final destination. Network hardware and software reassemble the packets on the receiving end. Packet switching has proven very popular for transmitting data over large distances. There is an international packet-switching standard called **X.25,** and a number of networks use this protocol, including the French Transpac network (see Figure 11-9).

Gigabit Ethernet is a high-speed standard for communications. At first gigabit Ethernet will require fiber optic lines, and its use will be confined to the backbone of a LAN. Because some 80 percent of local area networks use Ethernet already, the evolution to a faster version is more appealing than changing to some other communications technology. Eventually gigabit Ethernet should work over twisted pair wires over short distances, making it viable for connecting individual users to a LAN.

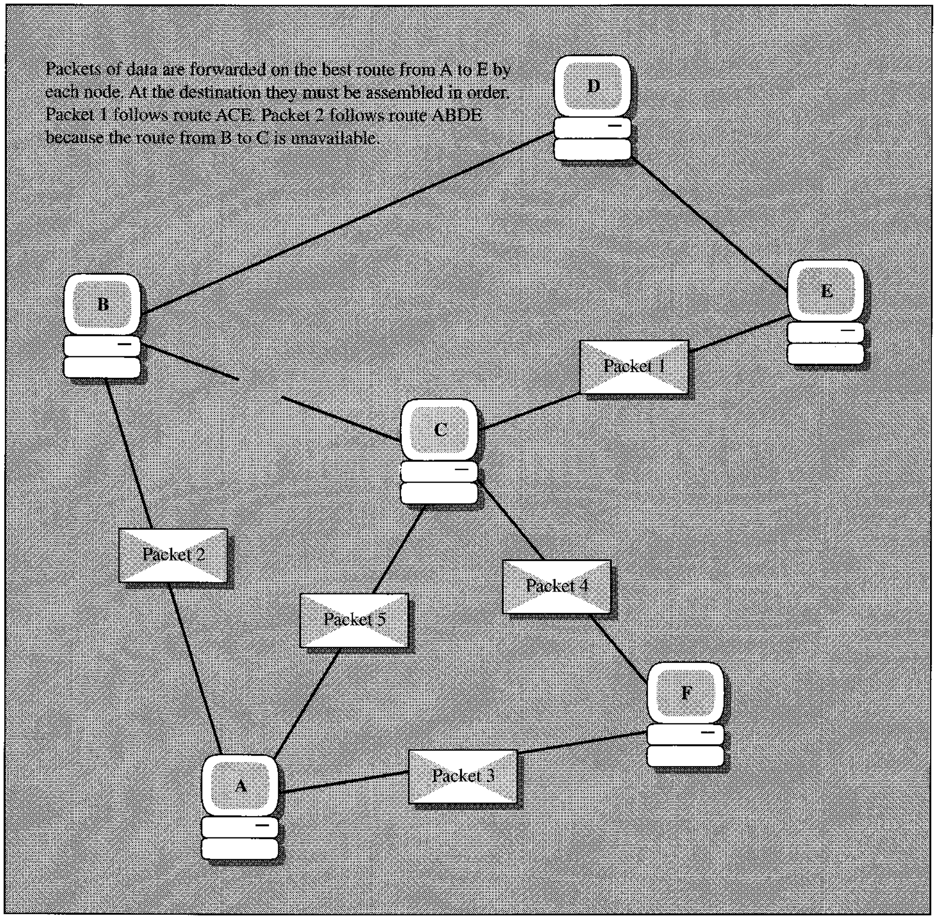


FIGURE 11-9
Packet switching.

Frame relay is a service offered by some of the common carriers to transmit data for wide area networks. The user chooses a data rate and connects to the common carrier's frame relay system through a router. The common carrier maintains a packet-switched "public" frame relay network, which offers higher speeds than some private network alternatives. This common carrier network also features extensive backup and rerouting capabilities, making a service outage less likely. Speeds with frame relay are lower than with ATM, ranging from 56,000 to 1,544 Mbits/second.

Another service is switched multimegabit data services (SMDS). Some regional carriers are now offering this type of service in the U.S. as an alternative to building a private network for high-speed data transmission. SMDS is a high-speed fast-packet data service with speeds ranging from 1.17 to 45 Mbits/second. With this service, there are no connections; it is a true packet-switched network. You

What Does Speed Really Mean?

We frequently talk about various speeds of transmission in numbers that can be a little hard to relate to as users. The following three types of transmission provide a little better sense of the difference transmission speed means in terms of sending a message:

- Using a 56 Kbps (bits per second) modem to change a digital signal to analog form and send a 1 Mbyte file would require 2.3 minutes if the total transmission occurred at peak speed.
- Using ISDN, which combines two 64 Kbits/second channels to yield a rate of 128 Kbits/second, this megabyte file would take 62.5 seconds to transmit at peak speed.
- Using a cable modem at 1 Mbit/second would take 8 seconds.
- Using asynchronous transfer mode (ATM) at 155 Mbits/second, the megabyte file would take 0.05 seconds to transmit. (ATM speeds range from 50 to 622 Mbits/second.)

Companies with large amounts of data to send are very interested in ATM networks based on this kind of calculation. Many of us would like to have ISDN lines to use for videoconferencing and to access the Internet.

can send data to any other user on the network if you know the recipient's address (and the recipient is willing to accept the data). SMDS is intended for corporate networks and can be used, for example, to integrate high-speed LANs.

Various common carriers in Europe, the United States, and elsewhere offer **integrated services digital networks (ISDNs).** ISDN services include voice and data transmission, although not at the high speed found on T1 circuits. With the right equipment, a pair of traditional copper wires can carry two simultaneous voice or fast-data signals. A third channel on this line is used for messages between the communications equipment. Each of the two digital data channels operates at a speed of 64 Kbits/second while the signaling channel operates at 16 Kbits/second.

While it has been slow to develop, ISDN offers some real advantages for business and even home use. Using compression algorithms, an ISDN line can obtain acceptable video and video conferencing. A business might use ISDN for a wide area connection between LANs, something that takes place on an occasional basis. ISDN has been used to transmit high-resolution CAT scans to a consulting physician located far from the patient.

As the cost for ISDN drops, its use becomes appealing to telecommuters and the home office. An ISDN card in the PC is the only interface needed after a common carrier installs the line. ISDN offers high-speed access to corporate computers; it can access the Internet (see the next chapter) and can be used for multimedia applications.

The transmission standards and protocols for ISDNs have been standardized, so eventually the service should be available almost worldwide. ISDN services are a viable alternative for developing a communications network, especially for an organization that does not need extremely high-speed or high-bandwidth communications.

Competing with ISDN is **asymmetrical digital subscriber line (ADSL),** which offers two rates of transmission depending on the direction. The line is connected to a modem at both ends, and it is possible to send both voice and data over the same twisted pair copper line at the same time. Data coming in move at a higher speed than data going out, which is well-suited when using the Internet. You send a small amount of information to a server and receive a lot of data in return. Data going to the telephone office move at speeds of 16 to 640 Kbits/second. Data returning travel at 1.5 to 9 Mbits/second. There are a number of limitations on ADSL, especially distance, and it is not clear how successful it will be at this point.

Your local cable TV company is also interested in providing communications, especially an Internet connection through a **cable modem.** Because cable has a great deal of bandwidth, the potential exists for extremely high-speed connections to the Internet. The nominal bandwidth for cable is 27 Mbits/second for data coming to your PC. However, this bandwidth is shared among a group of users, about 25 in most systems. With overhead and limitations on modem speed, the actual bandwidth available to an individual user is on the order of 500 Kbits/second to 1.5 Mbits/second. However, there are several challenges to be overcome before this approach is feasible. First, cable TV has traditionally been a one-way service: The cable company transmits data to your house, but you do not send much, if any, data back. For Internet access, the cable company must be able to handle meaningful two-way communications; the return path does not have to be as fast as the path to your house, but it has to exist and operate at a reasonable speed. Our local cable company has installed fiber optic lines and offers Internet access for a number of cities. The service is extremely fast and, so far, reliable. The company contracts with @home.com to provide an Internet portal. Because local subscribers share the same cable, the more customers using a cable modem, the slower the response.

Asynchronous Transfer Mode (ATM) is a form of packet switching that does not actually use the TCP/IP protocol. Instead, ATM uses cells of fixed length, generally 53 bytes. Because cell lengths are uniform, ATM can carry voice, video and data traffic without sacrificing much efficiency. A conversation requiring the carrier to dedicate a 64-Kbps line may only require 16 Kbps capacity on a packet-switched network, reducing costs and improving service. TCP/IP may send each packet via a separate path while ATM sets up a "virtual circuit" for the duration of a transmission, ensuring that the packets arrive in their original sequence. In 1999, AT&T announced that it would no longer buy traditional telephone switches, but would instead purchase ATM switches. In effect, this announcement marks the end of the circuit-switching era of communications and means that the major communications carriers are embracing packet switching.

Data Speeds in the Future Bell Laboratories, a part of Lucent Technologies, is at the forefront of research on how to expand the capacity of communications networks. A new technology called wave-length division multiplexing, or WDM, offers the possibility of dramatically faster communications at lower costs. WDM uses light of different colors, all of which are in the invisible infrared spectrum, to carry multiple streams of data. Each color goes from end to end of a glass strand in a fiber optics cable, and each color can carry its own stream of data. Today there are commercial WDM systems available with 40 hues. Lucent has sent data at a rate of one trillion bits per second using WDM in the laboratory. Such capacity would allow Hollywood to deliver movies to theaters in seconds. Speeds are anticipated to reach 200 terabits per second, enough to deliver the contents of the Library of Congress in a second. WDM is especially exciting because it uses existing fibers; there is no need to dig up cable. All of the changes take place on the sending and receiving ends of the circuit (*Business Week,* December 7, 1998).

What are the implications if this technology proves to be a commercial success? Imagine having a high-speed connection with anyone in the world for a nominal cost. Companies could be connected at extremely high data rates to all of their suppliers and customers. The possibility of extremely fast, virtually unlimited capacity communications at a nominal cost suggests many exciting applications that will change the way companies do business.

Why Develop Private Networks?

In the early days of communications among computers, firms typically designed a network for each application. A bank might have a network for demand-deposit balances, a network for inquiring about loan balances, and so on. The bank branch would be served by a number of separate data networks plus the public telephone system.

More and more companies are building communications networks that carry data, voice, and video signals over the same communications lines. With today's

Substituting Electronic Communications for Travel

In the middle of an economic boom, many companies are cutting back on travel due to rising airline fares for business travelers. American Express figures that expenditures for travel and entertainment have risen 25 percent since the Gulf War; business fares are up 20 percent or more in major markets. Some travel industry surveys have indicated that companies are reducing travel by up to 15 percent. Black & Decker has in the past sent employees on around 25,000 trips in a year, but this year it managed to reduce that number by 2000.

A company like Bell Atlantic is substituting teleconferencing for some face-to-face meetings. One manager now holds staff meetings on phone and video instead of flying eight employees to New York twice a month. Before each meeting, he distributes documents by e-mail. The total savings are $72,000 a year, and this manager figures the company could cut its travel expenses by 10 percent if it held more conferences electronically.

Electronic communications can substitute for certain kinds of travel, saving both money and the time of those who normally travel to face-to-face meetings. Social contact among people who work together is important, but communications allow you to reduce the number of physical meetings, though not eliminate them altogether.

technology and the deregulation of the communications industry, a firm can develop a network that includes common carriers or excludes them completely.

A company might lease lines and use the local telephone company for the local distribution of voice and data at the ends of the leased lines. Alternatively, it could bypass the telephone system completely by using satellite distribution. The brokerage firm discussed in Chapter 13 communicates with its branch offices throughout the United States by leasing time on a satellite transponder. It places a satellite dish on its headquarters and one on the roof of each branch office. The firm can now send voice, data, and video signals without using the public telephone network.

The offerings described in the preceding section—frame relay, SMDS, and ISDN—represent efforts by the common carriers to offer an alternative to private networks. Although these same carriers may lease lines for a network, it is likely that the total amount of service they provide will drop if a private network is installed. The decision whether to use common carrier facilities or develop a private network is a very difficult one. Even a small firm may lease a line between a corporate headquarters office and a factory some distance away. Large firms often have worldwide private networks.

The decision to develop a private network must be based on cost considerations, service levels, planned communications growth, and a forecast of what services will be available from common carriers. Also competing with a private network is the Internet, which can be used for a variety of communications needs. However, the Internet of today is not well suited to high-volume transactions like those that travel over the private networks maintained by the airlines and many banks.

Worries about Network Security

There have been many network security problems; networks are a tempting target for mischief and fraud. An organization has to be concerned about proper identification of users and authorization of network access, the control of access, and the protection of data integrity (Goldman, 1998). A firm must identify users before they are granted access to a corporate network and that access should be appropriate for the given user. As an example, an organization may allow outside suppliers access to its internal network to learn about production plans, but the firm must prevent them from accessing other information like financial records. Finally, the organization should preserve the integrity of its data; users should only be allowed to change and update well-specified data. These problems are exacerbated on the Internet, which we discuss in the next chapter, where individuals must be very concerned about fraud, invalid purchases, and misappropriation of credit card information.

Providing network security is a difficult challenge. Almost all networks require some kind of logon, including user name and password. Many people are casual with their passwords, making them easy to guess. A good password has both letters and numbers along with a few punctuation marks for added security. Most corporate security goes far beyond passwords, however. One common approach is a "fire wall," a computer that sits between an internal network and the Internet. The fire wall allows access to internal data from specified incoming sites but tries to detect unauthorized access attempts and prevent them from occurring.

For highly secure communications, a sender can encrypt data, that is, encode the data so that someone without the "key" to decode them cannot read the message. There are a number of encryption approaches, and controversy exists over how strong the encryption should be. The most secure approaches use longer keys, making it much more difficult for an intruder to compute the key. However, the U.S. government is concerned about terrorists and criminals who might have access to strong encryption that is beyond the capabilities of law enforcement authorities to decrypt. There are also export restrictions on encryption programs.

For Internet commerce, various schemes have been proposed for sending credit card or other payments over the network in a secure manner. Some involve encryption and others various forms of digital certificates or digital cash. Many firms worry that customers will not want to complete transactions on the Internet because of the fear their credit card numbers might be stolen. At least one card issuer has agreed to cover such losses completely, and there is a law that limits individual liability for credit card misuse to $50. How do you dispose of your copies of a credit card receipt from a store or restaurant? Do you throw them in the garbage where someone else can access your number? Is the Internet more or less secure than a paper credit card transaction?

THE CONTRIBUTION OF COMMUNICATIONS

Firms take advantage of the opportunities provided by telecommunications and networks in a number of ways. Two important contributions of this technology are electronic mail (e-mail) and electronic data interchange (EDI). In several industries, information technology is also used to create electronic markets.

Electronic Mail as a Communications Tool

One of the most beneficial results of the marriage of computers and communications technology is electronic mail. Computer users with appropriate software and communications links can send messages and documents to other computer users. Electronic mail is analogous to physical mail handled by the post office, except it is not stored or handled physically. When someone sends you an e-mail message, it goes into your "mailbox" on the computer. When you check your mail, the message is there for you to read and respond to if you like. It has been estimated that more than 40 million people in the U.S. use e-mail.

How does e-mail work in industry? Recently, some 53 engineers at Digital Equipment Corporation in Massachusetts, Arizona, Colorado, Singapore, and Germany collaborated on the design of a new disk drive using e-mail. Most had never met, and the engineers rarely phoned each other. DEC estimates that this diverse group completed their task a year sooner and with 40 percent fewer people than a comparable team assembled in one building.

Most companies with large e-mail systems also have large networks. Hewlett-Packard has a network of 94,000 mailboxes and a volume of 350 million mail messages a year for its 90,000 employees. (There are more mailboxes than employees because some mailboxes are assigned to workgroups.)

In 1991 the faction in the Soviet Union trying to overthrow Gorbachev told the world that he was "sick." They also told the Soviet population that the international community supported their new government. Within hours, computer and fax machines in Russia received information from around the globe that contradicted these assertions. Supporters rallying around Boris Yeltsin at the Russian White House received e-mail messages on a Moscow computer that NATO, the U.S., and other countries were on their side. It was easy for the members of the coup to control domestic newspapers, radio, and television, but it was not nearly so easy (and they probably did not realize it existed) to control communications via e-mail.

Electronic Data Interchange

When we discussed corporate strategy in Chapter 5, we made the point that the firm must be connected electronically with customers and suppliers. One rapidly growing technique for this type of interconnection is EDI. Detroit auto manufacturers were among the first companies to encourage suppliers to accept orders electronically. The idea is simple: A buyer sends an order electronically to the supplier, and the supplier acknowledges the order electronically. When the supplier sends the ordered items, the customer electronically acknowledges receipt. Similarly, the firms set up an electronic billing and payment system. The concept is very simple, but the reality of implementing EDI is much more difficult.

Because each firm has its own formats for each of the paper documents used prior to EDI, there are problems of compatibility. Where is the quantity-ordered field on a GM order? The American National Standards Institute (ANSI) has developed a standard known as **ANSI X.12** to specify common document formats for the transactions involved in ordering, receiving, and paying for merchandise. (It can take some 17 different transactions to complete an order.)

You can purchase packaged software to help implement EDI, and newer generations of this software allow for mapping. A programmer can map the fields from your invoice into the location of fields in a supplier's purchase order system. You can then place your order in its accustomed format, and the software will translate it into an order that the supplier's system can accept. Given all this overhead, it can take a significant amount of time to develop EDI links with customers and suppliers.

As you might have observed, this type of EDI is basically a batch transmission. At different times during the day, a firm connects its computers with different EDI partners to transmit and receive data. The next step in development will be on-line access. Customer and supplier computers will be connected all day so up-to-date information will always be available.

A Data Pipeline at Amoco

In today's oil business, an Amoco executive puts it simply, "The company that finds the most oil makes the most money." However, drilling for oil is very expensive. A high-speed network would let engineers and geologists rapidly access the information they need to identify promising drilling sites. The objective of Amoco's high-speed data pipeline project, begun in 1993, is to cut the screening time for drilling data from months to hours.

To accomplish this goal, the company built the Aries network, which has nearly a dozen T3 (45 Mbits/second) circuits and leased lines along with a satellite T1 (1.544 Mbits/second) link to offshore platforms. The network is based on ATM technology and includes routers, adapters, and ATM switches. Actual ATM services are provided by three different common carriers.

At a demonstration in Washington, D.C., a participant used the Internet to surf through Web servers in Minneapolis and returned information in minutes instead of the hours required using dial-up links. Geologists at workstations in Houston and Washington worked collaboratively on a huge seismic data set delivered from an offshore oil platform. A site in Chicago broadcast a full motion video segment to Houston, Washington, and Tulsa.

Amoco is ahead of most firms in setting up this kind of high-speed network. It is an excellent precursor for the kind of networks that should start appearing in business.

Beyond the Model T

Ford Motor Company has a rich history of technological innovation. After all, Henry Ford developed the first assembly line. Ford is continuing to develop closer links with its suppliers using EDI. It was a pioneer in the field in the 1970s. Ford began by compressing the time it takes to order and receive goods and is now working on eliminating the need to track goods on the way to its plants and to audit supplier invoices.

Most EDI is not real-time. While data are exchanged electronically, the transmission process sends a batch of documents at one time. For many firms there is no need for an order to be processed immediately upon transmission from a customer. However, as manufacturers move toward more just-in-time manufacturing, communications will have to be faster.

Ford established direct links with its suppliers who can now dial in to Ford's mainframe material system, which tracks inventory at the car maker's 20 assembly plants. Ford's 61 manufacturing locations and 10 of its parts supply sites will soon be on-line. Suppliers send their asynchronous inquiries to a value-added network offered by Tymnet. [A **value-added network (VAN)** provides a range of services to its customers. The network vendor generally leases lines from a common carrier and adds services or value to the leased lines.] The network converts the traffic to the IBM mainframe data stream needed to access Ford's computers. A typical supplier logs in four or five times a day to check Ford's inventory so it can coordinate production with the automobile manufacturer.

MANAGEMENT PROBLEM 11-2

Mary Levin works in planning for Loadstar, a large trucking company and barge operator in the Midwest. She has looked into a variety of systems to keep track of the location of trucks and barges so that the company can route shipments better and answer customer inquiries faster. Mary recognizes that barge and truck shipments are quite different.

"My major concern is with the trucks—our barges have commodities and take weeks to move something. It is much harder to keep up with trucking." Mary has collected information on a variety of products that can help track trucks.

"We could do something sophisticated. For example, the Global Position System (GPS) used for air and marine navigation would allow us to pinpoint the exact location of a truck." This GPS system uses a receiver that tracks satellites that move around the world in relatively low orbit. The clocks on the satellites are synchronized, so the receiver can tell how far it is from each satellite. It computes the length of an imaginary line between the satellite and the GPS unit. For navigation on land or at sea, three lines of position are enough to provide accuracy within a hundred meters or less. Loadstar would need a system that could identify the truck and send the ID and GPS data to headquarters. There are several packages the company could buy for this system.

Another possibility is to use a cellular phone in each truck and have the driver call in at certain hours. Mary said, "I don't need to know that a truck is at a certain latitude and longitude. If the driver says he or she is at milepost 50 on Interstate 80 in Nebraska, that's good enough."

What solution do you recommend? Why?

Large suppliers are even establishing dedicated links into Ford systems. Employees at Dana, a major components supplier, will be able to use the terminals already on their desks to toggle between Ford systems and internal Dana computers. Ford allows suppliers to update its database when they send a shipment of parts.

Ford no longer accepts invoices from suppliers. When parts arrive at a Ford facility, an employee scans a bar code on the crate containing the parts, generating an electronic receipt. The receipt message travels over Ford's network to the accounts-payable department, which matches the order with a price previously negotiated with the supplier. Ford mails a check (maybe someday an electronic payment will be possible) and sends an electronic remittance message to the supplier. Ford's suppliers all participate in the electronic receipts program while about 150 receive remittance information. The advantage to Ford is that the supplier has to audit payment, rather than Ford having to audit invoices.

As you might expect, Ford's EDI program does not end with suppliers. Ford has 12 major railroads with which it exchanges EDI transactions. Ford issues an electronic bill of lading when goods must be moved between sites, using the ANSI X.12

standard. The electronic bill of lading goes to the railroad via a direct link or through IBM's Information Network. The railroad returns an acknowledgment and takes over the responsibility for tracking the shipment.

Ford also wants to encourage its suppliers to communicate by e-mail. The firm wants to save on overnight-mail and long-distance charges, and to improve response times over the typical phone call (which ends up on an answering machine). E-mail could also replace a cumbersome paper-based process for cost-saving ideas submitted by suppliers. Ford figures that e-mail will make it so easy to send suggestions, it would get far more ideas from the suppliers than it does today.

Ford also has another network for sending computer-aided design (CAD) diagrams among plants and to suppliers that use Ford's CAD system. This packet-switched network uses a combination of public and private lines. Suppliers can download design plans from Ford to incorporate changes in different parts more quickly.

Building an Electronic Market

As companies use communications for buying and selling products, they are creating electronic markets, as we discussed in Chapter 4. One of the oldest and most successful electronic markets is the NASDAQ, the market for over-the-counter (OTC) securities (securities not listed on the New York, American, or regional stock exchanges in the U.S.). Members of the National Association of Securities Dealers use this system for trading. If you buy or sell OTC shares, your broker uses this system. The NASDAQ is an on-line computer system in which market-making firms post bids and ask prices for individual securities. Other brokers can accept these quotations and transact business for their clients. The system is very successful and was adopted by Japan to create an electronic market.

In the U.S. there are a number of other electronic markets including TELCOT, a market used for trading cotton. In France, the national Minitel system makes it possible for a number of firms to sell their products very inexpensively using computer terminals. To the extent that there are competing firms offering products, a Minitel user can compare prices among the different vendors, creating another type of electronic market.

We could argue from a strategic standpoint that batch-oriented EDI tends to reduce market competition by creating a close link between a supplier and a customer. With a proprietary interface, switching to another vendor is difficult. As industries adopt standards such as ANSI X.12 or use the EDI services of a value-added network, this linkage is weakened because now it is easy to switch to another supplier. In a full electronic market like the NASDAQ, where everyone is on-line at the same time, firms can easily switch vendors and there is little strategic advantage to an electronic link between one firm and another. All players tend to be equal in an electronic marketplace.

TRANSFORMING ORGANIZATIONS AND THE ECONOMY

In a mature firm, you are most likely to encounter an infrastructure that features networked computing. There will be computers of varying capacities at different

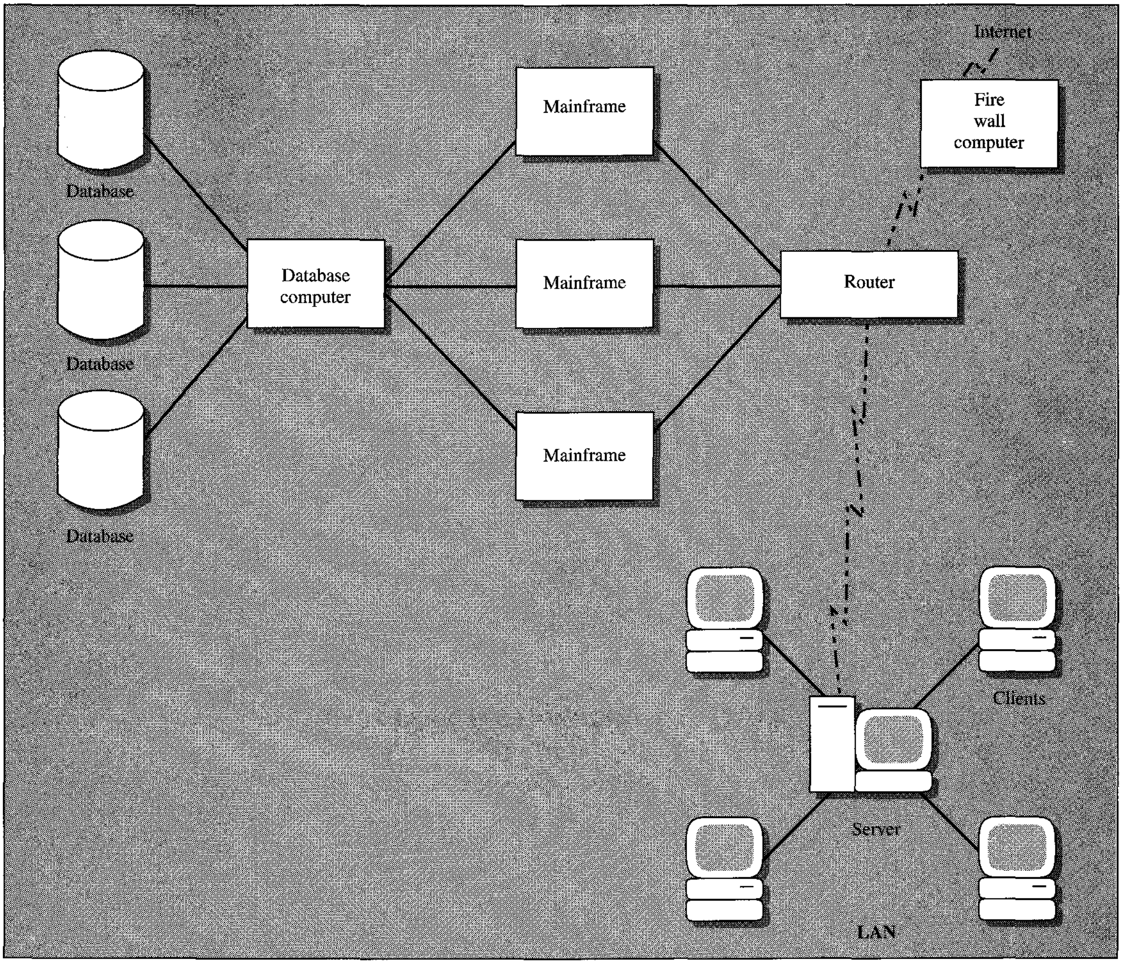


FIGURE 11-10
A typical computing complex.

nodes (see Figure 11-10). There are local workstations, **terminals** with significant logic, and built-in personal computers. Communications networks tie all the various devices together and help to interface dissimilar pieces of equipment. In Figure 11-10 we see a group of interconnected mainframes for transactions processing and access to large data files. The mainframes manage a large database through a specialized database processor. The mainframes also act as large servers for users on the network.

A router links the computer to remote workstations, consisting of personal computers and servers in a local area network. There is a gateway (a connection between two computers on different networks) to other networks as well. The firm is connected to the Internet over one gateway and has a server that allows

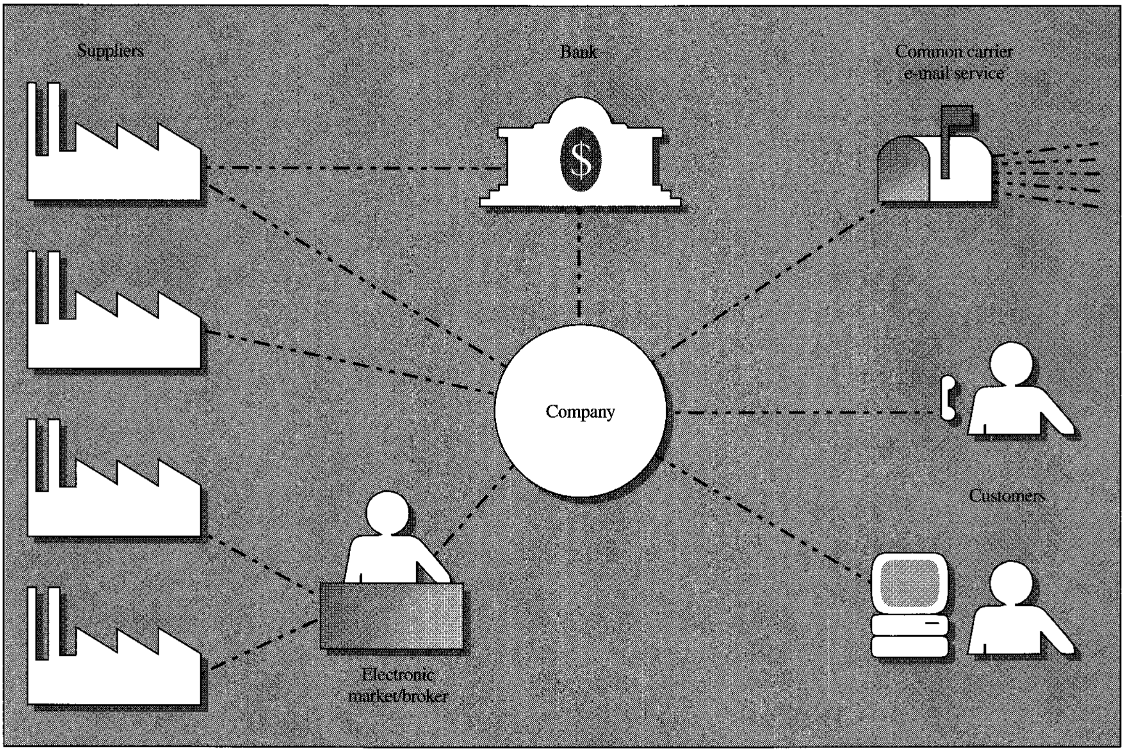


FIGURE 11-11
The electronic economy.

customers to obtain transactions information from the mainframe via the Internet. All these trends lead to an increasing availability of computation and significant opportunities for inventive information systems.

Figure 11-11 shows how this typical firm is connected with other organizations, including suppliers, customers, and financial institutions. The development of **interorganizational systems (IOSs)** is having a dramatic impact on the way firms operate. In the figure, the company is connected directly with its suppliers and customers, probably through some form of EDI using an industry standard format. For some suppliers, the company may make use of an electronic market for its purchases. The firm is connected to the Internet for e-mail, which it uses to communicate with a large number of other entities. Electronic links to banks and other financial institutions eliminate much of the paperwork involved in processing receipts and payments.

The vision of an electronic economy emerges from Figures 11-10 and 11-11. Firms are networked both within the firm and externally to other participants in the economy. They use electronic communications and linking and electronic customer-supplier relationships to design their organizations. Information technology makes possible the sharing of data and information while facilitating communications and coordination among key components of a postindustrial economy. It is this combination of computer and communications technologies that is transforming not only the organization but the economy as well.

CHAPTER SUMMARY

1. Communications is the key to developing greater connectivity among individuals within a firm and among different organizations.
2. The simplest communications occur between two computer devices, such as a PC connected to a server.
3. Your PC uses a communications protocol such as Ethernet to communicate with the server.
4. If you are using the dial-up phone network, a modem translates the digital signals from your PC to an analog format for transfer over the phone line. At the receiving end, a modem demodulates the signals and produces digital output.
5. Most long-haul communications lines and the lines within many cities are digital. The analog data from the local loop to your phone has to be digitized to use these lines. The phone companies also want to digitize video information (like movies) to send it to your home.
6. A network connects a variety of computers and other devices. The LAN is the smallest such network and may connect only a few computers in a department.
7. Larger networks extend over thousands of miles, and there are a number of global networks.
8. A company may lease lines from a common carrier in order to build a private network. The company can use this network for voice and data transmission.
9. The common carriers are also offering services that companies pay for on a usage basis instead of leasing lines. An example of such a service is frame relay transmission.
10. Greater connectivity through networking has increased the use of EDI, which draws customers and suppliers more closely together. It is one way in which communications and networks are transforming relationships among companies.

IMPLICATIONS FOR MANAGEMENT

The combination of computers and communications has a greater impact than either element alone. Computers alone are great for computation and for maintaining huge databases. Add telecommunications and you create a myriad of new ways to apply information technology. Communications and networks have finally convinced some skeptics who argued that computers are nothing but large, fast calculators. Computers and networks offer both computational and communications capabilities that allow for an unprecedented level of coordination and communication within and among firms. Communications is one of the fundamental tasks of management.

KEY WORDS

ADSL
Amplitude
Analog signal
ANSI X.12
ASCII
Asynchronous transfer mode (ATM)
Asynchronous transmission
Attenuation
Bandwidth
Baud
Block mode
Bridge
Byte
Cable modem
Character mode
Code
Compression
Concentrator
CSMA/CD
Demodulation
Ethernet
Frame relay
Frequency
Full duplex transmission
Gigabit Ethernet
Half duplex transmission
Host
Integrated services digital network (ISDN)
Interorganizational system (IOS)
Local area network (LAN)
Metropolitan area network (MAN)
Modem
Modulated
Multiplexer
Multiprotocol router
Network
Network Interface Card (NIC)
Node

Packet switching
Point-to-point protocol (PPP)
Protocol
Pulse code modulation (PCM)
Router
Satellite
Server
Simplex transmission
Switched network
Synchronous mode
Terminal
TI
Token ring
Transmission Control Protocol/Internet Protocol (TCP/IP)
Value-added network (VAN)
Voice-grade
Wide area network (WAN)
X.25

RECOMMENDED READING

Goldman, J. E., *Applied Data Communications.* 2nd ed., New York: John Wiley, 1998. (An up-to-date communications text with a management perspective.)

Panko, R., *Business Data Communications.* Upper Saddle River, NJ: Prentice-Hall, 1997. (A thorough coverage of communications, both voice and data.)

Varshney, U., "Networking Support for Mobile Computing," *Communications of AIS.* 1, 1999. (A well-written tutorial on mobile computing. Also look at http://www.cais.aisnet.org)

DISCUSSION QUESTIONS

1. Why were the first telephone communications over analog circuits?
2. What is a protocol?
3. What is the greatest limitation on transmission speed in the public switched telephone network?
4. What are the advantages of digital over analog lines?
5. Why are communications between computers digital in nature?
6. Why do we use an 8-bit code for transmission instead of one that is 5 or 6 bits?
7. Explain how Ethernet keeps two networked PCs from transmitting at exactly the same time.
8. Why are standards so important in communications?
9. What is the difference between synchronous and asynchronous transmission?
10. What is the advantage of using voice-grade lines for time-sharing in a university environment?
11. Why is packet switching so popular for computer networks?
12. Describe at least one network configuration. For what applications do you think it is most suited?

13. How do you connect different networks to each other?
14. How can you use packet switching to connect to the Internet with a service provider using your home telephone?
15. What are the major differences between a LAN and a WAN?
16. Why would a bank develop its own entirely private communications network using satellites?
17. What function does a multiplexer serve?
18. What is the difference between a multiplexer and a concentrator? A router?
19. When should a firm consider using the Internet versus developing a private communications network?
20. Why might a LAN not have a host computer?
21. Can you think of any disadvantages of satellite communications?
22. What has motivated the common carriers to develop frame relay, ISDN, and ATM communications lines?
23. Why is a communications specialist needed to design a network?
24. Think of a business with which you are familiar. In what ways would a network and data communications aid this firm?
25. Why does the systems designer need to have some knowledge of data communications?

CHAPTER 11 PROJECT

Database Assignment, Part III

Mary Simon looked at the portfolio application and said, "This is just what I need for a job I've just taken on. Of course, this job really isn't for Simon Marshall Associates—but then again, one good source of clients would be our alumni." Mary had just agreed to help in fund-raising for her school and realized that the campaign would require some good record keeping.

Your third database assignment is to set up the alumni contributions records system for Mary. The key to this assignment is to remember that relations can be merged through a join operation.

Alumni Records

Mary Simon is very active in the alumni affairs of her university. She has been asked to keep track of the alumni contributions flowing into the university, most of which we hope are for the business school. The records she needs to keep are contained in four relations:

Alumni
Contrib
School
Type

Please do the following exercises:

1. Create a list of donors who have given a chair or endowment.
2. Create a list of donors who have given unrestricted funds to the business school.
3. Create a list of cities showing total contributions from each. You will find it helpful to use the sort command and to create a report to do the subtotaling by city.
4. Use the report generator to create a report showing the last name, zip code, and amount of each donation along with a printed message showing the school and type. For example, if someone had a school of 4 and a type of 1, the report should read "Business" and "Endowment." Your report should include the sum of the donations.

Alumni

Last name	First name	Street	City	State	Zip
Smith	John	18 Portland Rd	Chicago	IL	12345
Doe	Mary	90 Trinity Place	New York	NY	10006
Carson	John	177 Dover Center	Omaha	NE	68114
Altman	Sam	1600 Pennsylvania Av	Washington	DC	11111
Giuliani	Rudy	City Hall	New York	NY	10101
Smith	Tom	34 Harvard St	Cambridge	MA	02139

Contrib

Last name	Zip	Type	School	Amount
Smith	12345	2	1	50,000
Smith	12345	1	3	40,000
Doe	10006	4	4	100,000
Carson	68114	3	2	50,000
Carson	68114	4	1	25,000
Giuliani	10101	3	2	10,000
Smith	02139	3	4	45,000
Smith	12345	3	2	75,000
Smith	12345	4	4	38,000
Doe	10006	3	3	150,000
Giuliani	10101	4	2	50,000
Giuliani	10101	2	1	10,000
Smith	02139	4	3	18,000

School

School code	Name
1	Arts & Sciences
2	Law
3	Medical
4	Business

Type code	Type
1	Endowment
2	Chair
3	Special
4	Unrestrict

CHAPTER 12

Networks and Electronic Commerce

Outline

Focus on Change

A decade ago, academic, government, and research organizations owned the Internet. Companies could not use the Net for profit-making activities. Since the government stopped funding the Net and removed the profit-making restriction, the Internet has literally changed the world. Almost every country in the world, and certainly all developed countries, are connected to the same computer network. Internet companies present new models for doing business, and their stocks sell for fantastic prices. The Net affects individuals, organizations, the economy and national governments. For an example of frame-breaking change from technology, we need look no further than the Internet.

Networks also facilitate the development of new forms of organization. They are key to building the T-Form organization discussed in earlier chapters. Networks make it possible to connect with partners and customers as they encourage firms to form strategic alliances. Networks facilitate the creation of virtual subunits, where your firm relies on another to provide a component that you would normally manage, such as a raw materials inventory.

•

One of the most important developments in the history of information technology is the evolution of the computer from a calculating engine to a communications tool. As a calculator, computers are extremely valuable. It is hard to imagine businesses operating on the scale they do today without the capabilities of the computer. However, the computer's role as a communications device may dwarf its impact as a calculator. Computers and communications are allowing us to change the structure of organizations and the nature of commerce.

In this chapter we look at the world of **networks.** The first networks were used by business for electronic linking and communications and for electronic customer-supplier relationships. Most proprietary or private networks were developed for use within a single enterprise. For example, the first bank networks connected tellers in branches with a central computer that had information about customer checking accounts.

Electronic data interchange involves customers and suppliers. Here companies agree to standards for exchanging information. Railroads and their shippers agree on a standard to use for the data that must be exchanged for shipping

More than a Phone Call

The existing U.S. telephone network is constantly upgraded. Higher speed and capacity links are having a dramatic effect on life in some parts of the country, especially in rural areas. Some 400 rural counties where population dropped during the 1980s are now growing, and 900,000 people moved to rural counties during 1990 and 1991. To revive its rural areas, Nebraska state officials pushed local phone companies to install fiber-optic lines and digital switches. The carriers laid 6700 miles of fiber-optic lines in the state linking all but five of the state's counties.

The impact of this new network has been dramatic. During the 1980s, Aurora, NE, with a population of 3800, had over 12 empty store fronts and the population was shrinking. Today the unemployment rate is less than 1.5 percent, and all the stores are occupied. An Aurora pet food plant uses the network to link to its headquarters in Ohio and to shippers and customers around the country. The company said that a decade ago communications would not be on its top 10 list of reasons to locate a plant someplace. Today it is in the top three.

One small high school in a town of 135 people uses the network for interactive television classes in Spanish since the school is not able to justify the cost of hiring a language teacher. Students use a fax machine for written work. Ainsworth, NE, has a two-way videoconferencing unit in the town library. Recently senior citizens used the system to discuss arthritis with nurses in Omaha.

products by rail. A new customer can begin exchanging data with the railroads by following this message standard.

Mass market networks appeal to consumers. Examples of these networks include **America Online** and the **ATT Worldnet** in the U.S., and the **Minitel** system in France. Minitel has grown to be more than just a mass market consumer network as it provides a number of business services as well. The most significant network in terms of growth is the Internet. This chapter explores the Net and examines the potential that all these networks have for electronic commerce.

THE IMPACT OF COMMUNICATIONS TECHNOLOGY

In the last chapter, we discussed the telephone system as an example of a large international network. This network has a number of important features. First, it is ubiquitous, at least in the U.S. where almost all residences have a telephone. Even though there are different phone companies, they all "interoperate"; that is, a call from a regional Bell company can be made transparently to a phone in a GTE company. By adhering to international standards organizations, telephone systems interoperate at the country level, and you also can direct dial phones in a large number of foreign countries. This phone network carries voice and data.

One of the nicest attributes of the telephone network is its physical presence. We have a communications infrastructure that makes it simple to plug a new telephone or fax into the network. We can buy a telephone from a number of different sources and know that it will function on the network because there are published standards and because vendors manufacture their equipment to meet these standards.

BUILDING NETWORKS

Developing **computer networks** is not as easy as adding a telephone. There is no single infrastructure for data comparable to the voice network. Of course, one can simply use modems and dial-up voice lines, but for many applications this alternative is either too costly or not feasible because the voice lines are too slow for data transmission.

In the U.S., we typically find that companies have developed two different kinds of networks, electronic data interchange **(EDI)** and/or proprietary data networks. Generally, EDI refers to networks in which multiple parties have agreed to follow a standard for exchanging data electronically. EDI networks exist in retailing, transportation, and insurance. There is a national standard in the U.S. called ANSI X.12 and a European standard called EDIFACT. Most EDI takes place in batch mode; a computer generates orders and sends them to a supplier. The supplier receives the order and processes it and other orders when convenient, possibly in a batch. There is little or no on-line interaction between people as there is when you use the Internet to order a product and interact with a company's Web site.

In private industry and government, EDI is extremely popular for lowering costs while increasing accuracy and quality in purchasing goods. One objective of EDI is to reduce manual keying, thereby reducing errors and speeding up the order cycle. By exchanging data electronically, organizations can change their production cycles and the kind of services they offer.

Despite their achievements, EDI networks have less impact than one would expect because they cannot rely on a common telecommunications infrastructure. As a result, to use EDI effectively takes expertise and resources. The high cost of networking gives larger firms an advantage over smaller competitors in using data networks. The Chrysler JIT-EDI example shows tremendous gains, but Chrysler is a very large company, ranking in the top 15 in sales in the U.S.

Given the lack of a data network infrastructure in the U.S., firms face a bewildering number of choices when considering the development of a network application. These applications are expensive to develop since there is much reinvention with each new network. For companies to exchange data they must completely agree on data formats. A firm sending a purchase order must put data in exactly the right place in the electronic message so the supplier can interpret it.

The **ANSI X.12** standard is intended to facilitate this process, but a number of industry-specific networks do not conform to the standard. Due to incompatibilities, some press reports indicate that up to 50 percent of the data exchanged via EDI need rekeying. A firm must change its internal computing systems or purchase special software to map the data from existing systems to an accepted EDI standard. While some service companies can help a company get started and PC EDI packages are available for smaller firms, the start-up and maintenance costs are too high for many companies. It is also hard to get all trading partners to use EDI. Generally, large firms are more sophisticated technologically and can afford the development cost.

To alleviate these problems, a group of Northern California companies created a consortium called **CommerceNet.** The objectives of this ambitious project are to allow companies that have never done business before to establish and maintain a relationship electronically. The company plans to use the existing Internet, discussed later, as its underlying network. It must develop agreements on standards for proposals, bids, price lists, and other transactions. The idea is that a company, say in Palo Alto, could put out a request for proposals in the morning and receive bids from respondents all over the world by evening. The next morning it could send an electronic purchase order to the winner. AT&T, Novell, and Lotus are also working together to allow companies to link Notes and NetWare networks more easily, thus creating another venue for electronic commerce.

Partially because firms cannot rely on a national data infrastructure, they have developed elaborate private or proprietary networks, sometimes using common carrier facilities and at other times bypassing them completely. Examples of familiar companies using proprietary networks include Federal Express and United Parcel for package delivery, United and American Airlines for their reservations systems, Frito-Lay for distribution and decision support, and Allegiance for supplying its customers. These networks are proprietary because they do not follow any kind of industry standard.

Each of these firms has to bear the expense of designing, implementing, and operating a proprietary data network. Some of these efforts even required inventing new

No Branches for 500,000 Customers

First Direct is an example of the future of banking in the world. This bank is located in the industrial city of Leeds, England, and its headquarters are in a huge building resembling an aircraft hanger next to a nuclear power plant. First Direct is a "telephone only" bank; there are no walk-up branches or windows. It is also the fastest growing bank in England, opening 10,000 accounts a month, or the equivalent of two or three physical branches.

Surprisingly, First Direct has used technology to create a more personal relationship with its clients, even though the banker and client do not meet physically. Some 24,000 calls a day come to First Direct's two facilities, staffed at peak times by 150 bankers. Scoreboards on the walls show the number of customers on hold and how long they have been waiting. Posters chart the sales of credit cards and other services for the month.

The bank becomes more personal by using technology to look for opportunities to cross sell new products and services to a customer. When, for example, a customer calls to check her balance and make a transfer to pay a credit card bill at a rival bank, the First Direct representative sees a message on the screen that says "No Adverse Risk" meaning that the bank would be glad to loan money to this customer. The representative sees the customer's employment and credit status and a list of prior transactions with First Direct. He asks if the customer has read the information First Direct recently sent on its Visa card, knowing that it carries a lower interest than the bank's rivals. The customer says she will think about it, and the First Direct representative sends her a prepared application for a Visa card.

First Direct is a division of Midland bank, and it tends to appeal to professionals with a good income. The average balance is ten times higher at First Direct than Midland while its overall costs are 61 percent less. First Direct makes money on 60 percent of its customers, compared to 40 percent at the average British bank.

Banking with IT will dramatically change the physical structure of the banking industry; First Direct is a model of what is to come.

technology. Frito-Lay undertook the development of a hand-held computer for its drivers to use for placing orders and keeping records. If a firm operates in an industry that cannot support or has not used EDI, it must decide whether it wants to develop a proprietary data network for its applications, use a service company's existing network, or develop its application on the Internet.

Commercial Network Providers

A few years ago the U.S. had a number of competing mass market services including Prodigy, Compuserve, Genie, **Microsoft Network,** and America Online. These companies offered their own services, chat groups, e-mail and entertainment. The development of the Internet threatened the business model for mass market services; most content on the Internet is free and available to anyone on it. Service providers, those offering content on America Online or the Microsoft Network, also had a need to be present on the Internet. There, they would have to provide at no charge what customers had to pay for on America Online. Most of the mass market networks have reconfigured themselves to be Internet service providers

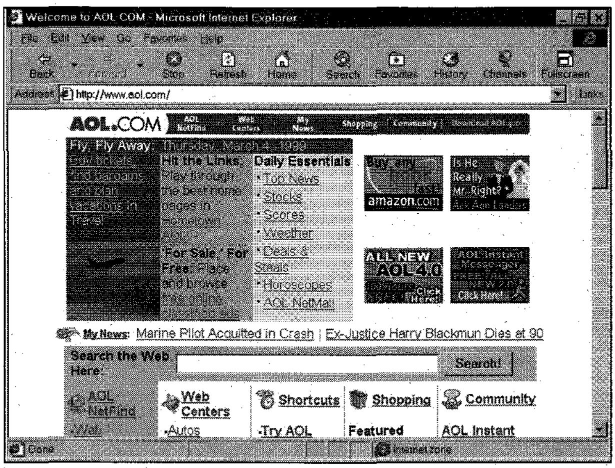


FIGURE 12-1
America Online home page.

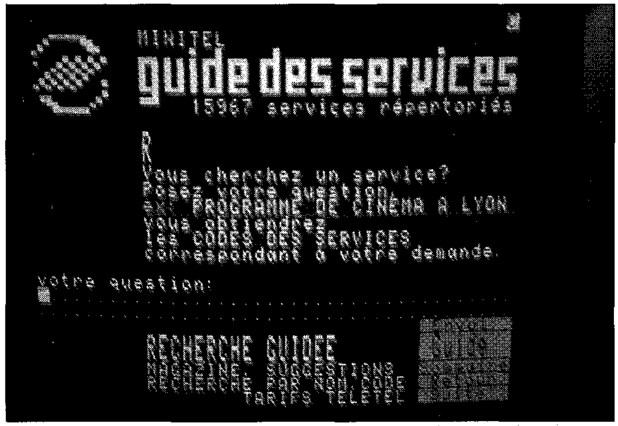
and gateways to the Net. Having purchased parts of **Compuserve** in 1997, America Online appears to be the most successful of these firms today. See Figure 12-1 for an example of a screen from AOL.

A NATIONAL NETWORK INFRASTRUCTURE: THE MINITEL SYSTEM

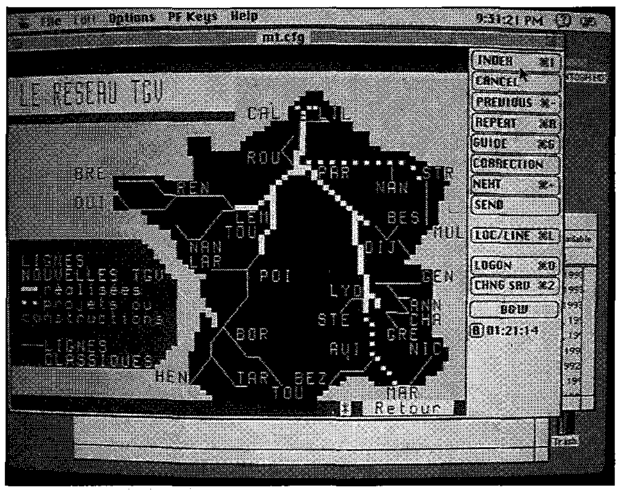
There are two examples of national and international networks that resemble the "information superhighway:" the Minitel system in France and the Internet based in the U.S. The French Teletel system, popularly called Minitel after the name of its first terminal, was introduced by France Telecom, the French government-sponsored telecommunications company, in 1982. Ten years later, Minitel was used in 20 percent of households and 80 percent of businesses in France. Today users access a wide array of communication, information, and business transaction services. Approximately 6.5 million Minitel terminals are in service in France, which has a population of 57.5 million. Another 500,000 residents of France use Minitel on their personal computers. Altogether about 40 percent of the nonretired French population have access to Minitel either at work or at home, and a total of about 15 million users are active on the system. Some 25,000 services are available on the system, a number growing at the rate of 10 percent a year.

Minitel is considered by many to be a mass market system aimed at the consumer. It is the first and only example of a successful mass market network venture in the world. It is successful in the sense that it reaches a large proportion of French households and businesses, offering a rich variety of information, communications, and services; and it is estimated to be profitable.

In 1989, France Telecom introduced a nationwide electronic mail system for businesses and the general public. Information services include the national, on-line



(a)



(b)

FIGURE 12-2
(a) The Minitel Guide to Service. (b) A display from the national railroad, SNCF.

telephone directory, schedules for the French national railroad, as well as want ads, stock market reports, and other information that might be found in a newspaper. There are also short-lived or highly specialized information services for the general public. For example, sports fans can access continuously updated information about the position of boats in around-the-world yacht races, and parents sending their children to camp can access daily lunch menus. The Minitel Guide to Service and a display from the national railroad, SNCF, are shown in Figure 12-2.

Because Minitel is built on a nationwide data network with open standards, businesses also make use of the network for business-to-business services. While

Minitel began with a mass market focus, in recent years residential growth has slowed and been replaced by a large growth in business applications. In 1990 about half the services were business related. Some of these business services are traditional information services, with information—such as stock market listings, economic data, or airline schedules—tailored to the interests of business customers. Other business applications are business-to-business transaction services, very similar to EDI and proprietary network applications in the United States. Brun Passot, the second largest office product supply company in France, discussed in Chapter 1, encourages its customers to order electronically via Minitel. For large volume customers, Brun Passot installs a computer with a proprietary connection to its order processing and reporting system.

A number of case studies conducted by Charles Steinfield at Michigan State University illustrate what can be done with a network that connects business to small firms and consumers. A large multinational, electrical appliance and consumer electronics manufacturer used Minitel for EDI-like connections to approximately 10,000 separate retailers and independent repair people throughout France. In addition to the major cost savings this manufacturer achieved by better managing inventory and reducing transaction costs, the firm also introduced a revenue-producing expert-system–based training application that assists the service force in the diagnosis and repair of appliances and electronics products. Repair staff are charged on the basis of connect time for use of this service. In addition, the expert system accumulates data on repair problems and provides feedback to the design and manufacturing divisions of the company in order to help detect and correct potential structural flaws in their products.

Ubiquity enables other innovative business applications as well. In one, a clothing manufacturer was able to use the Minitel terminals already in many boutiques to offer a custom-tailored business suit. A clerk takes a customer's measurements, ships them over Minitel to a computer-controlled cutting machine at the factory, and the factory returns a custom-made suit in several weeks. Another application is the trucking spot market created by Lamy, the French directory publisher. Freight forwarders transmit special shipment requests to a Minitel database that truckers search as they attempt to fill excess capacity or to fill up on a return trip. Upon finding a matching offer, the truckers immediately call the forwarder to make a bid.

Discussions with French firms suggest it is possible to develop a national order entry system using Minitel in several months for well under $50,000, something very difficult to accomplish in the United States if you must build a proprietary network for the application. France Telecom has been making about $1.5 billion a year on the service.

The major drawback to Minitel today is its slow speed and lack of interesting graphics. Minitel is well established in France, but the question is whether it can be modernized and maintain its dominant position given competition from the Internet. France Telecom, the operator of Minitel, is working to upgrade the speed of the network and to offer more exciting graphics. A "photographic" quality terminal is now available. Customers can arrange to access Minitel through an ISDN line, and they can connect to Minitel through a LAN. The Internet has grown less rapidly in France than in the U.S., probably because of its high level of content in English, the lower home ownership of PCs in France (about 16 percent), and Minitel itself.

France Telecom has a subsidiary, Wanadoo, that is an Internet service provider (ISP), and there is internal competition between Minitel and this ISP. France Telecom is also working with IBM to develop a network that allows customers to surf the Web with simple, cheap, screen-based telephones like the Minitel terminals. Most of the management and navigational information, such as user profiles, will be kept on network computers since the local terminal has little memory or logic. This network may be the largest implementation of the "network PC" concept.

After initially viewing the Internet as a vehicle of American colonialism, the Prime Minister of France finally endorsed the Net in 1998 and allocated one billion French francs to help wire the country. He has stated publicly that Minitel is a "brake on the development of new and promising applications of information technology." It is possible that in a few years, Minitel will disappear as the Internet expands. Such a transition, however, will place a heavy burden on Minitel service providers, so there will be resistance to phasing out this pioneering, profitable system.

Minitel illustrates the benefits of a national communications network; some of its applications are a precursor of Internet applications. The government encouraged the development of Minitel by giving away a large number of terminals, replacing printed telephone books with a national directory on Minitel, and making it easy for service providers to develop content for the network. Communications studies indicate that a network has to reach a "critical mass" to become successful; enough people have to use it and encourage others to join. A single telephone is not worth much, but a network in which everyone to whom you wish to speak has a telephone is extremely valuable. France Telecom used a variety of policies to reach a critical mass of Minitel subscribers and service providers.

INTERNET: A CASE OF PHENOMENAL GROWTH

While Minitel shows one way a national data network can succeed as a result of a centralized governmental telecommunications policy, the Internet provides a decentralized model of a government subsidized network. The Internet is a worldwide, interconnected collection of computer networks. It started in 1969 as the Arpanet, a military-sponsored research project on how to build reliable networks in the face of unreliable components. But over time, as additional research laboratories, universities, and even personal computer networks became connected to it, the Internet became an infrastructure for scientific and educational computing in the United States and in a significant portion of the world.

One of the Internet's main virtues is that it lets a variety of heterogeneous computers connect to the network using a number of different communications options. The network operates on two core protocols, TCP (Transmission Control

The Origins of the Web

". . . A couple of years ago, there was no Web. Suddenly it's ubiquitous. And if ubiquity weren't enough, it's still growing.

Where did the Web come from? . . . One day there was nothing; the next day there it was, fully deployed.

My first suspicion of something bom so instantaneously perfect is an alien origin. There was probably a meeting somewhere on a distant planet where they debated whether or not it was time for Earth to have the Web. 'They'll only botch it up,' the opponents probably argued. 'They'll put all kinds of garbage on it and ruin our good idea.'

But the alien proponents and supporters of the Web carried the day. 'The Earth has all kinds of talented people eager to get their material out to the public,' they undoubtedly said. 'Wonderful things will happen; just wait and see.'

Whatever its origin, the Web is here, and it is changing our view of information, society, and business. Perhaps most importantly, it is proving the efficacy of the long believed and hoped-for *Field of Dreams* approach—if we build it, they will come. The people of the earth have been empowered by the Web, and there has been an incredible outpouring of creativity and professionalism by amateurs everywhere. When you empower a few amateurs, it's not much competition. But when you empower tens of millions, surprising things happen, some of them breathtakingly good."

Protocol) and IP (Internet Protocol). These protocols break a data stream into packets and give each packet a sequence number. IP is responsible for getting the packets from the sender to the receiver in the shortest possible time. TCP manages this flow of packets and verifies that the data are correct. There are more than 100 **TCP/IP** protocols based on the core protocols described above. As a result, computers ranging from Sun workstations to personal computers to Macs can connect to the Net.

The Internet is not a single network. It is a collection of over 60,000 networks, all having at least one server. Networks can be connected directly to one another, but most often they are linked through six official network access points in the U.S. Hundreds of service providers exchange traffic at these access points. A large service provider will have its own communications network which will include a number of local access points so customers can minimize their long distance charges. The service provider's backbone network connects all its local access points to the Internet. See Figure 12-3 for the map of one carrier's (UUNET) U.S. backbone.

While the National Science Foundation originally subsidized the Net, costs today are shared by its users. In addition, institutions like universities supply labor in the form of highly paid professionals to maintain and upgrade the network. Institutions pay a flat rate to join the Internet, and individuals in these organizations do not pay any fees. External access providers generally charge a flat rate for users to access the network in the range of $15–20 per month.

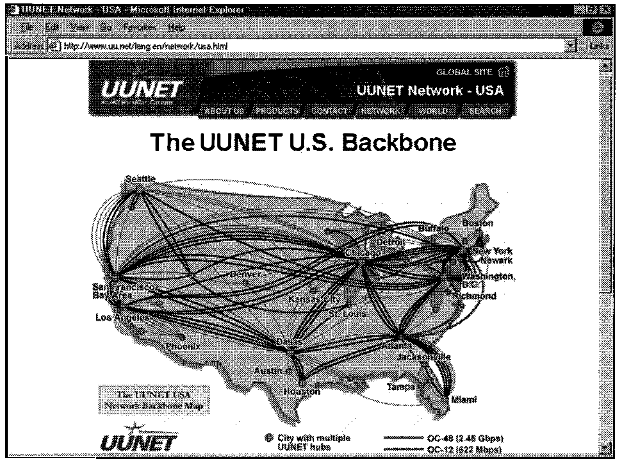


FIGURE 12-3
The UUNET U.S. Backbone.

While it is not known with any certainty how many users exist, there are over 40 million host computers on the Internet, and there are over 100 million users in at least 150 countries. Between 1991 and 1994, traffic on the Internet doubled annually. While scientists and engineers were early users, followed by academics, today the Internet is available to commercial firms and to the general public. Figure 12-4 shows the tremendous growth in Internet hosts.

The Task Force that manages the Internet is looking at new ways to generate IP addresses, an address that each computer on the Net must have so that it can send and receive information. The Chinese would eventually like to have a billion IP addresses! By the year 2000, it will not just be 200 million computers trying to connect to the Internet, it will be *billions* of computers, and the current addressing scheme will not be adequate for such numbers.

You can connect directly to the Internet through an organization's computers. The domain name identifies the type of organization. For example, our address is first initial followed by last name@stern.nyu.edu. An educational institution is designated by .edu, a commercial firm by .com, a government agency by .gov, and military by .mil. With this kind of address, your organization has a computer connected directly to the Net. From home, many people use access providers to reach the Net, and mass market services like America Online also offer access to the Web.

There are also ISPs that exist only to connect you with the Net and generally charge $10 to $20 a month for this service. In November of 1994, the business volume of 1-800 (toll free) calls exceeded the volume of other business calls for the first time. AT&T wants to see that it captures data as well as voice calls through connections to the Internet on its AT&T Worldnet service. These access providers will also have to contend with cable TV companies offering Internet access via cable modems, as discussed in the last chapter.

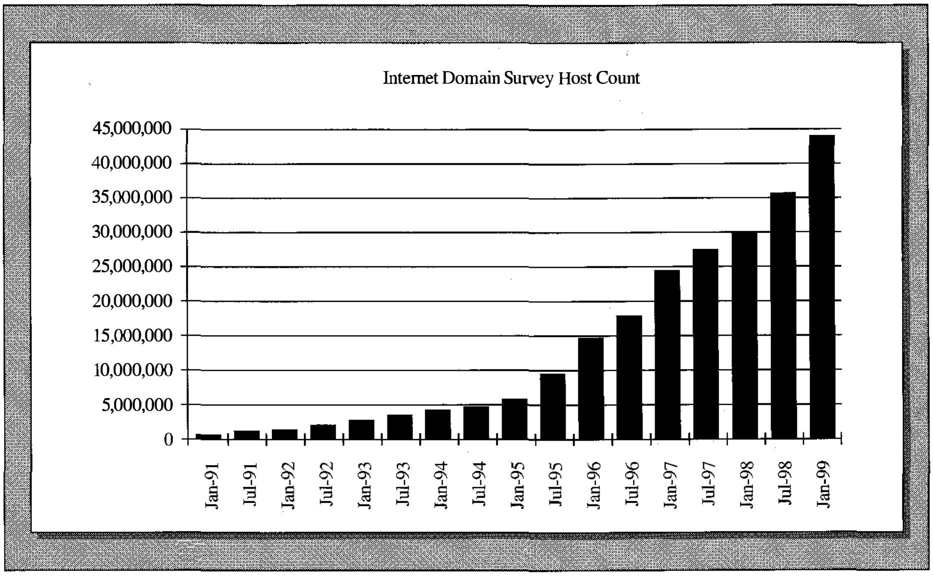


FIGURE 12-4
Growth of Internet hosts.

The Arpanet was originally designed so scientists and others could conduct research on computer networking itself and gain access to remote computers and files. The government also wanted to tie together diverse networks developed for the military by various low bidders, each providing different equipment. Within months of the opening of the Arpanet, however, interpersonal communication in the form of electronic mail and computerized bulletin boards became the dominant application. Today there are approximately 8000 bulletin boards distributed across the Internet. On-line real-time conferences, in which users join a group and chat by passing text messages back and forth, are becoming increasingly popular. There are also various multiuser recreational games.

Today the Internet contains a huge variety of applications and information sources. In Philadelphia, PCs provided reading-improvement courses over the Internet to 100 low-income homes in a recent test. No one signed up for classes when offered in the schools, but students and some parents eagerly registered when given the opportunity to use borrowed computers in the safety and privacy of their own homes. The Internet Talk Radio Show provides news and entertainment to users with audio software and speakers on their workstations. A project at NYU in New York City helped make the Securities and Exchange Commission EDGAR database of corporate findings available on the Internet. One can find current weather maps for any region of the country, an on-line exhibit of items from the Vatican Library, digital copies of art works from several museums, the complete Grateful Dead lyrics, and photos of Cindy Crawford, to name but a small set of services.

Government agencies post RFPs (requests for proposals) to Internet servers, and contractors can file their bids electronically. There are a number of job postings available on the network, and companies, including AT&T, list information about themselves on the Internet. Mead Data Central provides Internet access to its Lexis/Nexis database on a subscription basis.

The Internet is also used extensively to share and distribute software. Through an anonymous FTP (file transfer protocol), a user can log on to a remote computer as a user with the name "anonymous," use his or her Internet address as a password, and transfer files from the remote computer to a local computer over the network. Dell distributes new versions of its software via the Internet as well as through other channels.

Business Week estimates there are 150 journals published electronically. Some scientists are even calling for the elimination of paper journals since the lead time for publication is so great. A large number of journals are posting their table of contents on the Internet and some hope to provide information that is not included in the printed version. There are some 50,000 peer-reviewed technical journals, a $4 billion industry, and the threat of Internet publishing is very real to these businesses.

At first, the Internet was criticized for its difficulty of use, but the **World Wide Web** and graphical **browsers** represent major breakthroughs on the Internet. Researchers at CERN in Geneva developed the World Wide Web (WWW), which connected a group of an estimated 30,000 network servers using the **Hypertext Transfer Protocol (HTTP).** The Web uses hypertext links produced with the **Hypertext Markup Language (HTML)** to link documents and files. Hypertext is created by placing links on words to reference other sections of text or other documents. Clicking a computer mouse on highlighted text results in the retrieval of a new file or document, allowing the user to browse through related pieces of information. The retrieved documents may all reside on different computers, but the Web makes the retrieval transparent to the user.

HTTP is a connectionless protocol, which means that each client-server connection is limited to a single request for information. This way, the network is not tied up in a permanent connection between the client and server. (The disadvantage is that many connections may be made repeatedly to the same server to request information.) The Web is an excellent example of a client-server architecture—your computer is the client and you visit a variety of Web servers as you search for information. To see an example of hypertext source documents, run your Internet Browser and click on "View" and then "Source."

To use the WWW, you need a net browser. The development of a graphical Web browser is a second breakthrough, one made possible by the connections provided by HMTL and the Web. These programs work by "pointing and clicking" with a mouse, which is a vast improvement over character-based terminal access to the Internet. A browser connects users to different services, helping them navigate the confusing and disorganized structure of the Internet. You can also use browsers to create forms and facilitate the publication of data.

Host computers on the Internet generally provide some form of content, information that users access with their browsers. With millions of Web hosts, there is

Agents on the Network

An **agent** is an intelligent piece of software that a user programs to perform some task. As an example, you might instruct your agent to search a network for vendors offering a VCR that has slow motion, four heads, stereo sound, and costs under $400. The agent should report back to you the stores, prices, and characteristics of the six lowest priced versions it finds.

Another useful agent would be one that took your order to buy a share of stock and hovered in a broker's network until the stock reached the indicated price. Then the agent would execute the transaction. You might also appreciate an agent that could weed out junk messages in your electronic mailbox. Agents are a relatively new phenomenon spawned by the emergence of networks. They appear to have a bright future making it easier for users to obtain the resources of a network.

Agents are considered to be an important component of *electronic commerce;* they should facilitate buying and selling over computer networks. In electronic commerce, you will have supply agents that provide information to demand agents, an agent sent out with a request as described above. Sometimes agents are called "softbots" like their mechanical robot counterparts. An agent will have some or all of the following characteristics:

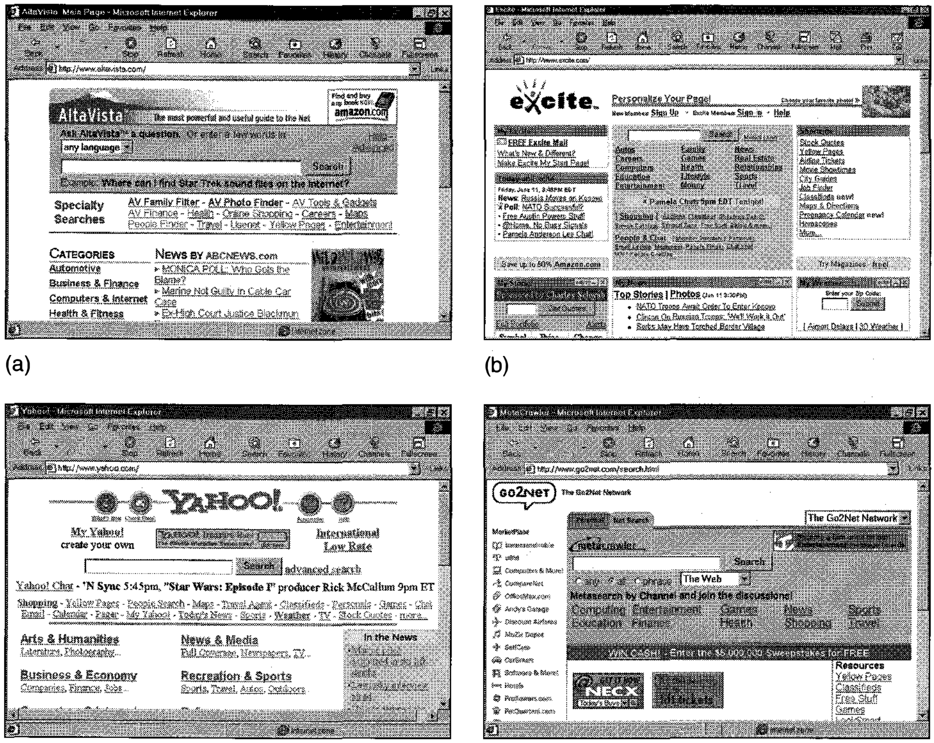
- *Autonomy*. The agent takes initiative and follows its instructions without user intervention.
- *Goal-oriented.* The agent accepts requests and acts on them; it decides how to achieve the user's goal.
- *Flexibility.* The agent does not follow a script but decides dynamically what actions to take.
- *Communications capability.* An agent can engage in complex communications to achieve its goals.
- *Mobility.* The agent can transport itself from one machine to another across a network.

While it may be a while before we have personal robots to clean house and do the laundry, software agents should be making life easier for us in the very near future.

an incredible amount of content available. To help you find information, there are over 30 "search engines" on the Web. These services, funded by advertising, accept your search queries and look for matching content on the Web. Figure 12-5 shows the AltaVista, Excite, Yahoo, and Metacrawler search engine screens.

Search engines do not actually search the Web for each query; rather they search the Web at various times (the middle of the night?) and build an index of terms. When you make a query, the engines search their indexes and give you the universal resource locators (URLs) that look like *http://www.stern.nyu.edu,* plus a few lines of text from the page referenced by the URL. (URLs are explained in a little more detail later in this chapter.) It is interesting to note that some of the advertisements on search engine sites are sensitive to the query you make; the search engine tries to show you ads that match your search.

The interaction with the Web described so far depends on the user's initiative; you search for and decide what sites to access. "Push" technology refers to services on the Internet that come to you automatically. You can sign up with companies that send news and other information to your client computer on a continuous



(a) (b) (c) (d)

FIGURE 12-5
Search engine screens. (a) AltaVista, (b) Excite, (c) Yahoo, and (d) Metacrawler.

basis. Originally, push technology was developed on the Internet, but it is spreading to Intranets as well (see below). Wheat First Union, a Richmond, VA, financial services firm, uses push technology to alert its stock brokers to important news and stock selling opportunities from large blocks of shares Wheat First Union buys several times a day.

There is currently a raging debate between visionaries who see the Internet as the next era of computing and those who see the Net as an important, but not revolutionary advance. The visionaries argue that so much information, software, and multimedia content will be available through the Internet, especially given Java's ability to share programs easily and safely, that no one will need a PC. This group is the one that favors the development of Net PCs. Sun Microsystems, the developer of Java, and **Netscape,** a company that provides Web servers and browsers, encourage this view. The most extreme position is that the Net will lead to the demise of Intel and Microsoft as Net PCs take over. As discussed earlier, the resolution of the conflict between Net PCs and full-featured PCs is still in doubt, but right now the numbers favor large highly capable computers over net computers (NCs). The need for a net computer is in doubt as the price for capable PCs drops below $500.

MANAGEMENT PROBLEM 12-1

Pat Washington is chairperson of a new company that sells PC software for children, a combination of education and entertainment. The firm has experienced rapid growth and two of its products are best sellers. Being chairperson of a technology company, Pat wants to take advantage of mass market services such as America Online. While her products are aimed at children, adults purchase almost all of their software.

Pat is particularly fascinated by the Internet and the World Wide Web. She says, "There must be a way to establish closer rapport with our customers, adults who purchase and the children who use our products, through the Internet." Pat is unsure what to do. Alternatives range from setting up a home page and a product catalog on the World Wide Web to taking orders over the Net.

What should Pat consider in her decision? What are the pros and cons of the different alternatives? How do the commercial services like America Online fit into her strategy?

In summary, the Internet was launched with government subsidies for the network and terminals that helped it become established. For most early users, the network appeared to be a free good. Early use of the network focused on interpersonal communications and the sharing of programs and information. Unlike Minitel, academics and scientists first used the Internet. Business use on Minitel began immediately while its use is a recent phenomenon on the Internet. The Internet's open standards allowed many users and service providers to connect. The network has an open, decentralized, and extendible architecture. The Net's open culture and free exchange of software encourages users to access it and providers to offer services. Products like Web browsers (e.g., Netscape and the Internet Explorer) make it easy to use the Net. A spate of articles on the information superhighway, "cyberspace," and the Internet (including a cartoon in the *New Yorker*) have made a network connection highly fashionable. All of these factors have led to the critical mass needed for the network to succeed.

Intranets and Extranets

Internet technology is having a major impact on companies through networks called "Intranets," as opposed to Internets. A firm sets up servers and clients following Internet protocols and distributes a web browser to its users. The network is probably not connected to the Internet; rather it is used to publish information internally within the company. This information is likely to be proprietary so the company does not want other Internet users to have access to it. An Intranet also provides a platform for developing and distributing applications that anyone with a browser can access.

How can a company benefit from this kind of technology investment? Morgan Stanley is a major investment bank and now a retail broker since its merger with

Combining a Lot of Components

VW in Mexico is combining much of the technology we have discussed to date into a single application to serve its dealers. First, the company implemented SAP's R/3 software to streamline its manufacturing processes. The system coordinates all aspects of manufacturing and parts ordering, including supplier orders, receipt of goods, warehousing, client orders, packing, and billing for VW's Puebla plant.

As a part of the $35 million project, the company is creating an Extranet for its 200 dealers. An Extranet is an Intranet that allows external sites access, generally through a password. In this way, a company can take advantage of Internet technology to create an on-line application that users can access from any location in the world that has an Internet connection. The dealers use the Extranet to streamline spare parts orders; the network provides access to the SAP databases from any level in the company. The turnaround time for ordering spare parts has been cut in half, which leads to both better customer and dealer relations. Dealers also can cut the number of parts in inventory, saving them money. Using an integration tool, VW was able to provide a connection to R/3 via a browser, which kept costs very low for dealers who only need a PC, browser and Internet connection.

In this example, an enterprise software package has been combined with Internet technology to produce a very successful nationwide, on-line system.

Dean Witter. Morgan Stanley has developed an extensive Intranet containing the research information that various parts of the firm develops. By having it on the Intranet, the information is available to anyone in the company. This way, members of the firm do not overlook research because it happens to be in someone's bottom desk drawer.

At Chrysler, an Intranet has replaced the company telephone directory; it provides a photograph and job descriptions in addition to phone numbers. The automaker expects to use its Intranet to broadcast information around the company, monitor projects, and reduce the amount of time needed to hunt for information. The Chrysler controller collected time-sheets from his staff to see where they were spending their day and he found that the paperwork to approve equipment purchases was taking up to 18 percent of some employees' time. Now a team is trying to figure out how to streamline the purchasing process using the Intranet. In addition, vehicle program managers post car-design changes to Chrysler's Intranet so they are instantly available.

The engineering department has invested $750,000 in its part of the Intranet in an effort to link isolated systems. Using the same browser interface, engineers can move from the main software design system, CATIA, to regulatory manuals and home pages that describe how different projects are going. The minivan team home page links to a progress report on the design of a new vehicle's body and executives can check progress without calling a meeting. The Intranet should help Chrysler achieve its goal of reducing the cycle time for vehicle design to two years from the current four or five years (*Wall Street Journal*, May 13, 1997).

The Internet versus the Government

The Internet has succeeded in confusing a large number of elected and appointed (many self-appointed) political leaders around the world. It is very difficult to regulate the Net since it is a rather amorphous collection of networked computers. United States senators and congressmen are very concerned about pornography on the Net, yet it is very hard to monitor a stream of digits to know that it is a pornographic image. A provider could simply move a server off shore, out of range of U.S. regulations, in response to any laws trying to regulate the Net.

This same problem applies to countries with regimes that try to control information available to the public, for example, the People's Republic of China and Saudi Arabia. In Saudi Arabia, Net users have explored topics like sex, religion, and politics—all subjects not often discussed in public. The Saudis are caught in a bind. They want to become technologically sophisticated but are concerned about the ability of the Net to undermine their strict regime. Business leaders want access to the Net, making it difficult to restrict its use.

Thousands of Saudis dial into the Internet in neighboring countries or through the U.S. They debate taboo topics from atheism to pornography beyond the reach of authorities. Even fundamentalists debate with Western atheists over the Net. The Gulf societies are very closed, so the idea of a free exchange of ideas tempts a lot of residents.

The Internet has made possible something that would be very dangerous to do in a group of people, by voice on the phone, or on paper. Its impact on governments will be fascinating to watch over the next decade.

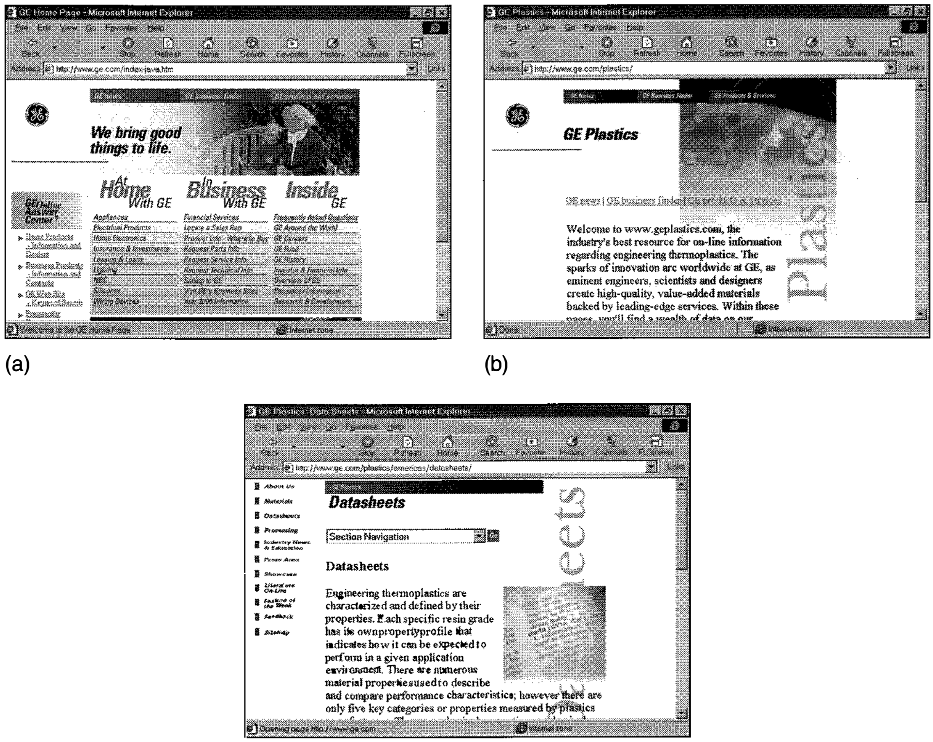
Intranets have the potential to tie together employees in an organization and disparate information systems as well. As firms create links between Intranet standards and legacy transactions processing systems, it is possible to envision an environment in which the major desktop application for each user is a browser. Using the browser and Intranet, an employee accesses all types of corporate information along with the data from internal proprietary information systems in the company.

It is also possible to provide external access to an Intranet so that customers and others can access your internal servers. An Extranet uses the Internet technology to provide on-line access to your internal net servers, generally through a password for each external user. With an Extranet, you can create an on-line system very quickly since you are taking advantage of the existing worldwide Internet.

THE POTENTIAL OF ELECTRONIC COMMERCE

With the opening of the Internet for profit-making activities, thousands of companies set up **"home pages"** on the Web. A home page is a starting place for someone seeking information. For example, you can create your own personal home page that gives a reader information about you. AOL and other services help you create and store your home page, or you can use Microsoft Word, a hypertext editor that comes with a Web browser, or a specialized product like Front Page.

Similarly, companies create home pages with links to other information. Figure 12-6 shows the home page for GE Plastics along with two pages accessed



(a) (b) (c)

FIGURE 12-6
GE home page (a), leading to GE Plastics home page (b), with link to database of characteristics of more than 500 plastics (c).

through links on the home page. This particular set of pages is well designed. The user can quickly access technical information about GE Plastics. A URL or universal resource locator is an address or link to a page on the web. These links begin with http://. Sometimes the // is followed by www, a period, and then the address of the individual or company. For example, the home page for the Stern School is found at http://www.stern.nyu.edu.

What opportunities does the Internet offer for **electronic commerce**—for facilitating trading relationships among companies and between individual customers and companies? There are a number of ways companies use the Net, including:

- *As a universal electronic mail system.* Various proprietary systems all have "gateways" to the Internet. If you use America Online and friends are on the Internet, you can send mail to them even if they are not subscribers to AOL.
- *As a source of information on a company and its products.*
- *As a portal that allows customers to enter orders and make inquiries.* Figure 12-7 shows the Federal Express pages for letting customers inquire about the status of

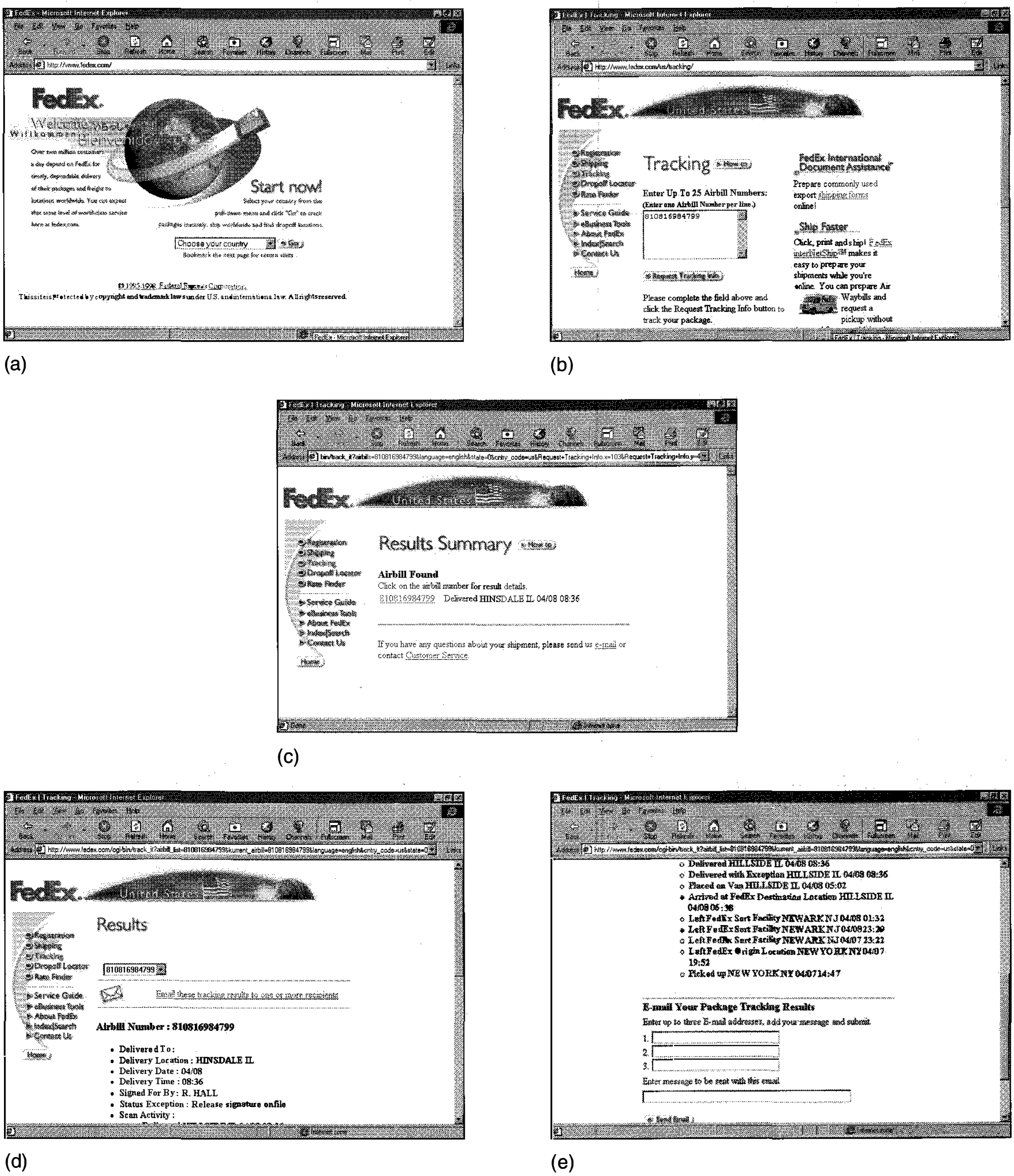
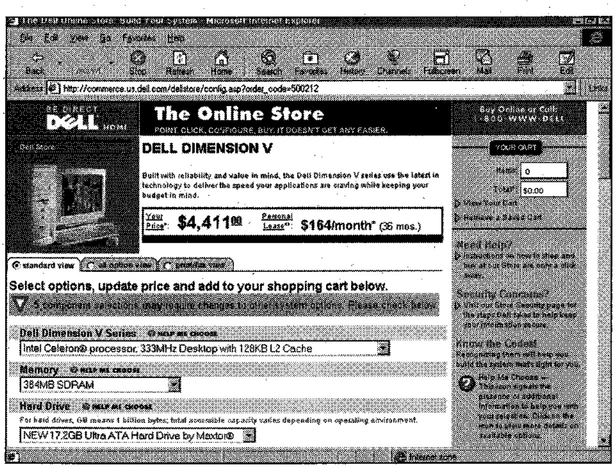


FIGURE 12-7
FedEx home page and package tracking screens.

a package. Using a "forms" program, Federal Express lets the customer input a package identification number; then the FedEx Web server looks up the status of the package and displays it for the customer. Customers can also use a Web application to enter shipping orders. FedEx gives large clients software to link to its tracking computers. Customers now do 60 percent of package tracking using a software connection to FedEx's tracking computer and/or the Web connection. The site receives over 400,000 "hits" a day, and 20 large servers respond over a variety of lines including a T3 and two Tl lines. There are also two servers that form a bridge between the Web site and FedEx's S/390 mainframes, which host the company's shipping database. Some 2 million of the company's 3 million daily packages are shipped or tracked on the Web or through FedEx's Windows' software over a proprietary network.

- *As a way to distribute software.* Hewlett-Packard uses its Web site to distribute revisions for its Unix operating system and new software for its printers. Customers download the software using the Web.
- *As a way to give customers information about their relationship with the company on the Web.* Wells Fargo Bank in San Francisco gives customers Internet access to the transaction histories of their checking and savings accounts as well as information on current balances.
- *As a source for electronic data interchange.* The CommerceNet consortium described earlier in the chapter provides an example of using the Internet for EDI among companies.
- *For the purchase and sale of goods and services.* This kind of Internet application is growing rapidly. Dell computer sells over 14 million dollars worth of computers a day from its Net site. See Figure 12-8 for a view of Dell's computer configuring page.

FIGURE 12-8
The Dell configuration page for buying a computer.



The Nature of Markets

Markets serve a number of important functions: They match buyers and sellers and facilitate the exchange of information, goods, services, and payments associated with transactions. They provide an institutional infrastructure subject to legal and regulatory constraints, which are in place to encourage efficient and fair market operations (Bakos, 1998). Electronic commerce affects all these characteristics of markets. In particular, e-commerce tends to increase the personalization and customization of product offerings. Technology for tracking consumers helps the merchant identify individual buyers to analyze their preferences and offer appropriate goods or services. Customization is particularly appropriate for information products like an electronic newspaper, which can be customized to the tastes of each individual subscriber (Bakos, 1998). Electronic markets also affect the buyer's search costs and facilitate price discovery; it is very efficient to obtain and compare products and prices using the Internet.

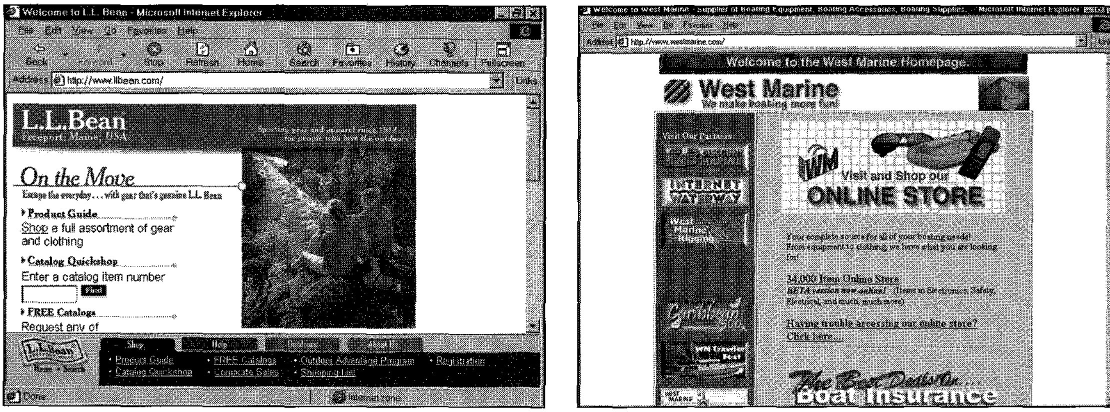
Table 12-1 divides Web commerce in two categories: transactions that favor the vendor and those that favor the customer. The first category is the retail customer purchasing from a vendor, as we saw with Dell. If the customer goes to Dell without any comparison shopping, the transaction clearly favors Dell, the vendor. Other examples of well-known companies that sell on the Web include West Marine and L. L. Bean; the Net fits nicely with a mail-order toll-free phone line business model. Please see Figure 12-9.

An **auction** via the Internet provides a convenient way for a vendor to reach a large number of affluent customers. Cathay Pacific airlines runs frequent ticket auctions. One auction drew nearly 15,000 bids for tickets from New York to Hong Kong, and some winning bids were as much as 60 percent off the regular round-trip fare. See Figure 12-10 for the bid site. American Airlines will notify anyone by e-mail who registers about special fares for each weekend. This

TABLE 12-1

TYPES OF ELECTRONIC COMMERCE

Electronic commerce favoring the vendor	**Vendor locks in customer; e-commerce makes it easier to do business with the vendor**
Customer orders from one vendor directly without comparison shopping using the Web	Vendor provides ability for customer to find enough information about the product to make a purchase and offers merchandise on the Web
Customer makes a bid	Vendor runs an auction of merchandise
Electronic commerce favoring the customer	**Customer uses Web for price discovery, comparison shopping, requesting bids**
Customer conducts own search of Web to compare products and prices	Company responds with its products and prices
Customer searches for multiple vendors using agents or electronic brokers	Company responds with its products and prices



(a) (b)

FIGURE 12-9
L.L. Bean (a) and West Marine (b) home pages.

FIGURE 12-10
Cathay Pacific Internet auction sweepstakes.

approach helps the airline sell seats that otherwise might be empty. These auctions favor the vendor who is trying to distribute a product or service.

Transactions favoring a customer involve using the Web to do research. A customer uses the Web to perform comparison shopping among suppliers. She might also use an electronic broker, for example, AutobyTel, which submits her specification for a new car to several dealers and reports back the best offer. The Web has helped the customer obtain information about products and services and assisted in price discovery. This process favors the customer who is now able to contact many firms in the electronic market. A number of comparison shopping brokers now exist. Junglee.com, a subsidiary of Amazon.com, will help you locate the best

FIGURE 12-11
A price comparison for jeans on Amazon.com's Shop the Web web site.

Can Anyone Make Money on the Net?

Companies like Dell Computer and Cisco Systems have experienced incredible sales growth rates from their Web sites. Of course, we need to remember that their customers are buying computer and network equipment and thus represent a group that is comfortable ordering over the Web. FedEx has over 500,000 customers using its package tracking application and estimates it saves $3 for each hit compared to a phone call.

Cisco estimates savings for customer support in one of the early years of Internet usage as follows:

- $125 million by using the Web to communicate with customers
- $85 million by distributing software on the Web, some 40,000 downloads a week
- $50 million by having documentation on-line

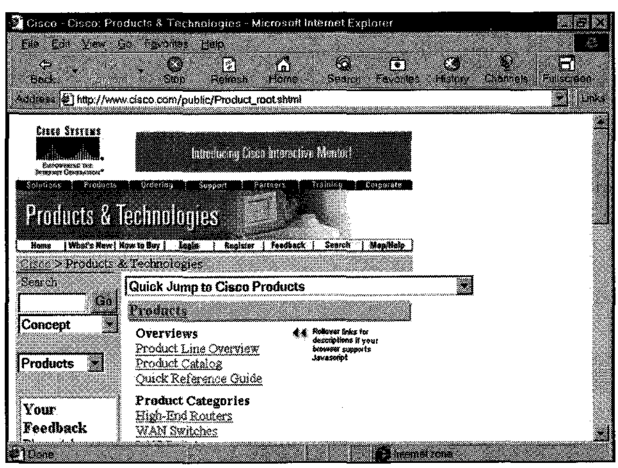
The total savings amount to $268 million. Over 60 percent of Cisco's customer transactions use the Web, some 250,000 a month. The result is that 500 fewer employees are needed for taking orders and providing customer service. At the same time, the firm is providing customer service that is more convenient than waiting on the phone for a representative. While these savings are only estimates, they suggest that it is possible to make money through the creative use of the Internet.

prices for items you wish to purchase. In contrast to Dell's site in Figure 12-6, which features only Dell products, Junglee will look across the net for prices from different vendors. See Figure 12-11.

In addition to retail commerce, there are many business-to-business Web transactions. Here, we include EDI and Web ordering. Most EDI is done through non-Internet systems, though groups like CommerceNet are working to make the Web easier to use for this application. Web ordering is similar to retail, but involves company-to-company sales. A good example is Cisco Systems, which makes about 80 percent of the routers used with the Internet. This company is selling over $3 billion a year of its equipment to companies from its Web site; nearly 40 percent of its orders come through the Internet. The rapid growth of its Web order volume has led Cisco's chief executive to forecast that the Internet will have $1 trillion in sales by 2000, much higher than the previous high forecast of $300 billion. (Of course, his sample has a lot of bias since it is likely all of Cisco's customers use the Web on a regular basis.) See Figure 12-12 for Cisco's Web site.

While the Web appears to be a promising channel for sales, it is by no means free for the merchant. Firms spend heavily to attract the consumer's eye. One sports company is paying $23 million for a three-year agreement with America Online to promote its merchandise on this Internet service provider's portal to the Web. The 1-800-Flowers Web site needs two major rebuilds a year to keep pace with technology changes and the competition. A physical store might need an upgrade once every three to four years. However, benefits come in the form of volume and profits. The 1-800-Flowers Web site in 1998 accounted for 12 percent of company sales, amounting to $30 million. Eddie Bauer in 1998 had revenue from its Web site that equaled the revenue from eight to ten physical stores. The Web site employs nine people while each store employs about 25. About half of the buyers at the site are new to Eddie Bauer, so it is not just taking sales from stores or the toll-free catalog operation. While there are high expenses for electronic commerce, these merchants are finding benefits and profits from their Web sales.

FIGURE 12-12
Cisco product ordering page.



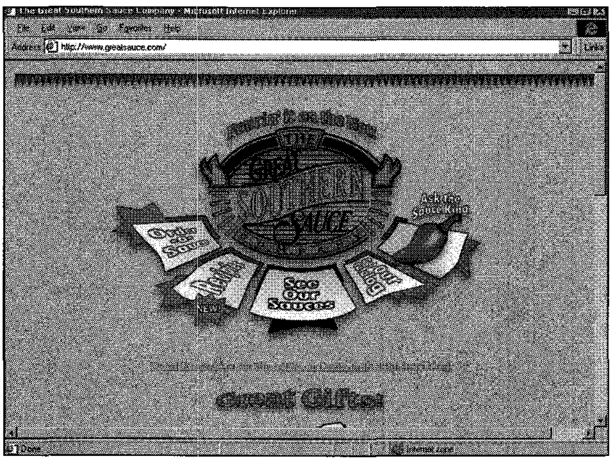
Advantage: The Small Firm

The Internet helps to provide a "level playing field" between small and large firms. Through a Web presence, a small business can generate worldwide sales when it could never afford to have a global sales force. The Great Southern Sauce Co. has annual revenue under $500,000, but it has a Web presence to sell more than 50 sauces.

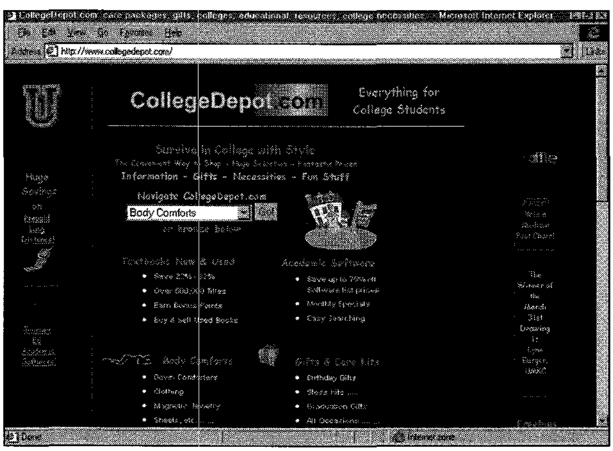
The College Depot has only two full-time employees and $100,000 a year in sales. Its presence on the Web looks as professional as that of a billion dollar corporation. Through the Internet, it can offer over 50,000 specialty products for college students.

A home on the Net is more important than a physical home for companies like these.

The Great Southern Sauce Company's home page.



College Depot's home page.



Transaction-cost economics describes a continuum for how a company acquires assets, ranging from the market to a hierarchy. A firm uses a hierarchy, for example, by making an asset itself or by going directly to a supplier rather than the market. A complex product or one that is difficult to describe is hard to buy in the marketplace. In fact, there may be a limited market for the product and very few producers. A market may not exist or the costs for using it are so high that the company uses other means to acquire the asset. At the other extreme, when there is a robust market, the firm will generally encounter low transactions costs and will choose to participate in the market.

Table 12-1 suggests that electronic commerce may be used to reinforce either hierarchy- or market-based transactions. Electronic commerce favoring the vendor in the top half of the table leads toward hierarchy; the customer is going directly to the vendor without exploring the market. In the bottom half of the table, electronic commerce encourages buyers to enter the market. The content on the Internet reduces the firm's search costs in using a market and should encourage the customer to search rather than accept the first offer. The communications capabilities of the Web reduce the cost of obtaining information and bids from multiple vendors. The ability to purchase over the Net also reduces transactions costs under conditions of both hierarchy or market.

The Internet is likely to change long-standing businesses. We expect there will be widespread "disintermediation"; that is, the number of market intermediaries will be reduced. Various kinds of sales firms may find themselves losing market

MANAGEMENT PROBLEM 12-2

California Runner is a mail-order company that sells athletic equipment, primarily for running and jogging. The product line includes clothing and, naturally, a large variety of shoes. The company processes orders that arrive via the mail, fax, or an 800 number. Almost 90 percent of the orders are by phone. The company uses UPS or Federal Express to deliver its products all over the U.S.

The president of the company, Jim Fleet, observed the Minitel system in France and was impressed by the extent customers used it to order merchandise and do home banking. "The future will be to sell over electronic networks; however, I am very concerned about payment mechanisms and security. If customers are worried about the theft or unauthorized use of their credit card numbers, how can we be successful with electronic ordering? I think the Internet is more secure than using your credit card in a restaurant or giving it to us over an 800 number, but customers don't see things that way."

In order to help California Runner, investigate some of the different payment mechanisms available to users of the Internet. What are their pros and cons? What are the risks for the customer and the merchant? What do you recommend to Mr. Fleet?

share to the Internet. Will houses be purchased over the Net, disintermediating the real estate agent? Currently you can obtain bids for cars over the Net, but you still have to visit the dealer. Will manufacturers start to sell directly over the Net and only maintain a dealership for service? Offsetting the loss of intermediaries will be the rise of electronic brokers. You provide Auto-by-Tel with a detailed description of the car you would like to buy via the Internet or phone, and it solicits bids from dealers who pay it a fee for the lead.

It is clear that the Internet is a tremendous vehicle for change. The range of applications for the Net seems only limited by your imagination and creativity. A relatively high-speed network that spans most of the globe is available at a very reasonable cost. What will you do with it?

New Business Models

The Internet enables a number of new business approaches that have the potential to restructure business and commerce. Dell Computer has used technology to create a different model for building and selling PCs. First, Dell was only a direct seller, using toll-free numbers or its Web pages. It has built custom Web pages for select customers and has a large number of foreign Web sites for orders. Communications technology lets Dell build computers to order, pulling parts from its suppliers only after having received a firm order for a computer. In addition, communications technology lets Dell coordinate closely with components that it does not build itself. If you order a Dell computer, all the parts will likely arrive on the same day because the various carriers are also connected

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In April 1998, Dell's on-line sales reached $5 million per day and by 1999, $14 million, and the capability is being embraced by a wide range of customers. Savvy consumers and home-office computer users were early adopters, but institutional customers are buying desktop and notebook computers, workstations and servers via www.dell.com in increasing volumes, as well.

And the scope of Dell's Internet business is global. Though the majority of the company's current sales through www.dell.com are within the U.S., sales from other markets grew to 20 percent of the company's on-line total in less than one year. To date, about 20 percent of the more than 2000 specialized Dell Internet sites created for large corporate customers are for companies based outside of the U.S., and there are versions of the company's Web site in 35 countries.

The company's increasing ability to sell computer systems via the Internet has earned Dell a good deal of attention. However, the potential of the Internet to simultaneously help increase customer satisfaction and lower operating costs is equally compelling.

Customers visiting www.dell.com can configure, price, and order computer systems—and much more—24 hours a day, seven days a week. They can get current order status and delivery information. They have on-line access to the same technical reference materials used by Dell telephone-support teams—45,000 service and support items sorted and presented by system model. Internet-based services are convenient to customers and reduce the number of telephone calls to Dell for such information—freeing support employees to provide higher-value service.

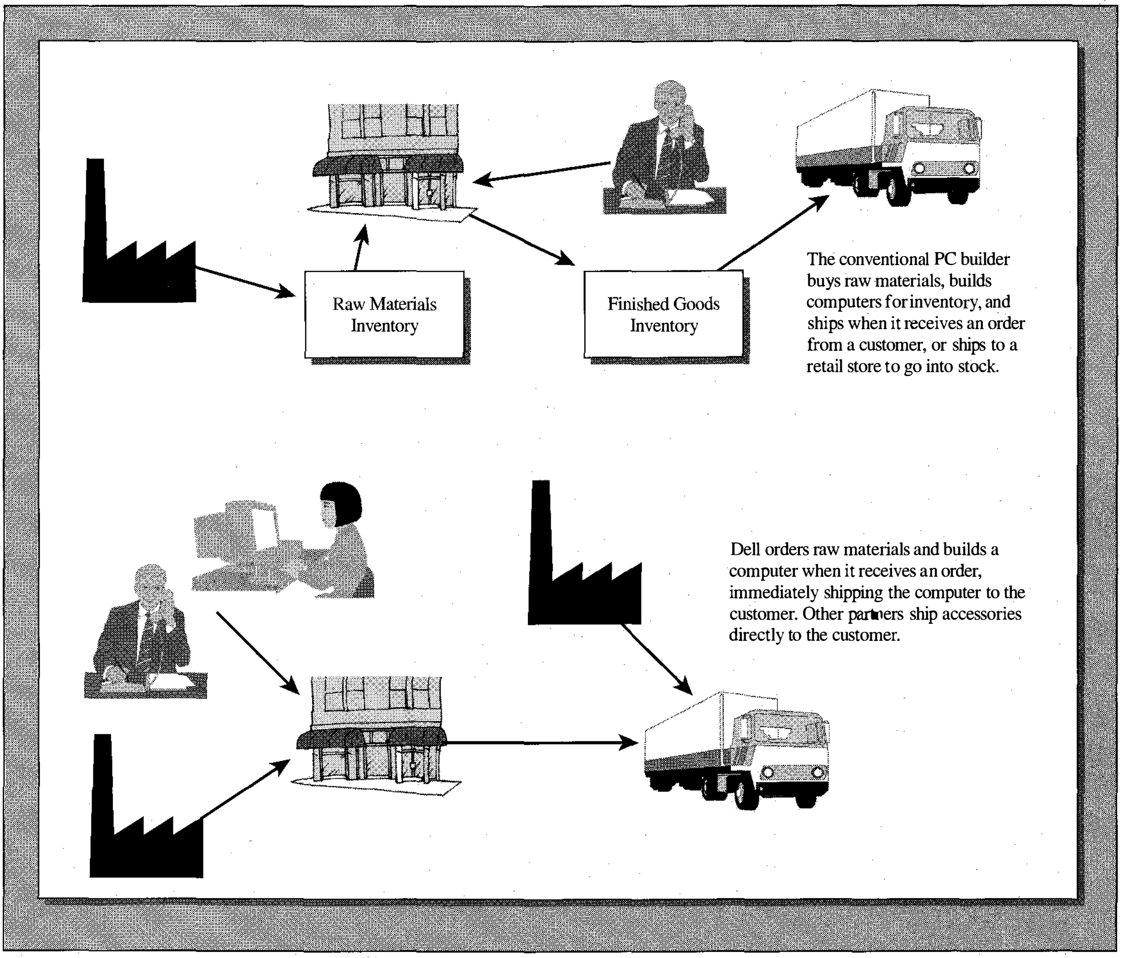

FIGURE 12-13
A new business model for building PCs.

electronically. Different vendors supply speakers, printers, parallel cables, and external storage devices while Dell sends the processor, monitor, keyboard, and mouse. The Web also provides after-sale service, making thousands of pages of system documentation and trouble-shooting information available to customers. Dell has used technology to become a highly efficient manufacturer with minimal raw materials and almost no finished goods inventory. See Figure 12-13. As of this writing, Dell had half the sales of Compaq, but a market valuation that is 25 percent higher than Compaq!

Another model is seen in Amazon.com, the Internet bookseller. Amazon provides customers with information about books, CDs, and videos. It accepts orders and credit card payments over the Internet, and forwards these orders to a com-

MANAGEMENT PROBLEM 12-3

Disintermediation is the process of eliminating an intermediary, for example, through the use of the Internet. If you were to purchase a house that you saw on the Internet without using a broker, you have "disintermediated" the realtor. Many people are aware of this phenomenon, but figure that it cannot happen to them. After all, they are not intermediaries. Or are they?

Faculty members have long considered themselves immune to the impact of technology on education. We have seen examples in this chapter of "distance learning," where networks help bring medical instruction to remote locations. Educators are confronted now with the need to think about the definition of the university. Does it make sense to continue to have physical classes? Do you learn more from face-to-face interaction than from a video link with an instructor? What is the role of distance learning? What can technology do to enrich the educational experience? How do you think universities could and should change to take advantage of advances like the Internet?

pany to which it has outsourced order fulfillment. A few weeks after the purchase, the customer receives e-mail from Amazon suggesting new titles related to his or her purchase. What is different about this model? Where is Amazon's inventory? It is, of course, virtual. Unlike booksellers with a physical location, Amazon receives payment before it has to pay for goods sold. A bookstore in a neighborhood mall buys books and displays them before a purchase, tying up substantial sums in a retail inventory that Amazon does not need.

Increasingly, companies are outsourcing manufacturing and service operations to other firms because the outsourcer can do the job better and/or for less cost. Many products sold today under brand names are really built by subcontractors or outsourcers. Communications over networks makes it possible for these outsourcers to look as if they are a component of your firm, giving rise to the "virtual organization."

The Amazon model works well for low-value, small items like books and CDs. What about the purchase of large expensive products like a new car? An increasing number of orders for cars come through services like Auto-by-Tel, and dealers report that customers come into their showrooms much better informed about cars than ever before. It is not unusual for a customer to have a copy of the manufacturer's suggested retail price and the dealer's invoice price to use in bargaining. In the future, will there be a few central locations to see and drive a car, with ordering and delivery through the Internet? Will dealerships exist primarily to provide after-sales service? Auto-by-Tel is an electronic broker, matching buyers and sellers of cars. There are similar new businesses on the Web that perform comparison shopping for a user or that operate electronic auctions for different products.

As we saw in Chapter 6, the Internet also lets every firm, no matter how small, undertake international sales. A business with a handful of employees can sell to the world from its Web site without having a sales force or representatives traveling the globe.

There are many different financial exchanges or markets. For hundreds of years, these markets have relied on individuals meeting on a physical exchange floor at a central location. The NASDAQ market was one of the first securities exchanges that did not have a physical location. Market makers use the NASDAQ system to enter their bid and ask prices. Individual customers, however, still have to trade through a broker. There is increasing movement toward electronic, global, and continuous time markets without any physical exchanges. While the existing exchanges are moving cautiously, entrepreneurs are taking advantage of technology to create electronic markets that function without specialists or market makers. The Paris futures exchange closed its "pits," where traders met physically, eight weeks after introducing screen-based trading. We expect that many markets will migrate to the Internet. Companies will list their shares globally and trade around the clock.

The huge increase in electronic brokerage accounts has motivated the markets to think about electronic exchanges; it has also frightened traditional, retail brokerage firms. From 1996 to 1998 the number of on-line brokerage accounts grew from 1.5 million to over 5 million. These on-line accounts make up a quarter of retail stock trades through more than 70 Internet brokers who offer trades, stock quotes, and research at low prices. Investors, however, still have to route their electronic orders through a broker even though they may wish to access the markets directly themselves. If this happens, the impact on full-service brokerage firms will be profound. Investment banks make high profits from IPOs (initial public offerings). Who will gain these profits if the IPO's stock is sold through an electronic auction?

The Association for Information Systems is a small professional organization of faculty who teach information systems throughout the world. AIS publishes two electronic journals, the *Communications of AIS* (http://cais.aisnet.org) and the *Journal of AIS* (http://jais.aisnet.org). The association could never afford to publish even a single journal if it had to follow the traditional model of printing, binding, and mailing each issue to members, but through the use of a Web server and passwords for members and other subscribers, it is economical to publish the journals. Traditional publishers of textbooks like this one are offering electronic versions and believe that eventually, they will phase out printed copies.

Networks and the Internet provide an incredible resource for developing new business models. Existing firms must continually reevaluate their businesses because these networks offer opportunities for radically new approaches to the way the firm operates.

CHAPTER SUMMARY

1. The telephone network offers great ubiquity and connectivity. Computer networks are striving to be easy to use.

2. A company that wants to develop a network is faced with a variety of choices. In many instances large firms have designed their own proprietary networks.
3. The common carriers are offering services that make using a network feel just like using the phone system. In this service, a common carrier is used for almost all parts of the communications.
4. Industries have tried to develop standards for EDI. The electronic interchange of information is expanding rapidly in industries such as retailing, transportation, and insurance.
5. There has been much talk of a national network infrastructure or "information superhighway." The French Minitel system was the first example of an information highway, and it offers a number of options for businesses.
6. The Internet, based in the U.S., is a network of networks. The development of the World Wide Web and browsers has contributed to the exponential growth of the Internet.
7. Companies provide a great deal of content on the Web, ranging from information about themselves and their products to sites that allow customers to order products directly from them.
8. Intranets offer a firm the ability to make information and knowledge available to all employees. They also provide a platform for developing different kinds of applications that help coordinate activities in the organization.
9. Electronic commerce is a new and exciting way of conducting business. Electronic markets will become more common because of the Internet.
10. Networks provide connectivity. They help transform the organization by connecting it to customers, suppliers, and alliance partners. The impact of greater connectivity will be to increase the pace of change in organization structure.
11. The combination of computers, networks, and databases enables new business models that offer many opportunities for managers. These new models are characterized by very fast response times and high levels of efficiency.

IMPLICATIONS FOR MANAGEMENT

The last part of the twentieth century will go down in history as the decade of the network. The Internet has exploded during this period, moving from a network consisting primarily of educators and researchers to one of business applications. The Internet offers companies the ability to provide multimedia information to internal employees, customers, and anyone else interested in the firm. As a manager, networks in general and the Internet in particular offer you another powerful tool for managing and communicating information. This technology reduces the impact of distance and time while dramatically increasing the speed of access for information. The ability for users to interact with the Net means they can search for information and order products through the Internet. The Internet is rapidly becoming the mechanism for connecting organizations and individuals throughout the world.

KEY WORDS

Agent
America Online
ANSI X.12
ATT Worldnet
Auction
Browser
CommerceNet
Compuserve
Computer network
EDI
Electronic commerce
Home page
HTML (hypertext markup language)
HTTP (hypertext transfer protocol)
Microsoft Network
Minitel
Netscape
Network
TCP/IP
Ubiquity
World Wide Web

RECOMMENDED READING

Bakos, Y., "The Emerging Role of Electronic Marketplaces on the Internet," *Communications of the ACM.* 41, no. 8 (August 1998), pp. 35–42. (A major section of this issue is devoted to information systems and economics.)

Kambil, A.; and J. Short. "Electronic Integration and Business Network Redesign: A Roles-Linkage Perspective," *JMIS,* Spring 1994. (A study of the impact of one network on business.)

Lucas, H. C., Jr.; H. Levecq; R. Kraut; and L. Streeter. "Minitel: The French National Information Highway," *IEEE Spectrum.* November 1995, pp. 71–77. (The story of Minitel.)

Zaheer, A.; and S. Zaheer, "Catching the Wave: Alertness, Responsiveness, and Market Influence in Global Electronic Networks," *Management Science.* 43, No. 11 (November 1997), pp. 1493–1509. (An interesting article looking at the requirements for success in global currency trading, which amounts to over $1 trillion a day, approximately 50 percent of which takes place over the Reuters network.)

DISCUSSION QUESTIONS

1. What advantages does the telephone system offer as a model for a network?
2. Why have companies developed so many proprietary networks?
3. Why are EDI standards hard to develop? Why will one standard not serve many different industries?
4. What industries are most likely able to take advantage of EDI?

5. How do networks contribute to the development of the T-Form organization?
6. What IT organization design variables are affected by networks?
7. What is the appeal of a mass market network?
8. What services to business do mass market networks offer?
9. What are the problems with completing transactions over these networks, that is, providing your credit card number after ordering merchandise?
10. Why has the French Minitel system been such a success?
11. What was the role of the French government in developing Minitel?
12. Describe the World Wide Web. How can a word or phrase in something you are reading on the screen result in your being connected to another computer that has more information about that term or phrase?
13. Why are people putting so much information on the Internet, information that they are not likely to ever receive payment for from readers? Is this behavior strange from an economic standpoint?
14. What is a Web browser? How have browsers contributed to the growth of the WWW?
15. Pick a specific company, and describe how it might make use of the Internet.
16. What is an Intranet? What is its role in an organization?
17. The first electronic filing of tax returns was plagued with fraud. How do you think one could defraud the system, and what could be done to prevent it?
18. What is the role of the government in stimulating the development of a national network infrastructure?
19. The Internet reaches most countries in Europe, Asia, and the Americas. Connections are more spotty in the Middle East and Africa. What are the implications today for a country being "off the net"?
20. There are concerns over pornography on the Internet, while authoritarian countries worry about the free flow of ideas on the Net. Is there any way to regulate information content on the Internet? Is it desirable to do so?

CHAPTER 13

Information Technology Architectures

Outline

Focus on Change

The basic architecture of the firm will influence the kind of systems that are developed and the linkages it develops with other organizations. A firm wants a flexible architecture to support a variety of technology initiatives. In today's environment, this architecture is likely to include networked workstations on the desks of most employees, larger computers on the network for processing transactions and sharing large databases, and Internet, Intranet, and Extranet access. As you read about airline reservation systems, broker workstations, and the Chevron client-server architecture in this chapter, think about the potential of these architectures to enable dramatic changes in organizations.

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In the early days, designers were advised to develop systems without considering the hardware or software that would be used to run the system. Design, after all, should be independent of hardware and software. Of course, available hardware and software had to influence how a system would operate. For example, a designer could not design an on-line system if the computer running the system was capable only of batch processing.

Beyond gross characteristics such as batch or on-line, however, design could be independent of hardware and software. Part of the reason for this independence was that designers worked with mainframe computers of differing sizes. In the 1970s, minicomputers became very popular as departmental machines or computers came to be used in applications where the power of a mainframe was not needed. Most minicomputers came with time-sharing operating systems, and the natural tendency was to design on-line applications for them.

In the early 1980s the personal computer proliferated and changed the way users thought about information systems. Extremely sophisticated and powerful packages are available for these computers. The packages feature elaborate graphical user interfaces with pop-up windows, mice for input, multiple windows on the screen, and so on. Personal computers made users more familiar with computing and raised their expectations about how information systems should perform. They also created a lot of dissatisfaction with mainframe and minicomputer systems developed in-house by the firm's own staff.

Clearly, the task of developing the architecture for an organization's computing system is difficult. If an organization is starting from scratch, one could conceive of buying a large computer, a midsized machine, or a network of personal computers. The question of which option to choose may require a major study and considerable effort. The organization that already has a number of computers in place must decide how to manage and expand its systems as users come up with new needs and ideas for computing.

WHAT IS HARDWARE AND SOFTWARE ARCHITECTURE?

Architecture is the place where all the technical topics we discussed so far come together. An organization's architecture includes:

- Computers, often of different sizes from different manufacturers.
- Operating systems, frequently more than one.

- Languages for developing applications.
- Database management programs.
- Packaged applications software.
- Networks ranging from those within a department to an international, private network to the Internet.

Beyond the technology, architecture also includes considerations of the way the organization processes information, particularly at the location processing takes place. We might ask the following questions to characterize a firm's architecture:

- Where is processing done? What computer among a group of computers processes information?
- Where are data stored for access by users?
- Where are data updated?
- What is the user interface? Where do the interface programs run, on which computer?
- What capabilities for data analysis does the user have? Is there local intelligence at the workstation level?
- What networks are in use, including Intranets and Extranets?
- What is the firm's presence on the Internet?

Just as there are many types of buildings, there are different types of information systems architectures. Table 13-1 provides examples of five architectures that are fairly easy to characterize. There are also many examples of mixed architectures, but generally they include the ones listed in Table 13-1.

Table 13-1 characterizes architectures according to several criteria:

- *Volume of processing.* The volume of information processed may determine the kind of architecture needed.
- *Database.* The amount of data storage available on each class of computer is increasing, but in general more data still can be stored on larger computers.
- *Interface.* What kind of user interface is generally associated with a given option?
- *Number of users.* How many users can the architecture support?
- *Discretion.* How much processing and ad hoc analysis can the user do on his or her own?

Mainframes for High Volume

The first option in Table 13-1 is the **mainframe,** the traditional machine for developing applications. Today mainframes are used for very high-volume transactions processing. American Express authorizes purchases for holders of the American Express card when a merchant calls to determine if American Express will agree to the charge. This high-volume application to access credit records and decide on approving the charge resides on mainframe computers (see Figure 13-1).

Mainframes are also associated with extremely large databases. It is not unusual for organizations such as banks and insurance companies to have data files

TABLE 13-1

TYPICAL ARCHITECTURES

Option	Volume	Database	Interface	Number of users	Discretion
Mainframes	High-volume transactions processing	Large	Simple character-oriented	Large	Limited
Midrange, fault-tolerant	Medium-volume transactions; designed for OLTP	Medium to large	Simple character-oriented	Moderate number	Limited
PCs and workstations	Low	Medium to small; user may input and download all data	Elaborate workstation	One at a time	Extensive
LANs	Low to medium	Medium to small; download capability	Elaborate workstation	Multiple	Extensive
Client-server	Varied	Small to large	Elaborate workstation	Multiple	Extensive

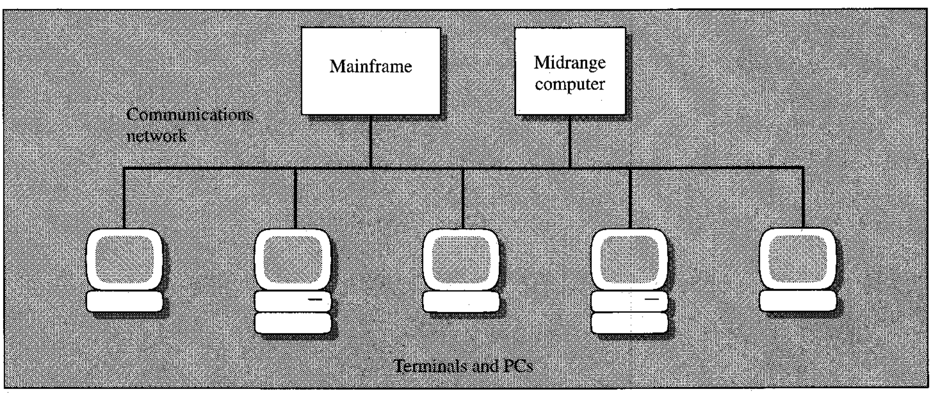

FIGURE 13-1
The mainframe and midrange architecture.

that contain many billions of characters (gigabytes) or even trillions of bytes (terabytes). These firms have entire rooms filled with disk drives containing important data that are on-line for inquiry and updating.

Mainframe applications typically feature a large number of users of the data. These machines are designed to manage huge communications networks in which users using remote terminals access the mainframe and its databases. However, what the user can do is fairly limited. Typically, certain functions are made available to each user. Although it is theoretically possible, most mainframe systems do not provide extensive data manipulation features to users.

Thus, the user's discretion is often limited. However, in transactions processing applications, designers usually do not want the user to have more than limited capabilities. It is not a good idea for a reservation agent to analyze flight data; that job should be done by the marketing or operations department of the airline. The transactions processing system is an operational system, not a system for analysis and reflection.

As discussed in Chapter 8, it appears that manufacturers of mainframes and minis are rushing to develop large computers that consist of multiple versions of popular chips. A good example is NCR, a former subsidiary of AT&T spun off to its stockholders, which is selling mainframes that consist of groups of Intel processors. NCR says that a unit of processing power on its new multiple-chip machines costs about one-eighth of what the same unit costs on one of its conventional, old-line mainframes.

The Midrange Computer Is (Usually) Smaller

Much of the previous discussion also applies to the second option in Table 13-1, except that a **minicomputer** or **midrange system** generally processes lower volumes of data and smaller databases. The demarcation between mainframe and midrange, however, is not always easy. Some midsized computers with extremely high transactions processing speeds are designed specifically for **on-line transaction processing (OLTP)** applications. Midrange computers are also used extensively in data communications systems.

To enhance the attractiveness of midsized computers in OLTP, several vendors introduced the concept of fault tolerance, or fail-safe operations. Tandem, purchased in 1997 by Compaq, manufactures a line of computers called NonStop—each component is duplicated and all data are written to two different disk drives. Because organizations tend to depend on their OLTP applications, fault-tolerant computers are very attractive. The New York Stock Exchange uses a number of Tandem computers for processing transactions, and the American Stock Exchange uses a Stratus computer, another fault-tolerant machine, to update stock quotations.

The PC Is Totally Different

When the personal computer first arrived, users treated it as a computer that belonged to them. Much of the early motivation for using PCs was to get away from the traditional information services (IS) department. The IS department has the reputation of being unresponsive and slow to develop applications, and with their own computers, the users could become independent of IS (see Figure 13-2).

At first there was hardly any software for PCs. But entrepreneurs soon saw tremendous opportunities in the eventual market of millions of computers with each owner buying their package. Of course, the package for the PC had to be a lot different from the package for the mainframe or mini. First, a user who was not a technology professional would evaluate and use the PC package. The program had

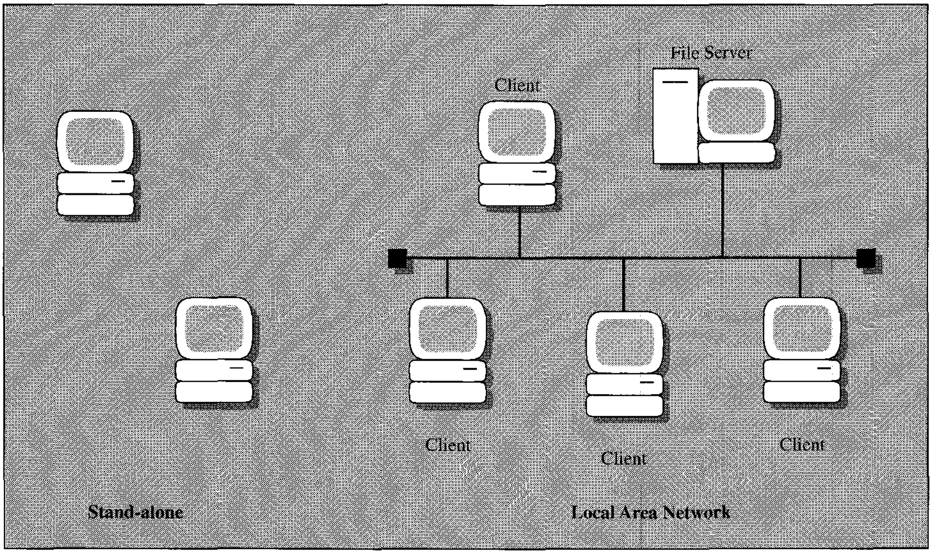

FIGURE 13-2
A personal computer architecture.

to be easy to use with a pleasant interface, giving rise to the term "user friendly," as opposed to "user-surly" in-house custom systems. The packages had to be easy to use because the vendor could not afford to provide training for a package that cost less than $500.

Users controlled the first PCs and generally entered their own data for analysis. The most popular uses of PCs are word processing, spreadsheet analysis, presentation graphics, and database management, though the number of applications packages continues to expand rapidly. User control not only frees the user from dependence on the systems staff, it also provides extensive discretion as to what program runs at what time on a computer. Since the computer is not shared, the user can choose when and what to run and has unheard-of freedom.

Of course, the PC seemed too good to be true. The first problem that came up was that users wanted data that were not easily available. The user might have data provided on a mainframe system, but could not get a machine-readable version of the data to the PC. Many organizations found users had to key into a PC data produced by a mainframe program.

This inelegance led to the development of PC-to-mainframe links—combinations of hardware and software used to establish a physical connection between the PC and a mainframe or mini. Just having a connection, however, is not enough. The user must be able to access mainframe data, which are likely to be stored in a way never intended for this type of access. What is the solution? One answer is to have IS consultants who help users obtain the data they want from the mainframe and download it to their PCs.

The user now is once again dependent on the IS staff, at least to obtain data. The user still has the discretion as to what programs to use and when to use them once the data are on the PC. Over time, the PC has become more integrated with the rest of the hardware and software in the firm.

How Do You Share?

As users work with their PCs, they develop new ideas for how they can be used. Within departments, the idea of sharing became popular: Why not share common data, expensive devices like laser printers, and so on? The **local area network (LAN)** makes this possible. The LAN enables users to share data through a special PC that is a dedicated file server (Figure 13-2).

Consider the pharmaceuticals firm that buys data from an international service that collects information about the sales of prescription drugs. The pharmaceuticals firm is located in New Jersey and the database of market data is in Europe. To reduce access costs, once each quarter when the database is updated, a large extract is loaded onto the file server of a LAN in the marketing department at the pharmaceuticals firm. Whenever a marketing analyst wants data, he or she downloads it from the file server to a PC for further analysis. All this activity is made possible by the LAN.

Now the PC can serve multiple users who want to share data. Some companies have developed applications that looked originally like candidates for a midrange system by using a LAN. Given present technology, there is some overlap at the boundaries for all the options in Table 13-1. Some OLTP systems on mainframes can run on midrange machines; some midrange applications can run on LANs.

MANAGEMENT PROBLEM 13-1

ABZ manufactures electronic components. For many years it relied on a mainframe computer complex. The company has several divisions and a dozen plants. Right now some customers need to know which plant makes the product they want to order. A strategic goal for marketing is having the company appear as a single entity to the customer. Senior management feels that it is necessary to centralize order processing so customers can call one number to place their orders for any product ABZ makes.

The plants are not completely happy with this idea. They would like to have midrange computers or client-server systems of their own. One plant manager said, "We may have to download some production plans from the mainframe at headquarters, but we want to control our own plant systems right here. In addition, our production processes are getting more and more automated. It just makes more sense to do things locally where we know what is going on."

What kind of architecture can you recommend for ABZ? Does your architecture resolve the conflicts between centralized and local computing?

Power to the Desktop with a Friendly Interface

The major trend we can see in architecture over the past three decades is computational power moving from a central computer facility to the desktop. The days of batch processing, where the user sends data to be keyed for the computer, gave way to on-line systems where users had terminals for entering transactions. Terminals spread to those who did not necessarily input a lot of data but needed to ask questions and make queries of the system. The personal computer made it possible for users to develop some of their own solutions to problems, but the user soon saw the advantages of being networked. At some point, we will not know or care which computer is working for us. The workstation on our desk will provide an interface to a large network of computers. Some computers will have special purposes; for example, a large machine may be in charge of the database while specialized processors perform the role of file servers. All this computing power will be delivered to your desktop, completing a movement that began when the first on-line systems were developed in the 1960s.

Moving toward the Client-Server Model

To further complicate matters, there is no real need to have a pure architecture. In fact, many organizations already have or will move to mixed architectures, we predict. Networks of mainframes, minis, and personal computers are typical. The PCs are on a LAN that has a gateway to a mainframe or midrange network (Figure 13-3).

The connection of PCs to networks of midrange computers and mainframes has resulted in the **client-server architecture.** A client on a personal computer connects to a PC, midrange computer, or mainframe that is the server. The **server** retrieves data and manipulates it in some way for the client. The client may also process the data further after moving it to his or her PC. A network may have more than one server. For example, our network has various servers for different departments, and some servers are dedicated to certain applications, such as running a mathematical problem-solving system. A user can connect to a

Networks at FedEx

Federal Express is the leading express delivery company in the world. All its 2200 locations are connected through the company's Intranet. The company is phasing out mainframe computers where possible and moving to a client-server architecture. The Intranet provides information as well as many other services such as multimedia training.

FedEx will install parts of its Intranet behind customers' firewalls so that it and the customer can be tightly integrated. This technology is tying FedEx more closely to its customers than even its Extranet can. The advantages for both parties are great; all users access information using a Web browser; there is no need to change interface programs with every new application. This suggests that companies in the future will be very tightly integrated through shared networks and shared applications programs.

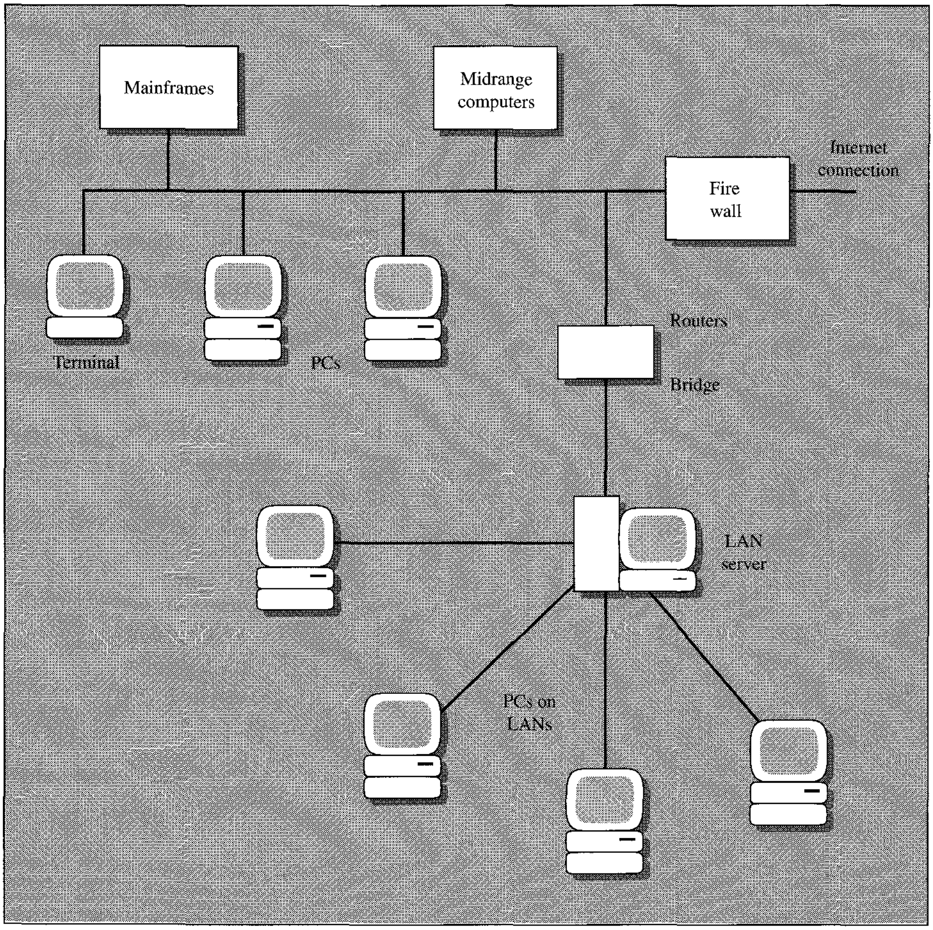

FIGURE 13-3
A mixed architecture.

number of different servers from his or her local PC. In a two-tier client-server system, the server performs most of the processing and contains the database while the user's PC runs an interface program and does some local processing. In a three-tier system, there is a server to perform most processing and a server to host the database.

Vendors like Sun Microsystems adopted the client-server model as the basis for their entire product line. Sun encourages customers to purchase client workstations and a larger workstation to act as the server. The company runs all its factories and distribution systems on client-server systems using Unix, and uses a client-server system for all order entry and processing. To provide powerful client-server systems in an effort to capture market share from minis and mainframes, Sun has developed a large-scale server expandable to 20 processors, each with up to a terabyte (10^{12}) of disk capacity and 5 Gbytes (10^9) of RAM. Sun claims that the server supports up to 1000 users initially and up to 2000 in its largest configuration.

IBM has advanced a vision of computing it calls "Network-centric." Its chairman feels that IBM's customers are working to become more efficient and competitive, reducing cycle times and becoming more responsive to customers. All these efforts require collaboration with customers and suppliers, and they all depend on networking. IBM is positioning its computers as servers and/or clients on large networks and providing networking services that charge transactions fees. For example, Walgreen's developed a system that lets doctors send prescriptions to pharmacies electronically over an IBM network, and the pharmacy pays a transaction fee to IBM for each prescription. IBM's strategy also led it to acquire Lotus in order to obtain Notes, a groupware product discussed in Chapter 21.

Other vendors promote what they call **open systems**—those that enable connections of different sized computers from a variety of vendors. Sun argues that this kind of open system is more complex than its client-server architecture, which runs only on Suns, because one expects greater complexity when several different types of computers are connected on a network. Of course, many companies have large investments in a variety of midrange and mainframe computers; in the short run their only choice is to move toward an open architecture in which there are likely to be different kinds of clients and servers on a network. It is also clear that individual users have developed favorite types of computers. It is almost impossible to dictate to someone what his or her workstation has to be.

Some users feel that a terminal is fine, and they do not need a lot of local processing power. However, they would like to have friendly software that provides windows, something associated with the use of a PC or engineering workstation. Researchers at MIT developed a terminal with these capabilities called the X Windows system. A number of vendors offer X Windows terminals and software so that a simple terminal can provide a graphical user interface.

The vision for the future is client-server computing where the user works with a client workstation to access data from a variety of servers. The size of these servers and their location are of no interest to the user who is accessing the information they provide. The Internet is an excellent example of this kind of architecture. Your browser communicates with one or more servers; as you follow hyptertext links from one server to another, you do not need to know the server's location. For a large corporation with distributed computers, this same model works well. If you add an Intranet and connect it to transactions processing servers in the firm, you may get to the point where the main program run on a client computer is a network browser.

Certainly there are a lot of choices in developing an architecture. Later in this chapter we try to provide some broad guidelines for matching a systems design to hardware and software architectures.

What Is Infrastructure?

IT infrastructure can be defined as the hardware, software, and networks that the firm maintains for common use. Some reserve the term for items that a single business unit cannot justify on its own but that make sense for the corporation. For example, it is unlikely a small department would develop its own Intranet, but it would take advantage of a corporate Intranet to publish material that others in the company would like to share. I generally think of infrastructure as the stock of hardware, software, and networks that exist in an organization at a given point in time. This stock is what you have available when the opportunity for a new IT initiative arises. It is important to keep the infrastructure up-to-date so that you can take advantage of these opportunities. However, it can be very difficult to convince management to invest in infrastructure in order to take advantage of some future option that you cannot identify right now.

The Advantages and Disadvantages of Standards

There are two kinds of **standards:** agreed upon and de facto. We have seen the importance of international standards in our discussion of communications and networks. International standards make it possible to directly dial phones in different countries. EDI standards have encouraged the exchange of data between companies. Internet standards make possible the World Wide Web and let browser programs display content from millions of servers.

Companies like to have their products become de facto standards in the industry. In the early days, IBM mainframes and their operating systems were a standard. Major changes in architecture, along with the development of mini and personal computers, local area networks, and the Internet changed that standard. Vendors with computers running Unix want this operating system to become a standard on midrange computers and servers. Microsoft has followed a strategy of making its products the standard for personal computers: Windows 98 and Microsoft Office have become a de facto standard in organizations. Microsoft wants Internet Explorer to be the browser of choice, and sees Windows NT as the appropriate operating system for the server today, and the desktop in a few years. Oracle sees itself as the standard for client-server database management systems, and SAP believes it is the standard for enterprise applications.

Such standards have both advantages and disadvantages for the customer. Standards encourage the sharing of information with minimal conversion from one application to another. We have seen that standards also facilitate interoperability. De facto standards, particularly from a single vendor, give that vendor tremendous market power and may reduce innovation. The development of the Net PC is an effort to break the de facto Wintel (Windows on an Intel processor) personal computer standard. While your organization will most often choose a standard, it is important to recognize both the advantages and disadvantages of this strategy.

EXAMPLES OF DIFFERENT ARCHITECTURES

Competitive Reservation Systems

The major airlines have developed complex and sophisticated **computerized reservation systems (CRSs)** (see Figure 13-4). American Airlines developed its SABRE system first to keep track of reservations, as manual reservation systems

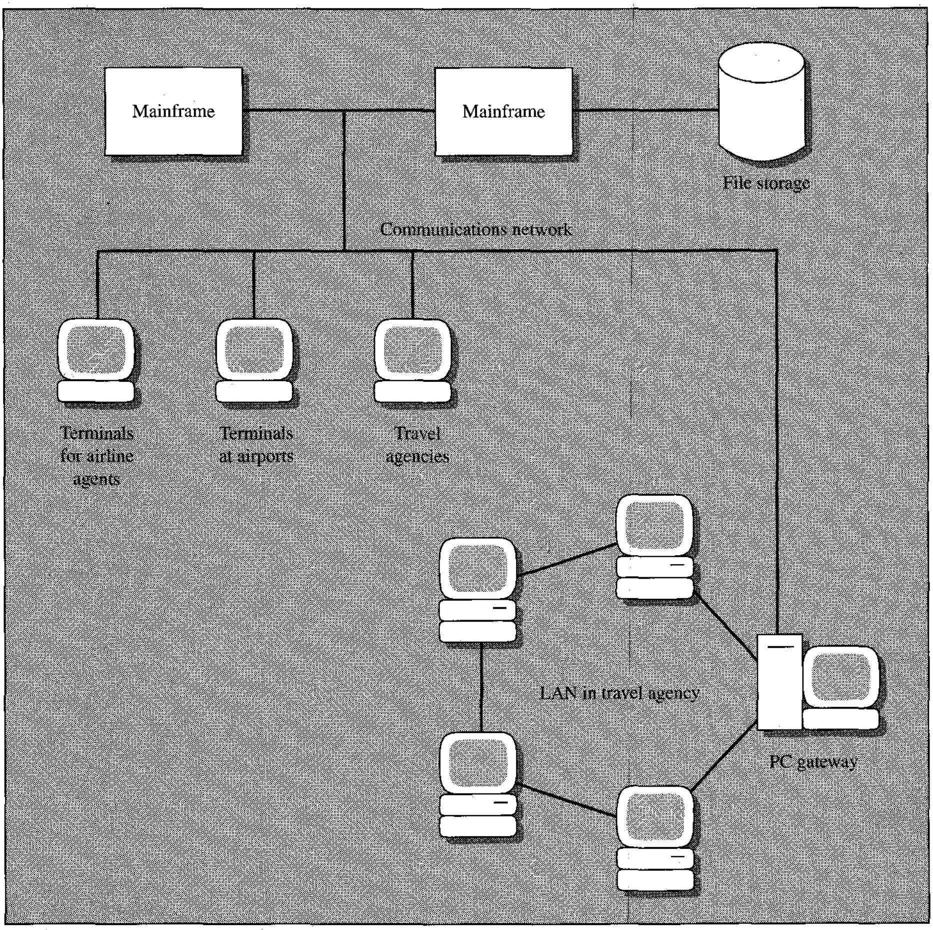

FIGURE 13-4
Airline reservation system.

were predicted to break down in the early 1960s with the expansion of jet travel. Other airlines followed American's lead and developed systems of their own in the 1960s and 1970s.

These CRS applications feature very large mainframe computers. In the case of American, 17 large IBM mainframes (with multiple processors) are specially connected in two groups, one for reservations and one for fare data. In each group, one machine is a backup that takes over if something goes wrong with one of the other computers. The SABRE database has contained in one month up to 45 million fares and experiences millions of changes each month. The system creates 500,000 PNRs (passenger name records) daily. The complex has processed a peak of 5300 transactions per second and serves more than 360,000 devices in 74 countries on six continents. There are 30,000 travel agents, 400 airlines, 39,000 hotels,

FROM SABRE'S WEB SITE

The heart of our technological infrastructure is in Tulsa, Oklahoma, the home to our 120,000 square-foot high-security data center. Housed in the data center are 17 mainframes with more than 15.3 terabytes of electronic storage, over 4,000 MIPS of processing power, 180 communications processors and numerous midrange, UNIX-based computers. This data center runs the SABRE Computer Reservation System (CRS) in a mainframe operating environment, the ideal solution for the high-volume, high-availability requirements of the distribution business.

The networking capability of SABRE is also impressive. We manage networks consisting of nearly 200,000 personal computers. In addition, we maintain over 45,370 telephone numbers and 10,200 voice mail boxes which handle more than 115 million calls annually. SABRE networking solutions include wireless technology as well as sophisticated voice and data telecommunications technology required to support a broad range of computing solutions, such as complex Internet sites.

and 50 rental car companies that use the system. The system processes an estimated 45 percent of all domestic U.S. airline reservations. SABRE is certainly a high-volume fast-response mainframe application.

In addition to reservations, CRS applications are expanded to include many other functions. The computers keep track of when flights depart and when they will arrive. (American Airlines jets send radio messages to the computer on takeoff to update flight monitors.) The CRS systems also help specialists load aircraft to keep them balanced. A CRS keeps track of special meal requirements and can connect with other systems to provide rental cars and hotel rooms.

One of the major expansions of reservation systems occurred when American and United decided to place terminals connected to their systems in travel agents' offices. Their systems already showed the flights of competing airlines so reservation agents could answer customer questions. All that was needed was a way to make reservations on other carriers' flights.

Now, the airline industry can be viewed as having a huge network of interconnected computers. The reservation systems are operated by individual airlines, but they all send messages to each other. USAir allocates a certain number of seats on its flights to the SABRE system. When the flight is to be closed, USAir sends a message to SABRE to close that flight segment, and so on. Millions of messages flow among the computers each day.

Travelocity: Interfacing a CRS to the Web

SABRE responded to the opportunities offered by the Web with EaasySabre and Travelocity. The first is an American Airlines-oriented connection to SABRE, while Travelocity is a more "neutral" system that anyone with a browser can use to access schedules and fares as well as make reservations. Figure 13-5 is a simplified diagram of how Travelocity works.

Different Approaches to Service

Sometimes technology can let a company enter a new market by making a new service economical. The Internet and Web provide many opportunities for providing service given the ease of developing a site and the availability of a worldwide network infrastructure. Korn/Ferry is one of the major executive recruiters in the U.S. Because of the effort involved in an executive search, Korn/Ferry specializes in searches for very senior managers who command large compensation packages. (The recruiter's fee is usually a percentage of the executive's compensation, which is paid by the company that requested the search.)

This recruiter has established a new subsidiary called Korn/Ferry: CareerLink which targets managers and professionals earning $75,000 to $120,000 a year. The kind of search performed for a senior executive would be too expensive for the fees generated at this salary level. CareerLink relies on the Internet to augment its usual search tactics. Corporate clients have asked recruiters to serve this market. Korn/Ferry has established an electronic database to match potential applications with vacancies. It interviews and screens the best candidates. Clients can download an interview videotape before deciding to meet a candidate. The addition of the interview and videotape is a value-added service compared to the many electronic job banks on the Internet. Korn/Ferry thinks that CareerLink may turn out to generate more revenue than its traditional business.

The challenge is to provide a variety of services through a group of Web servers. The customer must be able to access all the information in the SABRE databases using a browser, even though these data are normally accessed through SABRE programs running on a PC or terminal. The system has been described as a "travel mall," more than just an airline reservations system. The system receives feeds from 5000 data sources. The site must provide electronic commerce capabilities so that a customer can purchase a ticket. The commerce and merchant servers shown in Figure 13-5 serve this purpose. Worldview is a partner in Travelocity that compiles, reformats, and sells data on travel to various companies in the travel industry.

With so many connections and computers, performance becomes an issue. The system can provide 30–40 Web pages per second, and 4000–5000 database queries per second. There are some 300,000 Web pages available to the person browsing the site. Travelocity gets more than 30 million "hits" a month and makes money through transactions charges for reservations made using the system. Transactions volume has been growing at a rate of 20 percent a month, making it necessary to add capacity on a regular basis. Travelocity is an excellent example of adding a Web capability to an existing large complex application, in this case a computerized reservations system. Many organizations have created Web connections to existing applications to extend access to crucial data and provide new services to customers.

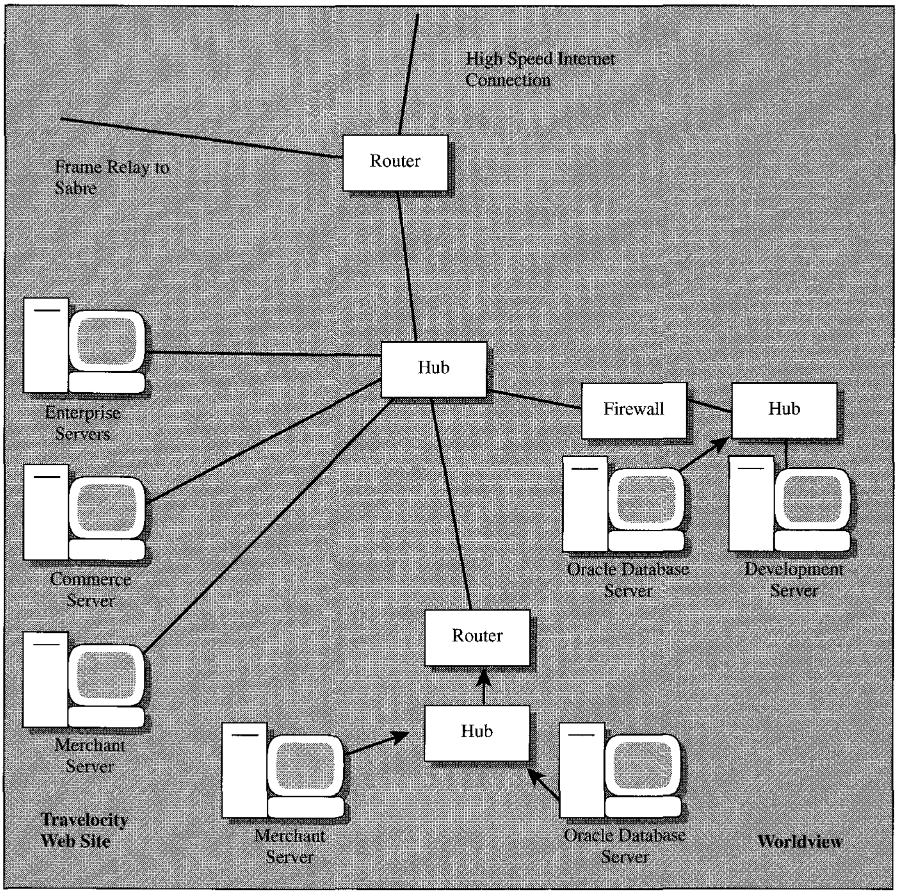

FIGURE 13-5
The structure of Travelocity. Travelocity interfaces the Web to mainframe systems.

A Broker Workstation

Stockbrokers assist their clients with investments. The broker is both a consultant and a salesperson, and is compensated based on the amount of trading he or she does for customers. The broker needs a great deal of data about the stock market, the securities and other instruments the public can buy, and the client. For many years, brokers have had stock quotation terminals on their desks so that they can get the latest price of a security. Many brokers added their own PCs to keep track of customer portfolios, write letters to customers, and do other information processing tasks.

Several major brokerage firms and independent companies are developing **broker workstation** systems. One of the largest U.S. brokerage firms installed 17,000 personal computers running broker workstation software for its stockbrokers. The objective is to replace all terminals with a single PC-based workstation for each

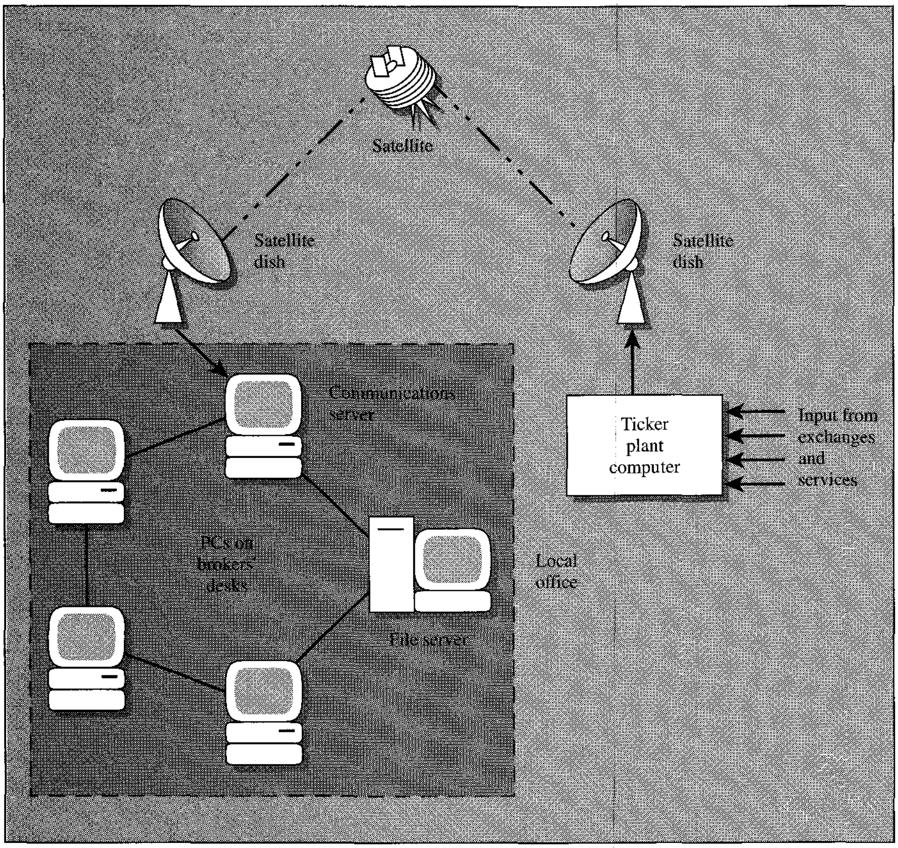

FIGURE 13-6
Broker workstation system.

broker. The schematic of one independent's system is shown in Figure 13-6. This firm operates a ticker plant in New York that accepts data feeds from the stock exchanges and companies that sell financial data. The ticker plant relays the data to a satellite, which then broadcasts the data throughout the United States.

A customer (generally a brokerage firm office) needs a satellite dish on the roof to pick up the broadcast signal. Within the local office, there are at least two servers and a local area network. One server maintains historical data, which can be accessed by the broker from the workstation. Another server handles communications and accepts the incoming data stream from the satellite.

Because many brokerage firms have their own corporate mainframe systems that maintain customer data, it is possible for the broker to open a window on the workstation and make that window emulate a standard IBM terminal to communicate with the corporate mainframe. The broker workstation provides a number of features controlled by the PC. It provides multiple windows that execute individual applications. The broker can set up monitors to follow a single stock or groups of stocks; for example, it can set alerts to go off if the stock of XYZ Company hits a certain price. A number of applications packages are also available on the system, including electronic mail, word processing, and presentation graphics.

Chevron Canada Client-Server Model

Chevron Canada used a client-server model to redesign a sales-monitoring application (Sinha, 1992). This application connects Chevron's Canadian distributors to the Vancouver corporate headquarters and replaced a 20-year-old batch processing, mainframe system. This system is used for order entry, tax, inventory control, and management reporting. Over the years, it has added on-line transactions processing capabilities and limited decision-support functions. As shown in Figure 13-7, the client-server design features a wide area network connected to local area networks. There are multiple servers along with a connection to a mainframe in San Francisco. Eventually the system will handle about 165,000 transactions per month from over 35 remote sites; some 65 local clients will also make requests. When completed, each client will be connected to a local server containing data relevant to that client. There will be some 300 relational tables distributed over multiple servers and replicated on a central server in a 3-Gbyte database.

Comparing the Applications

The broker workstation application features a much different architecture from the CRS example. The brokers do either limited or no updating of the database. The data are updated centrally at the ticker plant and copies are kept on each LAN. There is some two-way satellite transmission for broker queries of the database, but higher-volume transactions with the broker's own, in-house mainframe computer take place over terrestrial lines.

Users share the price data through the LAN, and the personal computer gives them extensive discretion on what they do. One broker may be analyzing a customer portfolio while another provides a customer with a stock quotation. At the same time, a broker's assistant may be using the system to send out a mailing to all customers interested in a particular stock.

In the Chevron case, the application is similar to the CRS in that both systems process a large number of transactions, but the airline CRS is centralized and Chevron has chosen a client-server architecture. Of course, the Chevron system processes far fewer transactions than an airline CRS, and that is the reason it can adopt an architecture dependent on a number of small computers. It is significant that LANs and client-server systems have developed sufficient power to be used in transactions processing applications at all. With extremely high volumes of transactions updating, you still need a mainframe or large midrange computer.

Travelocity offers a completely different architecture; it is a Web application built on top of an existing mainframe application. This approach to reaching customers and suppliers is very common; much of the data of interest to these users are on transactions processing mainframes. The Federal Express package tracking capability on its Web site also lets a customer with a browser access data on a mainframe system.

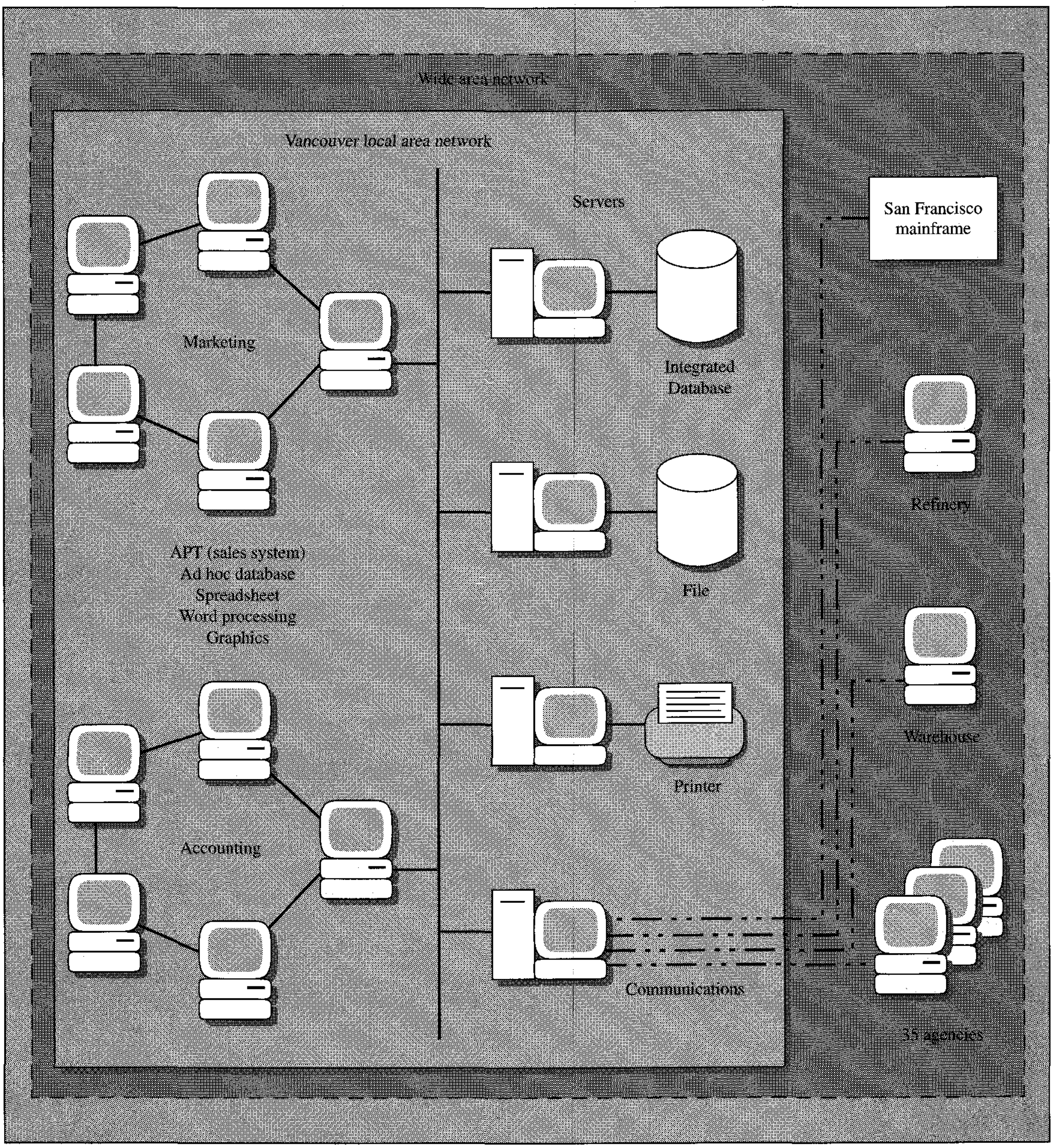

FIGURE 13-7
Client-server with WANs and LANs.

The president of Sabre Technologies stated that there is simply no other operating system that can handle 5000+ transactions per second at 99.95 percent uptime than the mainframe airline control program. Travelocity operates a large mainframe system for Web access. However, in general, client-server architecture is today steadily eroding the dominance of mainframes and mid-sized computers in on-line transactions processing applications. In the case of an airline CRS, the need for mainframes is clear. In other applications, the designer will have a choice. Today cost/performance advantage lies with client-server architectures for many applications.

MATCHING DESIGN TO AN ARCHITECTURE

When the Architecture Is a Given

In many situations, an application will have to run on an existing architecture because that is what the organization is willing or able to provide. In this case, the guidelines below can be used, but they must be modified to fit organizational constraints. Sometimes, however, the architecture can be modified to provide the appearance of a new system. It is very expensive to redesign large transactions processing systems, and some firms have been updating the design of these systems by hiding the old system behind a new PC interface. One option is to maintain the mainframe system solely to process transactions and build a database. The firm adds separate servers to process queries and provide decision-support software to client computers.

MANAGEMENT PROBLEM 13-2

With the ability to embed computers in many different places, choosing and defining an architecture becomes more challenging. The Singapore Port Authority has a variety of processors that work on moving containers from trucks to ships and vice versa. Transponders identify the truck, and a video system reads the identification number on a container on the trailer. These data go over a wireless transmission to a yard control computer. This computer downloads instructions to computers on a yard crane and on the quay crane.

Some researchers, especially at Xerox's Palo Alto Research Laboratory, believe that computers will fade into the background completely; they will be embedded in buildings, automobiles, briefcases, and maybe even clothing. Computers will be ubiquitous, but also unobtrusive, at least compared with today's computing environment.

What are the implications of these trends for architecture? How does something like the Internet compare with client-server computing? Do you care what computer happens to be acting as a server at the moment?

Suggested Guidelines

In this section we suggest some guidelines for considering the interaction between hardware and software architecture and systems design. The type of architecture will influence design. As systems designers, we have radically different choices depending on whether we plan to implement on a LAN or a mainframe with terminals. Some basic guidelines are as follows:

1. Start sizing an architecture at the smallest and least expensive option. Can a suggested application be completed on a PC with packages? If there are multiple users accessing a central database, the answer is probably no. The same is true if there are too many simultaneous users. A PC will probably run Windows 98 or Windows NT and will make use of a popular "suite" of office applications that include a spreadsheet, word processor, presentation graphics program, and database management system.
2. If a stand-alone PC is not adequate, can a system be developed using a LAN? The LAN accommodates multiple users who can share data files. The same software as discussed above is appropriate, but the server will probably run Windows NT. At some point, there may be too many users for the LAN, or more likely there will be too high a volume of activity for the servers. It is also possible that the system must handle a large volume of transactions, in which case the LAN is not currently the best alternative.
3. A client-server architecture featuring workstations or midrange computers as the server is a cost-effective alternative for many applications as long as the system can handle the processing load. The server here may run NT or Unix, while the clients run Windows 98. User applications may be developed using the PC database management package or a midrange DBMS like Oracle or Sybase.
4. Midrange computers have the capacity to handle a large number of transactions and large databases, and can control large communications networks. You may program these systems in the language of a DBMS or in a language like C++.
5. Mainframes can handle large volumes of transactions and huge databases. They, too, excel at controlling large communications networks. If the mainframe application exists already, then you will probably have little choice in the programming language and operating system. However, if the application is new, and you are using a new, large computer, you may be able to use Unix as the operating system and C or a 4GL as an applications development language.
6. If users need local processing power and discretionary use of computers, a mixed network including mainframes and PCs is the likely choice. This configuration is also popular when the organization has a large number of legacy computers and applications; networking them provides users with the features they need and widespread data access.
7. Organizations today need to have connections to the Internet; they will also obtain many benefits from an Intranet and possibly an Extranet as well.

Fast Response Jeans

Levi Strauss has developed a fast-response system for mass customization. The company can sew a pair of woman's jeans to fit the size of the customer. The process begins when a clerk measures a customer for jeans in one of the company's Original Levi's stores. The clerk inputs the data into an expert system, which sends it to a Notes server at Custom Clothing headquarters in Newton, MA. Notes sends the data to a fabric-cutting machine at a Levi's plant in Crystal City, TN. Factory workers tag the special order with a bar code and send the cut garment out for laundering. It then returns to the factory for stitching. The bar codes match the finished pair of jeans with the customer file. The company sends the finished jeans to the original store or to the customer's home.

Some experts in manufacturing suggest that mass customization or "agile manufacturing" will be the next major trend in industry. It allows companies to focus on customer service and quality, selling something beyond the basic product to the customer.

Dealing with the Problem of Data

A fundamental aspect of design is where to keep data and where to update it. In the airline CRS, all data are maintained centrally because of the need for instantaneous information and the frequency of update. In the broker workstation system, the users do virtually no updating of the data distributed from the ticker plant. Because fast response is important for brokers, it is a good design decision to duplicate the data locally. The price server in each office has identical information that it accepts from the satellite dish on the roof.

In other systems the trade-offs will differ. The designer has to balance response time, updating frequency, the need for up-to-date information, and the cost of duplicate storage. If there are to be copies of the data, we must also be concerned with the integrity of all copies. Does each copy have to be updated whenever the master record changes? In the broker workstation, a constant stream of data updates the local file server. In other applications, it may be adequate to refresh local databases less frequently.

CONTEMPORARY TRENDS IN ARCHITECTURE

The discussion in this chapter suggests that the role of the mainframe is changing. Mainframes have been making a small comeback and are likely to be around for a long time. What is happening to mainframes, or large computers, to rekindle their sales? Mainframes are declining in cost, an estimated 50 to 75 percent during the 1990s, because they can take advantage of some of the same technology as PCs. Mainframes are undergoing dramatic changes in their architecture as they become more modular or come to feature totally parallel operations. Vendors are producing smaller, more powerful, and more affordable mainframes. They are switching from older, more expensively fabricated circuits to

Customer Service at Corporate Express

Jirka Rysavy bought an 11-employee money-losing local office supply store in 1987 for $100 and the assumption of $15,000 in overdue accounts. The store had $300,000 a year in sales. Eight years later, the store was a multinational corporation with $1 billion a year in sales. Integral to the success of Corporate Express is the high level of customer service, which is evident in its Web-based ordering system.

A customer logs onto the Corporate Express Extranet using her name and a password. The system, called E-Way, checks records associated with the name to identify where to deliver the order and to note any custom information such as spending limits, approval routings, etc. Each department shares a corporate number so that the company as a whole gets the best corporate discount possible. The customer can use a predefined template for standard orders or can enter individual items directly. The system features a catalog search option with pictures of the products a company has authorized for purchase.

The customer also is able to check off specific reporting and ledger codes on the order for internal purposes. The customer can send a copy to her manager for approval, though the system itself has built-in spending levels for individuals and departments.

Corporate Express's Web ordering system, E-Way, provides a high level of customer service and routes information within client companies. It is a good example of taking advantage of the infrastructure provided by the Internet and World Wide Web.

CMOS (complimentary metal oxide semiconductors), a less expensive technology. This technology lets the manufacturer put more logic on fewer chips and circuit boards. IBM is also selling a line of mainframes that feature parallel architectures using RISC-based technology.

A basic requirement of any new design is that the mainframe remain compatible with existing software and meet the timing requirements of on-line systems. Within these requirements, designers are free to try novel approaches to the hardware in an effort to improve the cost/performance characteristic of mainframes.

The role of the mainframe is evolving. Instead of performing all calculations, the mainframe will become an extremely powerful server on networks. It will handle multi-billion-byte databases, providing data to clients on the network. The clients will do much of the processing of these data before returning them to the mainframe server to update the database. Trends are clearly toward client-server architectures, and a variety of computers will take on the roles of client or server.

However, as this and the previous chapter have stressed, the future of technology is in the network, both inside the organization and externally through private nets and the Internet. The architecture here is pure client-server. The power of technology comes from the combination of computational capabilities, huge searchable databases, and communications. These technologies have truly changed the world!

CHAPTER SUMMARY

1. The designer used to be able to remain independent of the hardware and software architecture until fairly late in the design process. Now, architecture interacts with the design because it is central to decisions about the user interface, the volume of processing, and the design of the database.
2. Architecture is the place where all of IT comes together: computers, databases, communications, and networks.
3. Architecture is also concerned with the location of processing and the pattern of computer users' access.
4. Architecture is closely related to infrastructure, the stock of technology available in the firm. Investments in infrastructure provide you with the technology to take advantage of new opportunities to innovate with IT.
5. Mainframe vendors are working to improve cost/performance characteristics of their products compared with smaller computers. An increase in sales for new mainframes suggests they are succeeding. Firms use mainframes for high-volume processing tasks and to continue executing critical legacy systems.
6. Midrange computers may be used for on-line transactions processing and as servers in networks.
7. The PC is the workstation of choice for the average user.
8. The most popular architecture today is client-server, where client PCs connect to servers that may be other PCs, midrange computers, or large computers. All these computers form a network linked to the Internet. The firm is also likely to make use of Intranets and Extranets to make information available internally and to external business partners.
9. It is difficult to develop guidelines for choosing an architecture. In general you will want to develop an architecture that costs the least while providing the processing power you need.
10. Frequently you will confront an existing architecture because the firm has been using technology for a number of years. You will only be able to make small changes to this architecture because of the applications that currently run on it.
11. While you want a low-cost architecture, remember that transforming the organization requires an adequate technological infrastructure. Otherwise you will not be ready to take advantage of opportunities that arise to innovate with technology.

IMPLICATIONS FOR MANAGEMENT

An IT architecture is complex for all but the smallest organizations. The good news is that you will probably not have to decide on one alone. Developing an IT architecture involves both managers and IT professionals. As a manager, you want to see if there is a coherent plan for an architecture and if decisions about the acquisition of new hardware, software, and communications devices are consistent with that plan. A second managerial responsibility is to be sure the firm has an IT infrastructure that allows the firm to take advantage of technology when new opportunities arise.

KEY WORDS

Broker workstation
Client-server architecture
Computerized reservations system (CRS)
Local area network (LAN)
Mainframe
Midrange computer
Minicomputer
On-line transactions processing (OLTP)
Open system
Server
Standards

RECOMMENDED READING

Copeland, D.; and J. McKenney. "Airline Reservation Systems: Lessons from History," *MIS Quarterly*. 12, no. 3 (September 1988), pp. 353–370. (An excellent history of the development of CRS applications by the airlines.)

Sinha, A. "Client-Server Computing," *Communications of the ACM*. 35, no. 7 (July 1992), pp. 77–98. (A comprehensive discussion of the technology of client-server computing.)

Weill, P.; and M. Broadbent. *Leveraging the New Infrastructure*. Boston: Harvard University Press, 1998. (A book presenting the results of a study of infrastructure in over 100 firms.)

DISCUSSION QUESTIONS

1. What is hardware architecture?
2. What is software architecture?
3. Why could design be independent of the type of architecture in the 1960s?
4. What kind of applications are best suited to a mainframe? Do you expect to see many new mainframe applications being developed?
5. What types of systems are probably best designed for a midrange computer?
6. Why are users so enthusiastic about PCs?
7. What led to the need for PC-to-mainframe links?
8. What is the purpose of a LAN?
9. What does a file server do in a LAN?
10. What are the advantages of mixed architectures?
11. Why might you want to centralize a database and keep only one copy of it?
12. In what situations might it make sense to have more than one copy of a database?
13. Are there applications where it does not matter if multiple databases are simultaneously updated?

14. What problems can exist if data are not updated on identical databases?
15. Why does the broker workstation system store a copy of the data from the ticker plant in the local office?
16. Why would it be difficult to redesign a CRS to run on another type of architecture?
17. What is the motivation behind client-server architectures?
18. Do you think that mainframes will gradually disappear?
19. Where might client-server systems not be applicable?
20. Why might a firm want to connect networks at different locations?
21. How is the Internet a model architecture?

CHAPTER 13 PROJECT

Simon Marshall Associates

In Chapter 9 Simon Marshall asked for your help in thinking about new operating systems. One consultant recommended to Mary that the company stay with Windows 98 and that it look at two types of local area networks: a network with a server or a peer-to-peer network. In order to run the groupware that interests John, the consultant said they could use Lotus Notes on the network with a server or buy a peer-to-peer network. What are the pros and cons of each approach? Which do you recommend for Simon Marshall?

CHAPTER 14

System Alternatives and Acquisition

Outline

Focus on Change

Dramatic applications that change the organization are likely to require the acquisition of new hardware and software. A manager must be prepared to make what are sometimes risky acquisitions to fashion systems that have a significant impact on the firm. There has been some movement toward outsourcing and toward strategic alliances to reduce the time required to develop significant applications. Buying instead of making is one strategy to bring about change more quickly in the firm.

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Managers are frequently involved in the evaluation of hardware and software. In fact, too often users try to make these decisions alone. The purchase decision is one that usually warrants advice from systems professionals. This chapter explores the problem of selecting hardware and software and suggests procedures for their acquisition.

After a brief survey of the industry, we discuss how a firm might acquire a major application for a significant system, one that involves a number of individuals in the organization. Then we discuss some of the problems of choosing packages for individual workstations as well as the acquisition of enterprise software. We close the chapter with an example of poor decision making on the acquisition of a network and discuss the consequences.

THE INDUSTRY

The computer industry today consists of firms that sell hardware, software, and services.

- Hardware firms range from the giant IBM to small companies making their own brands of personal computers from components purchased around the world. IBM, Fujitsu, Amdahl, and Unisys manufacture large computers as well as smaller machines. DEC, Hewlett Packard, Sun, and others manufacture and sell midrange computers, while a large number of companies like Compaq, IBM, Dell, Gateway, and similar firms sell personal computers.
- You can buy software from a large number of companies as well. Manufacturers of large computers often sell proprietary software for them, especially operating systems. (Remember our discussion of IBM and its MVS mainframe operating system.) Companies like Computer Associates sell a great deal of software for large-scale computers. Microsoft sells a wide variety of software for personal computers and servers as do many smaller companies. There are hundreds of small software companies that sell special purpose software, for example, a program for shipboard navigation using a notebook computer.
- The rapid proliferation of technology created a large service industry to help companies integrate technology with their strategy and operations. IBM has a consulting subsidiary that competes with Electronic Data Systems (EDS) and Andersen Consulting, a firm with over 59,000 employees in 46 countries working to implement IT solutions for customers. Service companies will develop a single technology application or contract to take over the operations of your entire IT effort, a process called **outsourcing.**

TO BUY OR NOT: MAJOR APPLICATIONS

The Decision Context

The first acquisition situation we shall discuss involves a multiuser application such as an order-entry system for the firm, or a production control system. (The design of this type of system is the topic of the following section.) A user makes a request for an information system. Assume a systems analyst responds with a preliminary survey, which is positive. Should one stop at this point and look for a package? Some in the field, particularly package vendors, would say yes, further analysis is a waste of time.

There are, however, several compelling reasons for further work before examining packages. First, undertake a preliminary analysis of the present system and create a high-level logical design. This design includes output requirements, database design, and input needed. You should have a good idea of the functions of the system and some of the features it must have in order for users to work with it. This preliminary set of specifications acts as a **benchmark** for evaluating various options.

Now the design team has a plan, a benchmark specification against which to judge various offerings from different vendors. It is far too easy to be swayed by a convincing sales presentation. With a benchmark, the design team determines exactly what is present and what is omitted from various available systems. Different packages can be arrayed against a custom system to estimate the extent to which each alternative meets users' needs and expectations.

Figure 14-1 shows how we might proceed. First, identify the problem and prepare a preliminary design document for a new system. Note that at this point one is not concerned with the acquisition of hardware. Although it is premature to think about acquiring computer hardware, it is important to determine roughly what scale of hardware is necessary for a planned system. Is the system capable of running on personal computers? On a network of PCs? Will it require a midrange or larger computer? These questions can be answered by estimating the size of the system: How many transactions have to be processed? What is the size of the database? What is the volume of file activity? What is the peak volume versus the average? The answers to these questions will help narrow down the hardware alternatives and in turn allow one to think more about the kind of package, since packages are written for certain sizes of operations.

Given a rough design and a feeling for the overall size of a system, alternatives such as those shown in Figure 14-1 can be explored. Alternatives are listed below:

- A custom system programmed to do exactly what is requested in the specifications. Of course, the specifications must be developed in greater detail for programming, but this is the traditional way of developing a system.
- A database management system like Oracle or Sybase. This package and the associated software for querying and possibly generating the actual application can speed development while providing many of the features of a custom system.

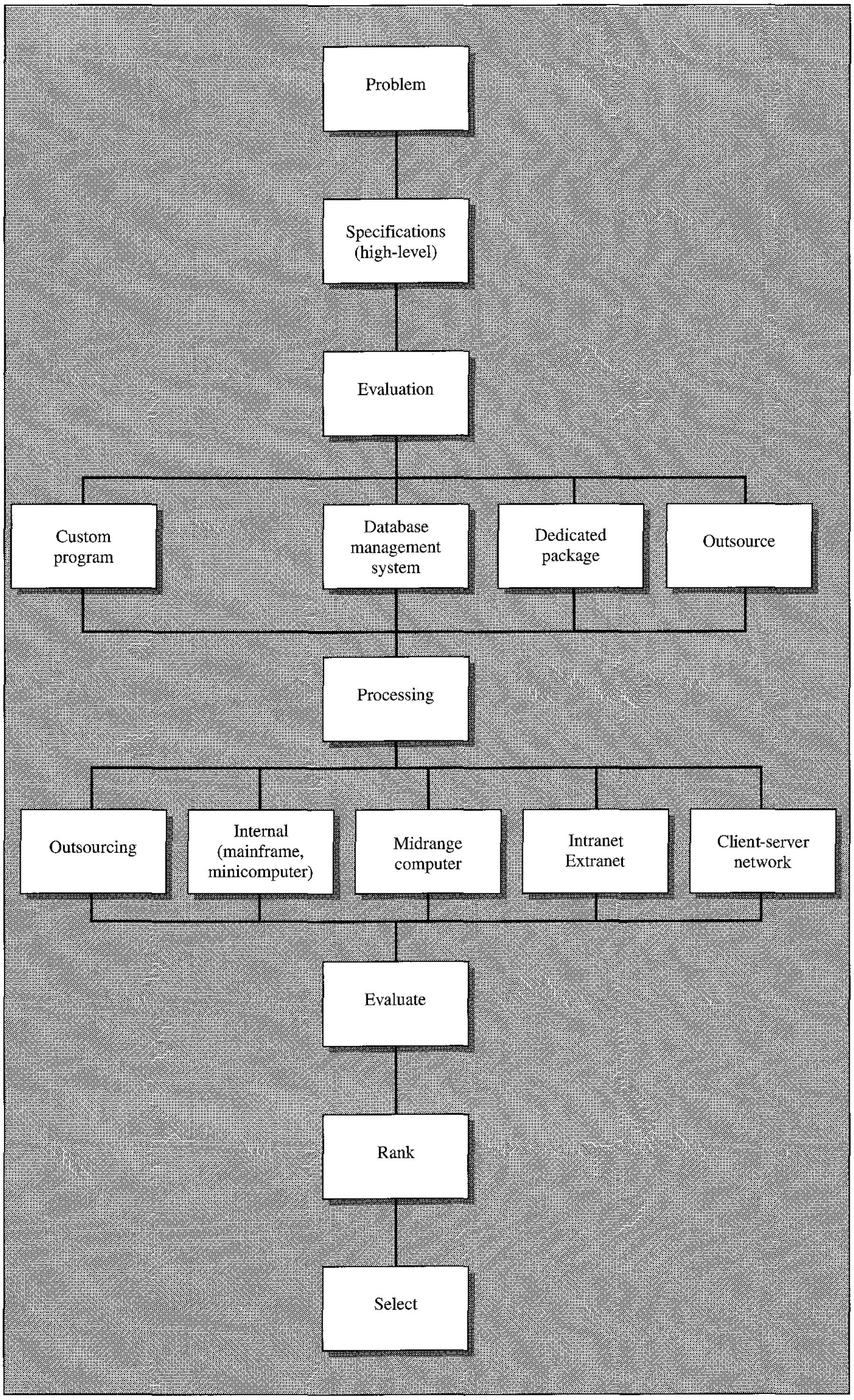

FIGURE 14-1
Selection alternatives.

How about Wearing Your Computer?

There are a tremendous number of options for data input; scanning has become extremely popular because you do not have to key in data. The scanner improves accuracy and reduces data entry time.

McKesson Corporation has found a wearable computer incorporating a laser scanning device; the input part of the package fits on the wearer's hand, wrist, and forearm; it is connected to a waist-worn portable computer that uses radio frequency links to download inventory data to a PC from any location in the warehouse. Warehouse workers use the computer to track pharmaceuticals and other goods when they are received and shipped.

The worker can actually scan bar codes from 10 to 15 feet. In one McKesson warehouse productivity has increased 10 percent and the number of incorrect orders filled has been cut by 72 percent. Of course, there is one key to the success of this system: The products coming into the warehouse have to be bar-coded by their manufacturers.

In general a wearable computer consists of a small motherboard (board containing CPU and memory chips), possibly no larger than a credit card, and a lightweight "heads-up" display built into an eyeglass. The user straps the computer to his or her belt and uses speech input to control the machine. We expect that in the next few years this kind of mobile technology will appear in a number of applications from automobile repair to stock brokers, real estate agents, and fire and police services.

- A dedicated package—software written by an external vendor particularly for the application under consideration. SAP is one of the most popular "enterprise" applications; it covers many of the functions performed by the typical firm. Oracle also offers applications software built around its database software.
- Locate an outside contractor or outsourcer to undertake all or part of the development process. A variety of software consultants provide services in all phases of the life cycle. For example, you might hire a firm to design the system, and/or hire programmers and staff from an external firm to carry out all the steps following detailed design.

If you select the package alternative, several computer trade journals publish annual surveys of packages. There are also proprietary services that purport to list all major software packages. If the organization already has a computer, contact the vendor representatives to determine if they are aware of any packages for their computers. Another good source of information is industry trade journals, for example, banking journals for finding bank applications. A search of the World Wide Web is also a good way to start looking.

Processing

In many instances, the decisions made in the top half of Figure 14-1 determine the hardware that must be used for processing. For example, if you choose a package that runs only on an IBM computer, you will have to find IBM-compatible equipment for processing.

If you are not constrained by the first decisions made in developing a system, what are some of the processing alternatives? First, an outsourcer can be used; these organizations provide all types of processing. The services themselves may offer special packages or may have data available that contribute to solving the problem. Many banks, for example, outsource the processing of their credit card transactions.

For internal processing, the options depend on the architecture the firm adopted, as discussed in the last chapter. The firm may already have a mainframe, midrange computer, or client-server network that new systems are expected to utilize. Processing requirements may determine which alternative is recommended for the design of a system, for example, database size or transactions volume. It may be possible to quickly create an application that runs on the firm's Intranet or an Extranet.

After exploring the options, you must compare the various possibilities. Each alternative should be examined on a number of criteria; then a decision can be made on the best way to proceed, considering both software and hardware.

THE SERVICES INDUSTRY

We have stressed that custom development is no longer the automatic choice while planning a new application. There are a number of ways to obtain technology support in both the development and operation of computing applications. In this section we discuss some of these possibilities.

1. *Computing power.* Service organizations have offered computing time and power for a number of years. While some organizations need extra computing power, the steady decrease in already low hardware costs suggests that the market for raw computing power in general will disappear. Service organizations already offer a number of custom programs and proprietary databases so that the customer can obtain a service that is not available in-house. A number of service firms provide value-added networks. A good example of an external service is General Electric Information Services Co. This company offers conversion software, network services, and EDI mailboxes to firms that want to conduct business using EDI without acquiring and setting up their own EDI capability. Today companies like IBM offer Web services that run on server "farms," large data centers containing hundreds or even thousands of Web servers.
2. *Proprietary applications.* Software vendors, service firms (as discussed above), computer vendors, and others offer applications dedicated to business functions such as accounts-receivable processing. Many of these systems have been through several major revisions based on feedback from users. The discussion of packages in Chapter 18 points out some crucial considerations in evaluating this type of software. What is the quality of the package? How well does it suit the organization's needs? How willing are the users to change procedures given the cost of modifications?

3. *Proprietary databases.* There is a large body of data that can be used for making various analyses and decisions. By making the data machine readable and easily available, vendors of information create new businesses. One can purchase information on the expected trends in the economy, various statistics about companies and stock prices, and the texts of legal cases, to name a few. These services can be used as an adjunct to an application or may furnish some of the needed input directly.
4. *Communications.* A number of vendors offer communications services and equipment as discussed in Chapter 12. Some of these vendors act as common carriers and provide communications networks. Others offer services such as electronic mail or computer bulletin boards in which individuals communicate about a given topic by sending messages to each other's electronic mailboxes in a computer file.
5. *Consultants.* Software consultants or vendors provide programming and systems design services for custom systems, and some offer special packages as well. The software vendor may contract to manage an entire systems development effort or may furnish programmers to perform work assigned by the client. The staff of the consulting firm writes and tests programs.

Closely related is the systems **integrator,** an organization that pulls together varied hardware and software components to make a system. Because many organizations feature mixed systems with components from different vendors, integrators can be very helpful. Consider a firm that wants to develop a system to send data from a central mainframe to dispersed local area networks around the country. Such a system involves the mainframe and its software, some type of wide area communications network, the local computers, a LAN, and local computer software. A systems integrator would design the architecture of the system, help select the equipment, design and/or purchase software, and get the entire system up and running. Electronic Data Systems (EDS), Andersen Consulting, and IBM's ISSC are three of the largest and most successful systems integrators.

WHAT SOURCES SHOULD BE SELECTED?

What are the advantages and disadvantages of different sources for hardware and software? For discussion purposes, we can look at the two extremes in which all activities are undertaken either internally or externally through an outside organization (see Table 14-1).

Hardware

With an internal IS department, an organization must cope with the problem of managing the computer; thus overhead is introduced into the organization. For this price, management gains control over its own computer and communications operations. Data remain exclusively within organizational confines and are accessible only to employees. You establish processing priorities, and no other

TABLE 14-1

COMPARISON OF INTERNAL VERSUS EXTERNAL SERVICES

	Insourced	Outsourced
	Hardware	
Management	Must manage information services department	Contractual arrangement; no line management responsible except for data preparation
Control	Control potential is high	Only through contract, influence, withholding payment
Security	Under own responsibility; data remain at internal location	Data in hands of external organization; other customers a threat
Priorities	Assigned by own employees	Determined by external management
Resources	Must accommodate peak loads; high fixed cost	Variable cost, pay only for what is used (beyond possible minimum charge); may have contractual fixed charge
Capacity	Limited to what is needed	Frequently more powerful equipment than could be justified by clients
Backup	Limited by internal resources	Usually available because of higher capacity
	Software	
Management	Must manage program development	Contractual arrangements, specifications on cost, time, performance
Staff	May have to hire experts	Expect vendors to have expertise
Implementation	Probably easier in terms of users' reaction to internal staff	May be more difficult for "outsiders"

organization can preempt time from an organization with its own system. Management must provide sufficient resources to accommodate peak loads so there can be high fixed costs for computer equipment that may not be fully utilized under this alternative. Backup may be limited by the resources that management is able to provide.

Organizations choosing to rely on external services have a contractual agreement with the outsourcing firm. These companies have found that running a computer operation is best left to a firm that specializes in this activity. There are few management supervisory responsibilities because these tasks are delegated to an outside company. Control may be less than under the internal alternative because litigation over contracts is costly and time-consuming. Instead, the customer seeks to influence the outsourcer. Many firms worry about having sensitive data in the hands of another organization, particularly when other companies have access to

MANAGEMENT PROBLEM 14-1

Dennis Monroe is a plant manager for M&E Electronics. He has just reviewed a proposal for factory management featuring personal computers and is trying to figure out what to do. M&E has a large central computer facility that runs factory management software for the largest plant.

Dennis's plant, however, is relatively small. The amount of information he needs about production is limited compared with that needed for the main plant, which has 32 different work centers. Dennis is basically concerned with what goes into the production line and what comes out. He must keep track of yields as well, that is, the number of good units divided by the total number produced.

The proposal is to install a LAN and PCs on different parts of the plant floor. Each PC will be used to report data back to the server that will maintain a database on production.

Dennis is concerned because he has always figured that the plant would need a larger computer than PCs on a network. He wonders if a midrange computer like the IBM AS400 would be a better solution because it already has some programs that might be adapted to his plant. How would you recommend that Dennis proceed? What questions should he ask? What are the important variables in making a decision?

the same computer resources. The priority for applications is also in the hands of the organization providing services. Management influences, but does not control, processing priorities. With an outside organization, the customer incurs a variable cost and pays only for the resources consumed. Frequently, the client has access to more powerful equipment than would be installed internally since it is shared among a number of users.

Software

With internal software development, we must manage the development process. Internal program development often results in duplication. There may be a tendency to start from the beginning with each new system. Because IS staffers can be wary of applications not generated in-house, sometimes they do not adequately investigate package alternatives. Implementation problems, however, should be minimized because internal employees deal directly with the users in the firm.

External software services are handled on a contractual basis, but the customer may still need some individual who is familiar with information technology to work with the contractor and monitor progress. For the most part, however, clients will rely on the vendor's expertise. Implementation can be difficult for "outsiders," although the client may be able to take advantage of an existing package or set of routines whose cost has been amortized over a large group of users.

Bargaining for Your Car in Cyberspace

Doug Waikem is a car dealer in Massillon, OH. In three years, hundreds of customers have driven hours from as far away as Pennsylvania to buy cars and trucks. Waikem offers cars for less on the Internet than he does in his showroom because he pays far less for advertising and commissions. This year, 10 percent of his total sales, or 400 vehicles, will be sold on the Internet. Waikem is a member of Auto-by-Tel, which charges him $2160 a month for referrals. This company processes some 80,000 purchase orders a month for its dealers and has served one million customers since it began business in 1995. The Auto-by-Tel fee amounts to $63 per car, which compares to $300 a car in advertising for vehicles sold from the showroom. Two employees (on salary rather than commission) operate the Internet service.

Edmunds, another buying service, receives 50,000 hits a day on its Internet site. Chrysler Corporation has predicted that 25 percent of customers will buy a car on the Internet. Its own studies show that 70 percent of new car buyers have computer access and 45 percent say they will use the Internet next time they buy a car. Customers using the Internet have access to tremendous amounts of data about cars that interest them. Many manufacturers have sites that contain pictures, colors, and specifications for their models. Edmunds offers test drive results and reviews, as does Microsoft's Carpoint (carpoint.msn.com). These services provide manufacturer suggested prices and estimates of the dealer invoice costs. On the West Coast GM offers an on-line service that lets customers search dealer inventories and get the best price.

THE PROS AND CONS OF OUTSOURCING

One recent trend is outsourcing. This involves turning over some or all of your organization's IT effort to an outside firm specializing in operating, developing, and managing various aspects of information technology. Some articles make it sound as if outsourcing is a relatively new invention. In reality it represents more of a name change than a new kind of service. In the 1960s EDS began to offer what it called "facilities management" services.

Today EDS, Computer Sciences Corporation, a subsidiary of IBM called Integrated Systems Solutions, and other firms provide outsourcing services. These firms negotiate a contract with a company that wishes to turn all or part of its technology function over to the outsourcer. What kind of services might you want to outsource?

Obviously, the outsourcing consultant would be delighted to assume all of your IT activities. This firm would operate your existing applications, possibly on the outsourcer's computers or on your existing computers. The consultant would also gladly assume responsibility for running your communications network and for developing new applications.

Some clients have chosen to retain part of their IT functions and to partially outsource some activities. For example, a large brokerage firm outsourced part of its network management, keeping control of the part it felt was strategic. A major

MANAGEMENT PROBLEM 14-2

Carole Hunt is manager of information services for Brighton Corporation, a holding company that has 10 subsidiaries in different lines of business. Six of these companies manufacture their own products, and each has a different computer architecture. Carole has read about SAP and has visited several companies that use R/3 with a client-server architecture. She has also spoken informally with a consultant who is a personal friend about the challenges of implementing R/3.

After her research, Carole has come to the conclusion that R/3 might offer a solution for the entire corporation's enterprise software needs. "Wouldn't it be nice to have the same system in each plant so that we could learn from each other? What great flexibility in transferring staff!" She recognizes, however, that she may have to spend more than the cost of the package on implementation, and that she will need consulting help, which is scarce given the success of SAP. Carole is concerned that she may have missed something in her research. What are the pros and cons of SAP for Brighton? What do you recommend?

advertising agency outsourced its transactions processing and accounting applications while continuing to develop and manage systems designed to help the creative part of its business. Xerox outsourced its legacy systems (older IBM transactions processing systems) to EDS so that it could concentrate on developing a new client-server architecture in house.

Outsourcing is controversial: Some managers argue that it makes sense to let a firm that specializes in technology take over and act as an independent contractor. Why should we try to manage something that is not our specialty? On the other hand, others are not comfortable turning over to an external organization technology that may be crucial to corporate strategy. We discuss outsourcing further in Chapter 24.

Strategies for Acquiring Equipment and Services

No matter which alternative is selected, the customer has to acquire computer equipment and/or services. What is the best way to approach this problem? There are several considerations a potential customer should have in mind. First, check the vendor's financial condition. A number of small companies in the computer industry have gone bankrupt. Even major firms have sold or discontinued their computer manufacturing activities. How likely is a vendor to be around in the future to service the product and improve it?

An extremely important research activity for a customer is to contact present users of a product to determine their level of satisfaction. How well does the product or service meet the vendor's claims? What problems did users have? What kind of consulting assistance did the buyer need in implementing the software? If possible, visit users without a vendor representative to ask these questions. If it is not possible to see a product demonstrated, do not buy it. Too often, announced products are delivered years late; insist on a demonstration, and attempt to evaluate the performance of the product.

Evaluating Performance

A major activity in acquiring new equipment and software is an evaluation of the performance of the product. We also use evaluation techniques with an existing system to improve its performance through the acquisition of additional equipment. Performance is generally defined as the response time of a system or the volume of input it can process in a given period of time.

A cruise line presents an interesting example of how performance can be important in the selection of a computer system. The shipping line was investigating a software package for making cruise reservations. On the surface this reservations application sounds like any other, but there are a number of important differences. One is that passengers usually want to book a particular cabin or class of cabins when making a reservation. There can also be different itineraries for the passengers in the same cabin. Thus, a package must be specifically designed for cruising.

The cruise line in this example found such a package, but was concerned about whether it could handle the volume of processing for its ships. Fortunately, the package was in use at another, noncompeting cruise line roughly comparable in size.

The computer vendor offered a **performance evaluation tool,** which monitored data from the actual execution of a job and used these data to develop the parameters of a queuing model of the systems' performance. The user of the model could ask what-if questions to determine the impact of changing the hardware on system response time. For example, one could estimate the impact of moving to a different CPU, adding memory, and adding disk capacity.

The cruise line obtained monitored data from the firm already using the package and used the vendor's model to analyze the data. The model indicated that performance should be adequate for the cruise line and was helpful in recommending the computer configuration to acquire. In this instance, a combination of evaluation techniques was important in the decision to acquire a new software and hardware package.

Acquiring Computers

When you are acquiring a computer that will be dedicated to a single software application, the decision is usually fairly easy once you choose the package because (1) there are usually relatively few computers for which the package is written and (2) the vendor has experience in knowing what kind of computer should be used given the firm's processing demands.

The large number of computers available present a bewildering array of possibilities. The organization is probably well advised to develop a standard (say, to support two or three specific types of personal computers) and to avoid acquiring others because the IS staff can develop expertise to support only so many.

The organization may also be buying a network, following the client-server model example presented in the previous chapter. (See especially Figure 13-7,

Transferring Knowledge from One Industry to Another

We have used American Airlines and the SABRE systems as an example in a number of places in the text. Sabre Decision Technologies is a subsidiary of the airline that operates the reservations system and provides a variety of consulting services to different companies. One of its clients is the French national railroad, SNCF.

As European markets have become less regulated, the French railroads face competition. European railroads provide much more extensive (and better) transportation than passenger rail in the U.S. First, European cities are closer together than cities in the U.S., so a rail trip makes more sense than flying in many instances. Also, because of government subsidies, railroads have been able to invest in new services. France has been a leader in bringing new technology to the rails. Its Train a Grande Vitessse, or TGV (high-speed train), operates on new roadbeds at speeds in excess of 300 kilometers/hour (180 miles/hour). There are no grade crossings on the new line because the train could not stop in time to miss a vehicle on the tracks; it takes 2 miles for a normal stop and 1 mile for an emergency stop! These trains carry over 50 million passengers a year to 140 European cities. There are another 300 train units besides TGVs with 3000 scheduled departures per week.

SNCF was faced with the task of devising new schedules to provide customer service, while at the same time considering the profitability of its operations. Sabre Decision Technologies developed a yield management system for American Airlines, and both Sabre and the railroad thought that the same principles could be applied to passenger rail operations [see Chapter 21 for more details on yield management].

The alliance between Sabre and SNCF resulted in two new products, RailCap and RailPlus. RailCap allows the railroad to add new reservations capacity while RailPlus enables SNCF to build new rail schedules. Implementation of the two new systems was not easy; they tended to integrate both marketing and operating decisions, and railroad employees in these two areas were not used to working together or with new technology. By showing that the two systems could reconfigure a schedule in a few months compared to 2 to 3 years for the manual approach, the developers convinced skeptics that the technology had something to offer.

One of the main advantages is that the systems allow a scheduler to see the total profitability of adding a section; he or she can observe both the expected revenue and the costs of running an extra train. The systems allows the railroad to run more scenarios and reduces the number of empty shuttles that have to run each day. SNCF estimates that the two systems reduced operating costs by 2 percent. Better schedules have also brought more customers and, with them, more revenue.

Yield management is a process that can be applied in many industries. Sabre Decision Technologies has migrated this approach to planning operations to SNCF, cruise ships, hotels, and rental car firms. More than software, the company is transferring knowledge of a process that applies where customers make reservations to use some scheduled resource. The end result is better customer service and more profitable operations.

which shows a network with multiple clients and servers.) In these cases evaluating the capacity and performance of the network is very difficult because it may be hard to find a comparable system running the applications you have in mind.

Decisions on obtaining computers largely depend on the function for which they are being acquired. Many people first bought personal computers just to run spreadsheet analyses. Managers choose factory computers for how well they perform a specific task. One can still apply some of the considerations for larger computers when considering other types, specifically: expandability and compatibility, ability to communicate with other systems, the type of software, the user interface, and vendor support.

Organizations typically have a policy on what kind of computer configuration to obtain, and have professional IS staff members who provide advice on acquisition. The IT infrastructure, the servers and other computers that the IS staff or an outsourcer runs for the firm, is constantly upgraded by those responsible for providing IT services.

Dealing with Obsolescence

An ongoing problem in purchasing both hardware and software is obsolescence. The cost/performance curve for hardware continues to decline while new versions of packages appear about every six months. While cars improve each year, few of us can afford to buy a new automobile every 12 months. Is the same true for computers? Very few applications ever disappear from computers, and new ones are always being added. It is fairly obvious, then, that the total amount of computing in the organization is always increasing. Higher powered computers seem to stimulate the creation of more sophisticated and powerful applications. The first spreadsheet programs did calculations. Today's Lotus 1-2-3 and Microsoft Excel offer presentation graphics and programming languages that make the original Visicalc look very crude.

As a result, users apply ongoing pressure for new computers and software upgrades. To some extent, the organization has little choice. While you might still be able to do word processing and run a spreadsheet on a 10-year-old PC, what you do is unlikely to be compatible with other users who have newer models with newer releases of software. The task of managing a large variety of computers and different versions of software is also formidable even if your support staff try to keep all equipment and software at the same level to make its job possible. Thus, as a manager, you will be forced into continual upgrades. That is one reason why it is estimated over 45 percent of all U.S. capital investment is in information technology.

DEDICATED APPLICATIONS PACKAGES

A dedicated applications package is a program or set of programs written for a specific application like order entry and production scheduling. This package is used for a specific application as opposed to a general application like word processing.

The major attraction of buying a package is to avoid having to develop a custom system. Custom programming is expensive and time-consuming. When a package is available, it should be considered. Another obvious advantage of using a package is cost savings. The package developer expects to sell a number of packages to recover the investment in developing it. The cost is thus amortized over a number of users. The cost to the developer, though, is usually higher than the development of a single application would be since the package must be general enough to be used by a number of customers. This increased generality makes the package larger, more complex, and often less efficient to operate than an application specifically developed for a single application. Some of the trade-offs, then, for a package are as follows:

- Package generality versus ease of installation and use.
- Acquisition and modification costs versus the cost of developing the application within the organization.
- The elapsed time to install a package versus the time to develop the application within the organization.
- Operating efficiency of the package versus the alternative of a custom application within the organization.
- Implementation problems of the package versus those of an application developed specifically for the needs of the organization.

The most serious problem with purchasing a package is the need for the organization to customize the programs for its unique situation. (This problem is most severe with dedicated packages such as accounts-receivable programs, which may affect the way the firm has been doing business for years.) Of course, although individual organizations always claim uniqueness, it is often easy to change routine procedures to suit a package. On the other hand, there are also legitimate reasons for maintaining uniqueness in the organization.

We have stressed the importance of meeting users' needs and obtaining their involvement in the design of systems. Many systems developed on a custom-tailored basis fail completely or never reach their potential. It seems that packages are even less likely to succeed because they have a tendency to impose a system on a user. What can be done to lessen the implementation problems of packages?

The package vendors recognize this drawback and generally design packages to allow some custom tailoring. Two ways are often employed for providing flexibility: the use of modules and the use of parameters. The first strategy provides a modular set of programs in the package. The user configures a custom applications package by selecting appropriate modules for a particular set of needs. Little or no programming is required on the part of the user. Packages also make extensive use of parameters or data values to indicate unique features for a particular user.

Often, the customizing features provided by the vendor of the package are insufficient for an organization. The less expensive packages may have to be accepted as is, but for more elaborate applications, the customer often finds it necessary to write custom code to modify the package. Sometimes the modifications are easy and require only the addition of some reports or the alteration of reports already in the package. Code modification can become quite extensive and may involve rewriting significant portions of the package. One organization uses the rule of thumb that a package will not be considered if modifying it will cost more than 50 percent of the initial package cost. The important thing to remember is that the cost of a package is usually not just the purchase price. We must forecast and consider the costs of transition, modification, and maintenance as well.

Establishing Criteria

The information services department and a project team should agree on screening criteria for packages. Many times packages will be considered as alternatives to developing a system in-house. Table 14-2 lists some possible evaluation criteria for decisions on packages. The major reason for acquiring a package is the function it performs. We want to know how many desired functions are included and what effort is required to modify the package.

It is also important to consider the user interface. That is, how difficult is it to use the package? How much information does a user have to supply? Is it simple to prepare and understand the input? Is the package flexible, and can it be used if the organization's requirements change somewhat?

The evaluation team is also concerned with the package's response time as well as how much present procedures will have to be changed to use the package. Just as with hardware, it is necessary to evaluate vendor support. Updates and improvements for the package should be forthcoming, so we are dependent on the vendor remaining in business.

With software packages, documentation is important; the IS staff will maintain the package and may modify it. Finally, we must consider the cost. Remember we always underestimate how much it will cost to develop a comparable system ourselves and overestimate the cost required to modify the package!

TABLE 14-2

CONSIDERATIONS IN EVALUATING SOFTWARE PACKAGES

- Modifications required
- Installation effort
- User interface
- Flexibility
- Response time
- Changes required in existing system to use package
- Vendor support
- Updating of package
- Documentation
- Cost and terms

Making a Final Decision

In this discussion, we are interested in whether a package qualifies for consideration. Many of the criteria in Table 14-2 require analysis of package documentation by the systems analysis staff or programmers. We also should contact present users and ask questions about vendor claims and support. Almost all these criteria are subjective, which means several individuals should rank a package on each criterion, for example, on a one-to-seven scale. The responses can then be averaged for each criterion and a score can be developed for the package.

It may be desirable to divide the criteria into essential and nonessential groups. We can insist that a package get a "passing score" (established in advance) on each of the essential criteria to be considered for acquisition. Then we can examine the criteria to see if the package passes enough of them to be considered.

MANAGEMENT PROBLEM 14-3

Jack Caradine sat back in his chair and scratched his head as he muttered, "We really opened the floodgates with the ICPC two years ago. Now we can't keep up with all the user requests for packages and systems."

Jack is manager of systems development for Agrequip, a manufacturer of farm implements. Two years ago he helped one plant install a package application called ICPC for inventory and production control. It was an example of dedicated application: A small computer and the software were acquired specifically for the inventory and production control application.

Since that time, other users found out about the system and requested something similar. These requests presented relatively few problems since Jack's staff is quite knowledgeable about the package and is now installing it at three other plants. What Jack is concerned about now are the requests for many different types of packages. They start their own research with package vendors, and they don't have the slightest idea of what to look for.

Jack's staff is being stretched to respond to these requests and to evaluate the packages. "Users got the idea that a package is a panacea for any problem," Jack complained. "They don't realize what we have to go through to evaluate and then install a package. Every one we put in required some modification. Sure, it can be cheaper than doing it ourselves, but the cost is not just the price of the package; it's the installation, modification, and ongoing expenses of taking care of the thing. Also, we rarely find a package with all the same features we'd have put in a system designed as a custom job inside the company."

What kind of policy does Jack need? What procedures would you recommend for dealing with the explosion of package activities by users?

If a package is acceptable and is the only alternative under consideration, we will probably acquire it. However, if several packages are available, the ones that pass the screening test can be compared using ratings or through the **scenarios** described earlier. If the package under consideration is an alternative to designing an in-house system, use the criteria established by the project team to evaluate the package in comparison with other processing alternatives.

The users, then, help evaluate a package versus a custom-tailored application, and decide which would be best. If the user wishes to have the lower costs and faster development associated with the package, he or she will have to agree that all desired features may not be present. If the decision is for a custom application, the user must recognize that costs will probably be higher than the cost of a package and that it will take longer to develop the system.

ENTERPRISE SOFTWARE PACKAGES

Large applications such as SAP's R/3 and similar products from Baan, Peoplesoft, and Oracle are still packages, but the tremendous scope of their impact makes decisions about them much more challenging than the decision to buy Microsoft Office or Lotus SmartSuite. **Enterprise software** is designed to fulfill all the basic transactions processing needs of a firm, from entering orders through producing a product, accounting, preparing financial statements, and querying databases. Of course, you do not have to buy the entire package, but many of the benefits from enterprise software come from its integration.

As an example, consider processing an order. A comprehensive enterprise software package accepts the order, checks inventory, notifies the customer, schedules production if a product is not available, and tracks the order until it can be filled. The package creates an accounts-receivable entry when the order is shipped and makes the proper accounting entries when the customer pays the bill. All this activity is reflected in the firm's financial statements.

These packages cost multiple millions of dollars to purchase and implement, and can easily take several years. If you choose this alternative, the firm is committed to this package and to a costly implementation effort. What have you bought? Just as with any package, you have purchased debugged code, functions you probably would not have designed into a custom system, and a significantly shorter implementation time than custom development would allow. A decision to adopt SAP comes only once in many years, and you must comparison shop and study it just as you would any major business decision. Our comments on package programs still apply, but the scale of this acquisition decision demands significant research and management attention.

PACKAGES FOR PCs

Buying software for personal computers shares some of the issues with buying software for enterprise applications. We are still concerned with the user interface, user documentation, and speed of processing.

For most PC packages, modification is not an issue. These packages are too inexpensive for the vendor to customize for each customer. In order to protect future sales, the vendor rarely sells the source code for the program. The vendor does not encourage modifications because it does not want to support customers who make them.

Research for a PC package is slightly different from that for other types of technology. A number of magazines conduct product evaluations, or the potential buyer can look at package documentation at a retail computer store, see the package running, and sometimes even obtain a demo diskette from the manufacturer.

Some organizations have created internal consulting and support groups to help users with PC hardware and software acquisitions. These groups have packages to recommend and demonstrate for specific types of applications. Fortunately, the cost of much PC software is low enough that one can often afford to buy and use a package for several months or a year and then switch to something else. It is worth research and careful consideration, but there is nothing like trying out the software before buying it to determine the right choice. For generic applications such as spreadsheets, word processing, and presentation graphics, the support staff will encourage the adoption of a companywide standard. This standard makes it easier to share data and easier for the staff to offer support for the products.

An Example

We have discussed a number of acquisition scenarios in this chapter, ranging from buying a single package for a PC to outsourcing your firm's entire information processing function. A major university recently faced an acquisition decision that involved both hardware and software, which presents an interesting case study of an acquisition decision most people in the school now think was a mistake.

The school was installing a fiber-optic backbone network on its campus. It needed to choose a vendor to provide the networking software for the system. In addition, the choice of network vendor would also determine which file servers to install. The computer center at the school sent proposals to a number of vendors; two returned acceptable proposals.

Vendor A is a computer manufacturer with a strong support organization. Its networking software is proprietary, though it is based on a major PC software vendor's networking system. This network required fairly expensive servers that ran on the Unix operating system. Vendor B provided the networking software that was already in use at the school and is the market leader in networking PCs. The school staff also had experience with this software because three or four of its networks were operating with it while the decision was made. Vendor B's network used PCs for servers, making hardware costs lower than for Vendor A.

The computer center staff liked Vendor A, who they felt would provide extensive services and would better monitor and control their network. The staff convinced the dean responsible for making the decision that Vendor A was the best choice. Faculty with IT experience were in favor of Vendor B for the following reasons:

- The school had experience with the product from Vendor B. It would be throwing away most of that experience and starting from scratch with Vendor A.

- The system from Vendor A was more complex than Vendor B's. It required a great deal of memory on each client computer, which might make it difficult to run certain packages and the networking software simultaneously.
- It would be difficult to get outside help or hire people with experience with Vendor A's products since most professionals knew Vendor B's system.
- The more widely used system from Vendor B was better debugged than the newer product from Vendor A.

What happened? The decision was made to go with Vendor A. As you might expect, the implementation was a disaster. Students could not print in the PC labs because the network had significant problems handling printing. The entire networking effort has discredited technology in the school. Emotions were so high that an outside review panel was asked to report on the computer center. It concluded the school was in great difficulty from having chosen Vendor A's product. In fact, it turns out that the school had the largest installation of this product! In addition, Vendor A has started to "resell" Vendor B's network software, raising the question of whether Vendor A would continue to support and enhance its own offering. Three years later, the school abandoned Vendor A and moved to Vendor B!

How did this disaster happen? The evaluation failed to consider important intangibles such as the school's experience with Vendor B and the difficulties of finding and training staff for the complex system offered by Vendor A. In addition, it appears the computer center staff did not do an adequate evaluation. They failed to visit sites that used systems from both vendors and that would have been comparable to the school's environment.

This example should serve as a warning that you must be extremely careful in making major hardware and software acquisition decisions, especially those that affect the entire IT infrastructure of the organization. You must take into account intangibles and management considerations in addition to the technical features of technology products.

CHAPTER SUMMARY

1. Evaluating technology is an ongoing task for most organizations; large numbers of services and packaged programs are available.
2. The computer industry includes many different firms that sell hardware, software, and services.
3. Today most organizations are interested in reducing the cost, time, and risks associated with custom applications development. The first strategy should be to look for a package that accomplishes your processing objectives.
4. If you cannot find a package, there may be alternatives such as using a DBMS for implementing the application.
5. Outsourcing is becoming increasingly popular for developing applications and for running all or part of a firm's technology.
6. There are a number of tradeoffs between doing the task internally and using an outsourcer. Management has more control over internal operations, but it must take a very active management role in IT under this alternative.

7. Because companies are continually developing new applications, there is increasing demand for hardware and software. This demand means the firm is frequently faced with decisions on acquiring more computer equipment and more software.
8. The acquisition of large and midrange computers is fairly routine. If the firm has an architecture in place, that architecture may dictate which new computers to buy.
9. The IS staff will want to keep up with new technology in hardware and software, both to provide the firm with a powerful IT infrastructure and to make the task of supporting hardware and software manageable.
10. Because packages are such an attractive option, it is important to purchase packaged software with great care. For dedicated applications, do a rough systems analysis and design to provide a benchmark for evaluating different packages. For general packages like a word processor, the organization will probably want to adopt a single standard in order to make it easy to share documents and to ease support requirements.

IMPLICATIONS FOR MANAGEMENT

The "make or buy" decision is always a difficult one for management. The availability of new technologies in the marketplace and a movement by firms to get back to their core competencies have led many companies to select the "buy" option. Chrysler can get by with making 30 percent of the parts for its cars because it has EDI links with its vendors to make just-in-time manufacturing work. Because of the high cost and long time required to develop software, most managers look first at whether they can buy existing software and modify it if necessary to avoid programming an application from scratch. If you decide to buy, it is important to understand the technology and the application so that you can be an intelligent consumer.

KEY WORDS

Benchmark
Enterprise software
Integrator
Outsourcing
Performance evaluation tool
Scenario

RECOMMENDED READING

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DISCUSSION QUESTIONS

1. Why have established vendors been hurt by "open" architectures?
2. Why evaluate systems performance given today's technology?
3. Describe the trade-offs in considering a dedicated package for a new application.
4. Why would management with an internal IS staff be interested in using a systems integrator?
5. What are the drawbacks of mixing hardware from a large number of vendors?
6. Why should a company consider the use of applications packages? What are their advantages and disadvantages? In what situations would you expect applications packages to be most satisfactory?
7. Is performance evaluation important for purchasing PCs?
8. How would you characterize an existing computer work load for performance evaluation purposes? How would you include consideration for the changes in the work load that might occur in the future?
9. Why might an organization choose to outsource all its information technology?
10. What are the major differences between outsourcing the development of an application and outsourcing the operation of some part of your information technology activities?
11. Most organizations today have computers and software, all of which are supposed to work on a network, from different vendors. What are the potential problems with using products from many different sources?
12. What factors mitigate against the conversion to a different vendor's computer? How has the development and use of higher-level languages affected this type of conversion? What do you expect the impact of database management systems is on conversion to a new vendor?
13. Make a list of the types of questions and information desired for a survey of other users of an enterprise software package under consideration for acquisition.
14. How does the existing IT architecture affect the acquisition of new computer hardware and software?
15. What are the disadvantages of using some weighted scores for ranking competing proposals for computer hardware and software? What advantages are presented by using scenarios for describing how the company would function under each new alternative?

16. Why is it not a good idea to be a pioneer with new hardware or software? That is, why should a company wait before acquiring a newly developed computer system? How can the IS department avoid making frequent requests for additional computer capacity? What are the dangers in your strategy? How does the development of a plan for information technology affect this problem?
17. What applications might the firm want to retain if it is planning to outsource some of its IT activities?
18. Why should applications packages be seriously considered as an alternative to programming and implementing a system? What are the most significant problems with these packages? How can the ease of modifying the package be determined before its acquisition?
19. Compare and contrast the major sources of software. What are the advantages and disadvantages of each?
20. Who should be involved in the decision on new computer hardware? What about software? Does the type of software make a difference?
21. What are the major differences between packages for PCs and for midrange and large computers?
22. Why do some programmers show a great deal of resistance to applications packages?
23. How can the vendor of an applications package make it more appealing to potential customers?
24. How does an "open" architecture provide purchasing flexibility for a firm?
25. There is a great deal of free or low-cost software available for PCs. What are the advantages and disadvantages of "shareware"?
26. Why might a systems integrator be faster in developing a complex application than your internal staff?

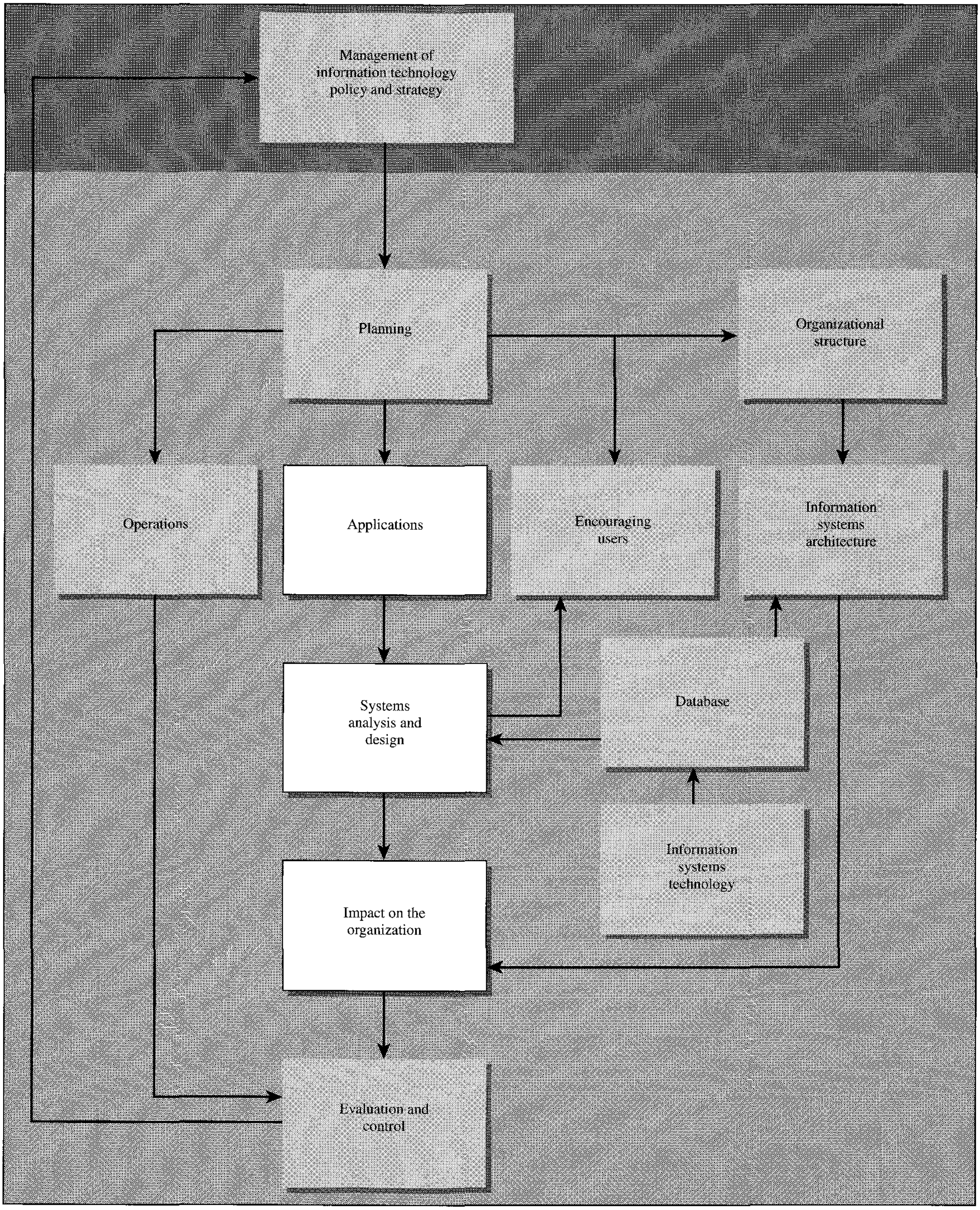
CHAPTER 14 PROJECT

Buying a PC

Several of your friends are thinking about buying a new personal computer. Look through popular magazines such as *PC* and *Byte* for the advertisements from different mail-order PC vendors. Then develop a matrix comparing the features of different machines and their costs. Describe what features you would recommend for your friends in each of the following cases:

- The casual user who will do mostly word processing on the computer.
- The "power user" who will mostly run spreadsheets.
- The fan of GUIs and presentation graphics who wants to experiment with desktop publishing.
- The Internet surfer who downloads programs and graphics from the Web.

Be sure to explain the reasoning behind each of your recommendations.


Management of
information technology
policy and strategy
Planning
Organizational
structure
Operations
Applications
Encouraging
users
Information
systems
architecture
Database
Systems
analysis and
design
Information
systems
technology
Impact on the
organization
Evaluation and
control

PART FOUR

SYSTEMS ANALYSIS AND DESIGN

In this part of the book, we follow the life cycle of a system from its inception through final installation. From the considerations on organizational issues discussed in Part Two, we recommend an approach to systems analysis and design in which users have control over the design process. The chapters in this part stress the roles of the manager and user in each stage of systems analysis and design. The systems analyst aids the user in making crucial decisions and performs the technical tasks necessary to develop the system. Chapter 16 contains an appendix that provides a great deal of detail about the design of two different systems—one system follows structured design approaches and the other illustrates object-oriented design.

CHAPTER 15

Building Systems: Creativity with Technology

Outline

Focus on Change

The firm invests in applications of technology to change the organization by restructuring work, forming alliances with other organizations, altering reporting relationships and communications patterns, and in a myriad of other ways. The firm has to identify applications and then build them. The manager has an important role in developing applications that will create dramatic changes in the firm and industry: developing the idea for a system, allocating resources to it, participating in its design, and monitoring progress on the development project. For systems to transform the organization, they must be well designed and they have to work.

THE DESIGN TASK

The design of a new information system is a demanding undertaking. First we become aware of an opportunity to use technology to gain an advantage or solve a problem with existing information processing capabilities. We assess the benefits of using IT to improve these procedures. Then we develop an abstract model of the current processing procedures, and a systems design team creates a new information system. The team converts the new procedures into system specifications and finally into computer programs. The final stages of development include testing, conversion, and operations.

The design of an information system is a creative and labor-intensive task. It is creative because we are building a new set of information processing procedures, just as an architect designs a new building. **Systems analysis** and design is a human, intellectual task. There are some portions of design that can be automated, but most of the creative aspects require human thought. A recent consulting group survey reported that almost one-third of systems development projects were canceled before completion. Another half experienced dramatic cost and time overruns, and reductions in the features originally promised. There is much room for improvement in systems design. One helpful strategy is to have those who will use the system heavily involved in its design.

What are the roles of the user and manager in systems analysis and design? In this chapter, we introduce the systems life cycle and discuss the resources available for developing new systems. We shall see that users and managers have crucial roles in all aspects of systems analysis and design.

What Is a System?

In previous chapters we have seen many examples of information systems which consist of a number of interrelated components, only some of which are easily seen. For example, it is difficult to characterize the actions of individuals who are involved in making decisions as a part of an information system. The flow of information and the processing of data by computer programs and/or individuals can also be obscure.

A Discouraging Failure Rate

The Standish Group is a consulting company that, among other activities, surveys companies about their success rates in developing applications of new technology. They report that the U.S. spends over $250 billion a year on developing IT and estimate that this expenditure involves 175,000 projects. The average cost of a development project for a large company is over $2 million, for a medium-sized company, over $1 million, and for a small firm, about $400,000.

Standish's survey suggests that companies will cancel some 30 percent of these projects before completion. Over half of the projects will experience cost overruns in the neighborhood of 190 percent of their original estimates. The cost of failing projects can be very high as well. The new Denver Airport could not open because its automated luggage handling system was not working; the delay cost the city $1.1 million *a day.*

Is there any good news? Companies report that slightly more than 16 percent of software projects meet their budgets and time schedules. However, completed projects have about 40 percent of their originally proposed features and functions.

This picture is discouraging; what might be responsible? First, it is clear that developing a new application of information technology is replete with uncertainty. It is very difficult to specify all desired features and functions in advance so it is not surprising that time schedules and budgets at the feasibility study stage are not accurate. Purchasing a package is one solution, but implementing a package has its own set of costs and risks. Sometimes firms abandon package installations just as they cancel custom development projects.

One lesson from these data is to specify as much of the system in advance as possible. The better one understands the functions of an application of IT, the more accurate the estimates should be for budget and completion time. In addition, it is important to actively manage a project to see that it does not get out of control.

One of the major tasks in systems analysis and design is to describe systems, both existing and proposed. Later in this chapter we discuss some of the tools available for preparing descriptions of systems, but first we present an overview of a system.

Information systems can be described by five of their key components:

- Decisions
- Transactions and processing
- Information and its flow
- Individuals or functions involved
- Communications and coordination

It is difficult to observe the decision process, though we can see and review results of a decision. Transactions are usually more visible, though many current systems use computer programs, which are not easy to understand, to process transactions. In principle, an observer can see information and its flows. Individuals can also be observed, but it is not always easy to figure out what information processing functions they perform. Systems also have implications for the way individuals communicate and for coordinating a firm's activities.

Much of systems analysis and design, as mentioned above, consists of developing a sufficient understanding of a system to document it. Consider the following example of a simple inventory system:

Decisions

- What to reorder
- When to reorder it
- How much to reorder

Transactions and processing

- Place an order
- Receive merchandise
- Withdraw goods from inventory

Information and its flow

- Quantity on hand for each item
- Historical usage of each item
- Forecasts of usage
- Cost of each item
- Holding costs
- Reorder costs
- Interest cost (to finance inventory)

Coordination and communication

- Communication between the warehouse and purchasing
- Communication between marketing (forecasts) and purchasing
- Communication with vendors
- Coordination of inventory replenishment among the above departments and with vendors

Individuals or functions involved

- Warehouse managers
- Stock clerks
- Receiving clerks
- Purchasing agents
- Vendors

Several other systems are also related to this one, including purchasing and accounts payable. This list serves only to describe the simple inventory system. We could further document this system by going into more detail, especially concerning the flow of information. We could prepare dataflow diagrams, which are discussed later in this chapter, to help visualize how the system works. We could also document the various decisions in narrative form to provide a better understanding of the inventory system.

Unfortunately, there is no one standard for what constitutes a system or how to document it. A number of different approaches are used, and individuals have to develop descriptive techniques for conceptualizing a system. Most people find it easiest to start at a very high level and then fill in the details. In our example above, we stated the system is first concerned with inventory. To anyone with experience in working with inventories, this description should bring to mind how inventory systems operate in general. By listing decisions, transactions, information flows, and functions, we add details to the inventory system. Further details can be added in top-down fashion as our knowledge about this particular system increases. In the end, everyone involved in learning about this system should share a common concept of it and an understanding of the documents describing it.

Multiuser versus Single-User Design

It is important to distinguish between multiuser systems and single-user applications when thinking about systems analysis and design. The types of systems discussed in this part of the text are largely multiuser systems, those used by a number of individuals in the organization. One group usually develops these systems for use by another group of employees. As such, development requires input from the individuals who are likely to be affected by the application.

This kind of multiuser system should be contrasted with a more personal system designed by the eventual user. Individuals frequently develop systems for their personal computers. These applications do not have the same requirements as multiuser systems because the systems designer is the systems user. He or she does not have to worry about developing a system for others to use nor does the system have to meet the needs of many different individuals.

Even a personal computer system we use ourselves can benefit from good design practices, but the requirements are not nearly so stringent as for a multiuser system. In these larger systems, we must worry about editing, error controls, usable input screens, retrieval capabilities, and file design. We must design for others as well as for ourselves, a much more complicated task!

A SYSTEMS DESIGN LIFE CYCLE

An information system has a life cycle just as a living organism or new product does. The various stages in the **systems life cycle** are shown in Table 15-1. The idea for a new information system is stimulated by a need to improve existing procedures or take advantage of a new opportunity. This leads to a **preliminary survey** to determine if a system can be developed to meet the objectives of the individuals suggesting it. If the results of the survey are positive, it is refined to produce a more detailed **feasibility study.** From the outcome of the feasibility study, a decision is made whether to proceed with the design of a system. If a positive decision is made, one of the alternatives sketched in the feasibility study is chosen for development.

In systems analysis, the existing information processing procedures are documented in detail. During requirements analysis, designers attempt to learn what users expect the new system to do. One major task during this phase is to define the boundaries of the system. Does the problem concern only inventory control, or

TABLE 15-1

THE SYSTEMS LIFE CYCLE

Inception	Programming requirements
Preliminary survey	Manual procedures
Feasibility study	Building the system
Existing procedures	Programming (or some alternative)
Alternative systems	Testing
Cost estimates	Unit tests
Systems analysis	Combined module tests
Details of present procedures	Acceptance tests
Collection of data on volumes, input/output, files	Training
Requirements analysis	Conversion and installation
Design	Operations
Ideal system unconstrained	Maintenance
Revisions to make ideal acceptable	Enhancements
Specifications	
Processing logic	
Database design, input/output	

should any new system also consider problems in purchasing when inventory has to be replenished? During analysis, data are also collected on the volume of transactions, decision points, and existing files.

The most challenging and creative part of the life cycle is the **design** of a new system. One approach to this task is to develop an ideal system relatively unconstrained by cost or technology. This ideal system is then refined until it becomes feasible. Designers must prepare detailed specifications for the system being designed. They specify the exact logic to be followed in processing and the content structure of the file. Designers select input and output methods, and develop the formats for input and output. These requirements for processing, inputs, and outputs lead to the specification of programming requirements, which can then be turned over to a programming staff for coding.

In the building stage, we develop the components needed to construct the system. Often this involves writing computer programs to perform the logical operations of processing. In some firms, this task is done by a separate group of programmers. Other organizations use analyst-programmers: The same individuals who perform the systems analysis and design also code the resulting programs. Programs have to be tested carefully, first as units and then in combined modules. Usually a programming task is broken down into a series of smaller subtasks or modules. All the individual modules must operate together if the system is to work properly. During the final stages of **testing,** there will be some type of acceptance test in which users verify that the system works satisfactorily.

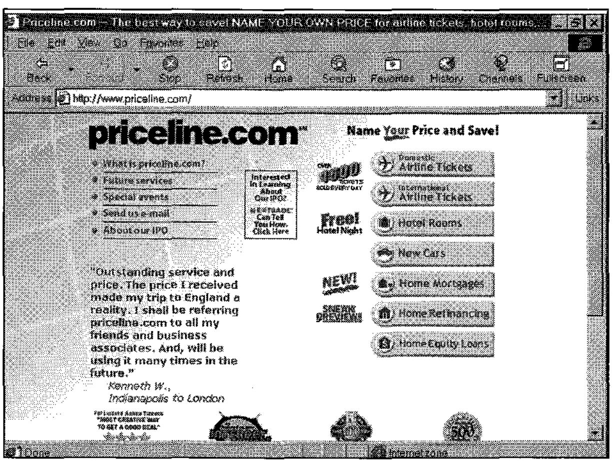
Since one purpose of the new information processing system is to change existing procedures, **training** is crucial. All individuals have to understand what is required by the new system. When training has been completed, it is possible to undertake **conversion;** it may be necessary to write special programs to convert

A Different Model for Buying a Car

There are a number of Web sites that provide information about new model cars. Auto-by-Tel, which used to operate only by phone, also has a Web site that refers customer requests to dealers. The dealers pay Auto-by-Tel a monthly fee to receive the referrals; Auto-by-Tel provides the customer with the names of nearby dealers who are in its program. The customer then negotiates with the dealer directly

Priceline.com has a different model; the customer describes the model of car and the price he or she is willing to pay. The customer also indicates the date by which the car must be available and how far he or she is willing to travel to pick up the car. Priceline searches for dealers willing to sell the car at that price, or who are willing to make a counter offer, and sends the specifications by fax to the dealers. (Priceline withholds the customer's name.) The customer pays Priceline $25 and the dealer pays $75 for its services. There is a $200 penalty if you don't buy the vehicle after a dealer has accepted your price.

Priceline said that the design of its system was fairly simple and that it only needed to add two Web servers and a fax distribution system. A clever idea, a straightforward systems design, and the infrastructure provided by the Web and Internet have produced a different model for selling cars.



existing files into new ones or to create files from manual records. Finally, after all these stages are complete, a team installs the system.

The operational stage begins after the problems of installation are resolved and the organization has adjusted to the changes created by the new system. The system now operates on a routine basis. This does not mean we do not change the system; however, there is a constant need for maintenance and enhancements. **Maintenance** is required because programs inevitably have errors that must be corrected when they appear. Because of the creative nature of design, users and the

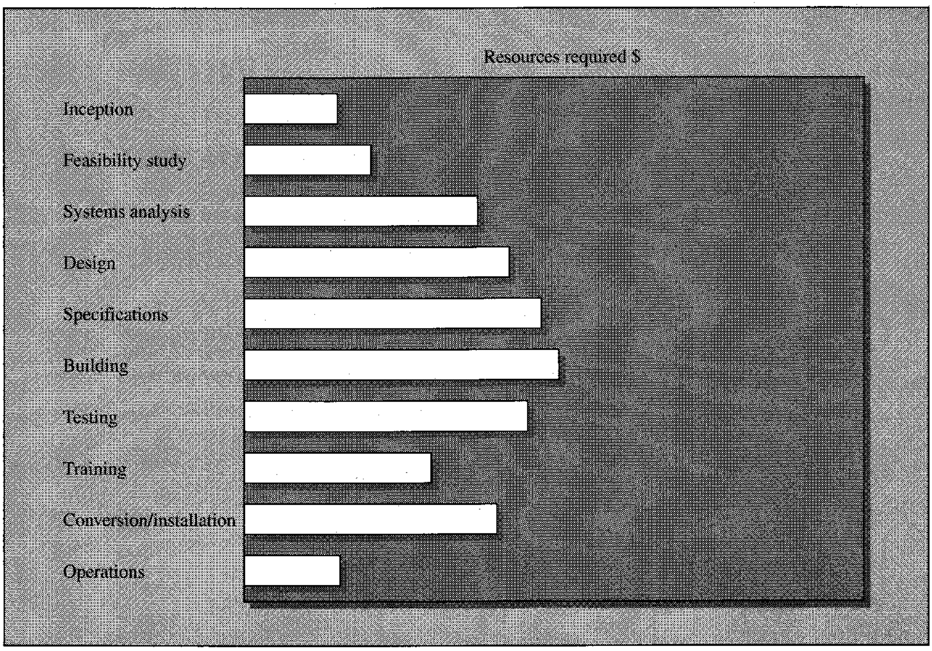


FIGURE 15-1
Resources required during each stage of the life cycle for a typical system.

IS staff may not have communicated accurately, so certain aspects of the system must be modified as operational experience is gained. As users work with the system, they will learn more about it and will develop ideas for changes and **enhancements.** It is unreasonable to consider any information system "finished"; the system continues to evolve throughout its life cycle if, in fact, it is successful.

Figure 15-1 shows the resources required during each stage of the life cycle for a typical system. (The pattern of time required would be much the same.) Few resources are usually required during the inception and feasibility study. Once systems analysis is begun, more expenses are incurred as analysts and users work on the system and its design. These stages culminate in the preparation of specifications for building the system. The building stage is intensive and requires the most resources. Often building involves writing a large number of programs. For a large project, the entire design process can last two or more years, of which more than a year may be required to build the system. Training will occur in parallel with the later stage of building the system, and finally the system will be converted and installed. After this time, the system reverts to operational status and is run on a routine basis. The resources required at this stage are steady, with some increases as the system becomes older and more changes are requested.

It is important to spend adequate time in analysis and design rather than rushing into development. If a system is well specified, there are fewer changes during programming. These later changes often require major redesign of programs and files, a very time-consuming and costly process. The entire systems life cycle can be compared to constructing a building. Changes are relatively inexpensive in the early conceptual stages. They become a little more expensive at the blueprint stage and exorbitant once the walls are erected. Systems changes are much the same. In the conceptual stages of analysis and design, they are reasonable. However, while programs are written and some are complete, major design changes have the potential for creating huge time and cost overruns.

THE ROLES OF MANAGERS, USERS, AND DESIGNERS

Users, managers, and the information services staff interact in a number of ways during the analysis, design, and operation of information systems. In this part of the text on systems analysis and design, we often refer to the responsibilities of each of these groups in the development of successful systems. Because this task is so complex and demanding, it is essential that all three groups cooperate during the analysis and design process. Table 15-2 restates the stages in the systems life cycle and suggests the appropriate roles of users, managers, and the IS staff.

The user initiates the preliminary survey by suggesting a potential application. The information services department responds with a rough estimate of its desirability and with several alternative systems, such as a package or a custom-developed system, each meeting some percentage of the users' needs. Management must approve the basic suggestion and the idea of a new application for this area of the firm and participate in setting objectives for any new system. In fact, it appears that one important role for management is to be a **champion** for the system. We have observed a number of cases where systems failed because of the lack of a high-level sponsor and where they succeeded with such a champion.

A preliminary survey evaluates each alternative on criteria developed by a selection committee. The selection committee, with management participation, authorizes a feasibility study, possibly eliminating some alternatives suggested in the preliminary survey.

The IS staff conducts the feasibility study with help and advice from users. Users conduct an analysis of the existing system to evaluate various alternatives on criteria specified by the selection committee. Management reviews the feasibility of the proposed alternatives and develops an understanding of what the system will accomplish. The selection committee chooses which alternative to implement with participation and review by management. Possibly the committee selects the alternative of no new system, in which case the application may be held in abeyance until changing conditions make it feasible.

If the decision is made to proceed with the development of a new system, users and the IS staff collaborate to analyze the existing system. Users explain existing processing procedures and provide data. The IS staff uses this information to document the existing system and help establish the boundaries of a new system. Management has a key role to play in this stage. It must provide adequate resources both for the IS staff and for users. It may be necessary to hire additional staff so users can participate or hire additional analysts to work on the project.

TABLE 15-2

RESPONSIBILITIES DURING THE SYSTEMS LIFE CYCLE

Stages	Users	Management	Information services staff
Inception	Initiate study, suggest application, sketch information needs, describe existing processing procedures	Serve as sponsor, approve area for application, set objectives	Listen to requirements, respond to questions, devise alternatives, assess using rough estimates, prepare preliminary survey
Feasibility study	Help evaluate existing system and proposed alternatives, select alternative for design	Review feasibility, understand proposal, choose alternative	Evaluate alternatives using agreed-upon criteria
Systems analysis	Help describe existing system, collect and analyze data	Become system champion, provide resources, attend reviews	Conduct analysis, collect data, and document findings
Design	Design output, input, processing logic; plan for conversion and forecast impact on users; design manual procedures; remain aware of file structures and design	Encourage user design, provide rewards, attend reviews, plan impact	Present alternatives and trade-offs to users for their decisions
Specifications	Review specifications, help develop specifications for manual procedures	Understand high-level logic, key features	Combine users' needs with technical requirements to develop specifications, develop technical conversion plan
Building	Monitor progress	Monitor, provide buffer, extra resources	Organize programming, design modules, code programs, report progress
Testing	Generate test data and evaluate results	Review	Test program modules individually and in entire system
Training	Develop materials, conduct training sessions	Review	Aid in preparation of materials and train operations staff
Conversion and installation	Phase conversion, provide resources, conduct postimplementation audit	Attend user sessions, demonstrate management commitment	Coordinate conversion, perform conversion processing tasks, help in postimplementation audit
Operations	Provide data and utilize output, monitor system use and quality, suggest modifications and enhancements	Monitor	Process data to produce output reliably, respond to enhancement requests, suggest improvements, monitor service

Next, the design of a new system begins. We advocate that users design their own input and output and basic processing logic. The information services department acts as a catalyst, presenting alternatives for users to consider. Management encourages user design through its own attendance at review meetings. Management may provide special rewards, prizes, or other incentives to encourage user participation in design. At this point, management must also plan for the impact of the system on the organization. Will the structure of the organization be changed? How will work groups be affected? What will specific individuals do as a result of the system? A plan for conversion should be developed, including a forecast of the system's impact on all potential users.

The IS staff develops detailed specifications based on the logic and requirements specified by users and prepares a technical conversion plan. The users on the design team review the technical plans and work on the development of specifications for manual procedures. It is vitally important at this stage for both users and managers to understand the system. Users must be familiar with the output, input, and processing logic. Management must understand the overall flow of the

MANAGEMENT PROBLEM 15-1

Most IS managers would advise first looking for a packaged solution to an information processing initiative as opposed to developing a custom solution. This advice raises some interesting management and educational challenges. Why should you read the chapters in this section and learn something about systems analysis and design if it is likely that you will purchase an applications package? What conditions lead to a situation where you are unable to buy a package?

To discuss the first question, think about evaluating a package. You must know something about the "ideal system"; that is, what features and functions do you need in a package? One way to find out is to talk to the package vendor for information. Why should this not be the only source of information? What role might a preliminary, logical design of a system have prior to looking for information about packages?

Is there a package for every application? There are packages for many applications, and there are pieces of a solution you can buy and integrate. However, there is always the possibility that the application you have in mind is unique, or has a possibility of providing a competitive advantage so you will want to develop and protect it as long as possible. A major brokerage firm has invested close to $1 billion in a workstation for its retail stock brokers. It is buying some pieces of the software and services like data feeds from the stock exchanges. However, the system has a large number of functions and much of the firm's investment is for significant custom development.

What are your conclusions about the role of systems analysis and design in a world of packages?

system and be aware of key decisions. For example, management should be aware if inventory items are to be grouped into classes and different reordering rules applied to each. Management should help set the classification and reorder rules, and understand how the logic is to work.

The users' role and management's role during programming are to monitor progress. Is a project schedule maintained and are resources reallocated as necessary to achieve installation on schedule? The bulk of the responsibility during this design stage rests with the information services department. The IS staff must design program modules, code them, and test them alone and in combination. Managers should realize they need to help when problems arise. The development of an information system is similar to a research and development project; it is very difficult to anticipate every contingency. There will be project slippages, budget overruns, and other problems. The role of management is to provide a buffer for the project and furnish additional resources where they will help.

During testing, users should define data for test programs and attempt to generate data with errors to ensure that the system will catch them. Users should carefully examine test results and evaluate the adequacy of processing. Management should also participate in the reviews of data processed by the system. Some kind of acceptance test should also be conducted by the information services department, and the results should be evaluated by users. A parallel test of old and new procedures or pilot studies may be used for this purpose.

Training is essential for smooth conversion and installation. Users should develop materials and actually conduct the training sessions whenever possible. Managers remain aware of the training program, attend occasional sessions to communicate support for the system, and check that their knowledge of the system is accurate. Training can often be combined with testing. The preparation of test data serves to help train users. The IS staff aids in the preparation of materials and trains the operations staff.

Conversion is a crucial part of the systems life cycle and should be done in phases if possible. For example, can one department or geographic area be converted first? The information services department coordinates conversion and performs conversion procedures such as creating initial files for the new system. Users and the IS staff should jointly conduct a postimplementation audit and report the results to management. How well does the system meet specifications? How good were the specifications? That is, how do users react to the system now? How do the original estimates compare with what was achieved? These data can be helpful in making estimates for future projects.

Finally, during **operations,** users furnish data for input and work with the system. Users and management will probably suggest enhancements and modifications to the system over time. The information services department itself should also look for improvements and respond to modifications suggested by users.

Potential Pitfalls in the Life Cycle

It is widely recommended that stages in the systems life cycle just discussed be followed. When we have seen them followed rigorously as a checklist, however, the result has usually been systems that fail. What is wrong with the life cycle? Is the concept invalid? There are several major difficulties with rigidly following the stages listed in Table 15-1 in the development of a system.

First, the stages tend to focus attention on a particular design approach. We shall see several alternatives to conventional design in subsequent chapters. The steps in the life cycle also imply that the analyst is in control of the design process. If a design team works under this impression, there will be too little participation by users.

A very serious shortcoming of the life cycle model is that many analysts seem to interpret it as requiring the development of only one alternative. Users and managers need to have a series of options from which to choose. They are poorly served by designers who provide a single design for a new system rather than one with alternatives to the status quo. There may be ways to shorten the life cycle and to skip certain stages. Most discussions of the life cycle do not suggest shortcuts in development.

The systems life cycle provides a complete list of tasks, but we need to be flexible in how those tasks are accomplished and in what alternatives are presented to management.

USER-ORIENTED DESIGN

Problems with the Conventional View

In the conventional approach to systems analysis and design described above, the analyst is a skilled leader. The analyst interviews users, collects data, and returns to the information services department to create a new system. Instead of viewing the analyst as the designer of the system, we recommend strongly that users design their own systems. Does this joint approach mean users actually undertake some of the tasks normally carried out by the analyst? The answer is definitely yes. Our recommended approach raises two questions. First, why should users assume this role? Second, how can they do so? Our experience indicates that users are capable of responding to this approach and that successful results are possible.

A more user-oriented approach to design may require deviations from the standard systems life cycle. Although the conceptual steps represented in the cycle may be followed, innovations will be included. For example, design is often facilitated by prototyping. A **prototype** is a smaller-scale version of a planned feature for a new system. A good example is sales forecasting. We can code the new forecasting routine on a personal computer and analyze past data for a limited number of products. Users will be intimately involved in this test so they can provide feedback on the prototype and evaluate its output. When they are satisfied, the prototype can be programmed in final form with more error routines, data manipulation features, and so forth, which had been excluded to keep the prototype simple.

As a user, you must be sure you have adequate input in the design process. The professional systems analyst never uses the system—he or she moves on to another system after completing yours. Users often figure out too late that they are stuck with an inconvenient or unusable system. If you insist on influencing the design of the system and develop ownership of it, the chances for success are much greater.

MANAGEMENT PROBLEM 15-2

The information services department at Madison Drugs is trying to stimulate user participation in the design of information systems. A new system for financial management is in the planning stages, but problems with users seem to occupy most of the planning sessions in the department.

One of the key figures in developing the new system is a user named Keith Ryan. Keith has been at Madison for 20 years and is responsible for all financial transactions. The information services department chose him as the most obvious user to head the design effort. Keith is in sympathy with this selection, but says, "I don't have time to spend designing a system; I work 60 hours a week as it is!"

The IS staff recognize the extent of Keith's efforts and devotion to the company, but ask why additional staff cannot be hired to remove some of his load. Keith says that he has tried to break in new people, but the demands of the job are too rigorous and they all leave.

The president of Madison wants to know why the design of this new system is taking so long. What should the manager of the IS department do? What can he suggest to the president?

Design Team

To coordinate users and the IS department staff, we recommend the formation of a design team with a user as head of the team. Having a user in charge makes the users' role apparent, ensures time will be available from other users, and demonstrates a strong commitment to users on the part of the information services department. Normal job activities should be reduced for the user in charge of the design team.

In case there are too many individuals for all of them to be involved, liaison representatives are suggested. These people interview other users and brief them on the system as it is developed. They are responsible for soliciting participation in the phases where it is meaningful.

The IS department's systems designer guides the design team, teaching the tools and techniques necessary to complete the design and providing required technical advice and support, for example, by developing detailed file structures after users complete the logical database design. Systems designers monitor the project, describe the different stages, and help to schedule them. The actual analysis and design work is done by the users with the assistance of the analyst, which is the opposite of how it is done in conventional systems design.

THE SPIRAL MODEL OF DEVELOPMENT

The development approach presented in this chapter, which features the systems development life cycle, is sometimes called the waterfall model: each stage flows

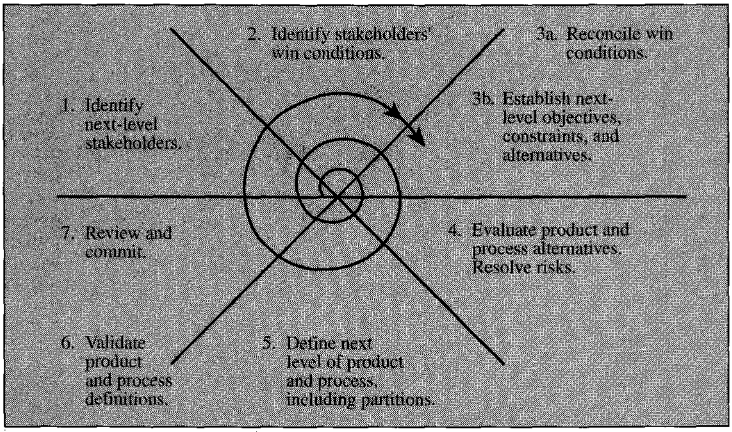


FIGURE 15-2
The spiral model of design shows the source of objectives, constraints, and alternatives.

into the next. We have indicated that the reality is different; designers revisit the stages in an iterative fashion. One of the first people to recognize the shortcomings of the waterfall approach was Barry Boehm, who developed the spiral model of development (Boehm, 1998). An extended model is shown in Figure 15-2 (Boehm et al., 1998.) The model extends the waterfall approach by recognizing the different cycles. It also incorporates risk analysis, and makes clear the places where the developer or client may want to terminate a project. The approach is one of incremental development. You might not design the ideal system entirely in the beginning, but instead define the highest priority features and then go back to fill in the details.

The spiral model defines four major activities within its lifecycle:

1. Determine the system's objectives, constraints, and alternatives; what processes does it affect? What products does it produce?
2. Evaluate alternatives and identify major sources of project risk.
3. Define the product and processes involved.
4. Plan the next cycle; partition the system into subsystems and consider terminating the project if it is too risky.

The extended model shown in Figure 15-2 adds three activities at the beginning of each spiral:

1. Identification of the key stakeholders for each subsystem; who will the system impact? Who needs to support the development effort?
2. Determine how to make the system contribute to achieving stakeholder goals; how can a successful system be seen as a "win" for the stakeholder (hence the name of this variation, the WinWin spiral model)?
3. Negotiate and reconcile differences so that developers and stakeholders all "win."

The spiral model features iterative development beginning at the center of the circle and working outward. Successive iterations follow as more complete versions of the software are built. Unlike a linear trip through the systems life cycle, the spiral model makes it clear that design is a circular process. One designs the overall objectives of a system, and then divides it into subsystems, each of which has a life cycle or spiral of its own.

The model is a guide that can help deliver systems faster to the client; it is based on a continuous refinement of a system, not unlike a prototyping approach. Explicit points to assess risk are a way to help manage development. The model recognizes that you cannot know everything in advance and that you will discover more information on each cycle. Models like this are used infrequently in business organizations because professionals are not always aware of them and because they require time to use. The high failure rate of projects, however, is a good argument to try something new like the spiral model.

DATA COLLECTION FOR ANALYSIS AND DESIGN

What techniques are available to the design team for collecting data? As discussed earlier, the objective is to develop an understanding of key decisions, communications, and coordination requirements, and how they are supported with information. The team needs to examine decisions, the flow of information in the organization, communications patterns, and the types of processing undertaken.

Observation

One technique for collecting data on a process is to observe that process. Frequently in systems analysis and design we will "walk through" a system, observing crucial information flows and decision points. Then we may use one of the graphical techniques described later in this chapter to document our understanding of how the system functions.

Observations can also be quite structured. We may develop a rating form of some type to collect data on the frequency of inquiries, say, in a credit office. The analyst prepares a form showing the possible inquiries and then, during a sample of different days and hours, codes the actual inquiries.

Interviews

The systems analyst spends a great deal of time interacting with others, particularly in interview settings. Interviews have varying degrees of structure. For a first meeting, there may be no structure at all; the analyst may be getting acquainted with the user and gaining a broad understanding of the problem area. Often, as the project progresses, the analyst conducts more structured interviews. The analyst may wish to prepare in advance an interview schedule containing the questions to be asked and the points to be covered. The main thing is to be prepared.

Questionnaires

A questionnaire allows us to obtain data from a relatively large number of people at a reasonable cost. A questionnaire can be thought of as a structured interview form

TABLE 15-3

SAMPLE INTERVIEW/QUESTIONNAIRE ITEMS

1. Please describe your job.
2. With whom do you interact in your work?
3. What are the key factors in your work unit's success?
4. What factors are critical for your personal success?
5. What type of information and data do you use in your work?
6. Where does it come from? What do you do to change it in some way? Where does it go after you have worked on it?
7. What major bottlenecks exist in your sources and use of information and data?
8. What kind of technology do you use?
9. What do you like about your current technology platform?
10. What are the drawbacks of your current technology platform? What problems do you have? How do you resolve them?
11. If you could have any technology you wanted, what would it look like?
12. If you could redesign the entire work unit here, what would the flow of work look like?

with questions designed so they can be answered without a face-to-face encounter. The design of a good questionnaire is a difficult task. Although the idea is an extension of a structured interview form, the questionnaire is, in principle, capable of being completed by the respondent alone without an interviewer present. Table 15-3 presents some examples of questionnaire and/or structured interview questions.

Comparing the Alternatives

Both questionnaires and interviews are important for the analyst, though interviewing will probably be used more often. An interview makes it easy to follow a new tangent. The respondent is not constrained by the limitations of the questions but can expand in other directions. If the question is ambiguous, the interviewer explains what is desired. Interviews are the best technique in an unstructured setting and when it is necessary to probe issues in depth.

Questionnaires offer the advantage of being relatively inexpensive to administer to a large group of respondents. They are well suited to expanding data collection beyond the interview. For example, assume a system is developed for a number of sales representatives nationwide. If the firm has 500 sales representatives, it is impossible to include all of them on a design team. Instead, we would use liaison representatives chosen as typical of the types of salespersons on the force. This group might assist in developing a questionnaire for the rest of the sales force, previously uninvolved in the design process. The questionnaire could explain some of the chosen trade-offs and characteristics of the system to all potential users to obtain their input and feedback.

STRUCTURED VERSUS OBJECT-ORIENTED DESIGN

In response to the high failure rate for new systems (that is, many systems do not meet their original specifications or time and budget targets), we have seen the development of two approaches designed to improve the chances for successful development. Both approaches emphasize logical and structured views of design. The first of these approaches is called **structured design** while the second is known as **object-oriented design.**

The Role of Structured Design

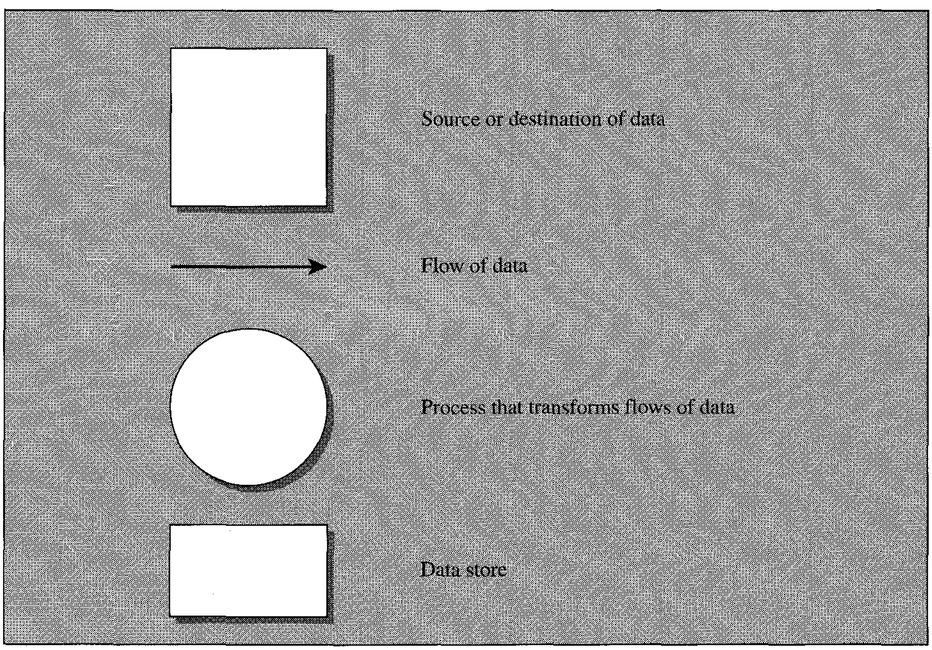
What is structure in design? Basically, we try to take a disciplined, step-by-step approach to reduce complexity. A good example is **top-down design;** this philosophy means that the designer first concentrates on an overview, then moves to successive levels of detail. If at any step the designer becomes confused, he or she backs up one level to a diagram with more of an overview. The major purpose of this approach is to improve understanding and communication.

The process is very similar to the set of plans developed by an architect. When a client asks for a new building to be designed, the architect develops rough sketches and adds detail over time. In presenting drawings to the client or even to construction workers, the architect does not provide a first page with the details of the electrical wiring! Instead, we usually find that the first page is a perspective of the building. The next page might be four side views, followed by a page with a high-level floor plan. As each page is turned, we find more detail.

Data Flow Diagrams

One of the most popular structured approaches to design is the use of data flow diagrams (see Figure 15-3). Compared with traditional flowcharts, the **data**

FIGURE 15-3
Data flow diagram symbols.



flow diagram (DFD) is far less complex; there are only four symbols used for the highest level of detail.

The DFD approach is more than just the symbols. It is important for the analyst to exercise discipline in preparing the charts. The recommended strategy is top-down: begin with a high-level diagram and place succeeding levels of detail on subsequent pages. In addition, because adding detail makes the drawing cluttered, the analyst should take one process or subsystem and explode its detail on a separate sheet of paper. DFDs can easily be read and prepared by users. One of their most important contributions is to facilitate understanding among all of those involved in a design project.

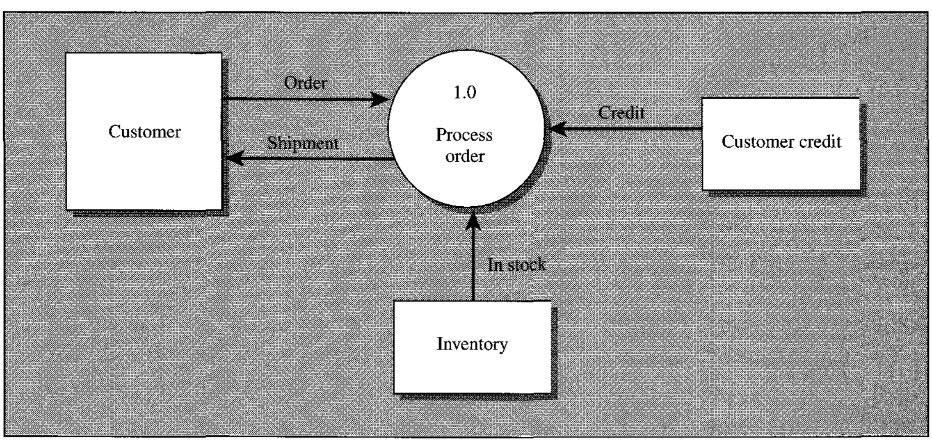
An Example of Structured Design

Imagine that a group of entrepreneurs decides to open a mail-order business selling software for personal computers. A customer sends in an order form, and employees of the business ship the software to the customer. Figure 15-4 is a high-level DFD for this firm. At this level, we see the basic flow of an order coming to the firm and a shipment going to the customer. Before shipping an order, an employee must look at an inventory record and check the customer's credit.

Figure 15-5 presents the next level of detail. We see that the first action is to check the inventory to see if the software program ordered is in stock. If so, the employee places the order in a file marked "to be filled." The warehouse staff removes orders from this file, finds them in inventory, packages the programs, and sends the shipment to the customers. If at any point you lose track of the process, it is necessary only to back up one or two diagrams to get an overview.

In Figure 15-6, the designer addresses the question of what to do when the warehouse is out of stock. Management decides that back-ordering is probably not

FIGURE 15-4
Overview of mail-order business.



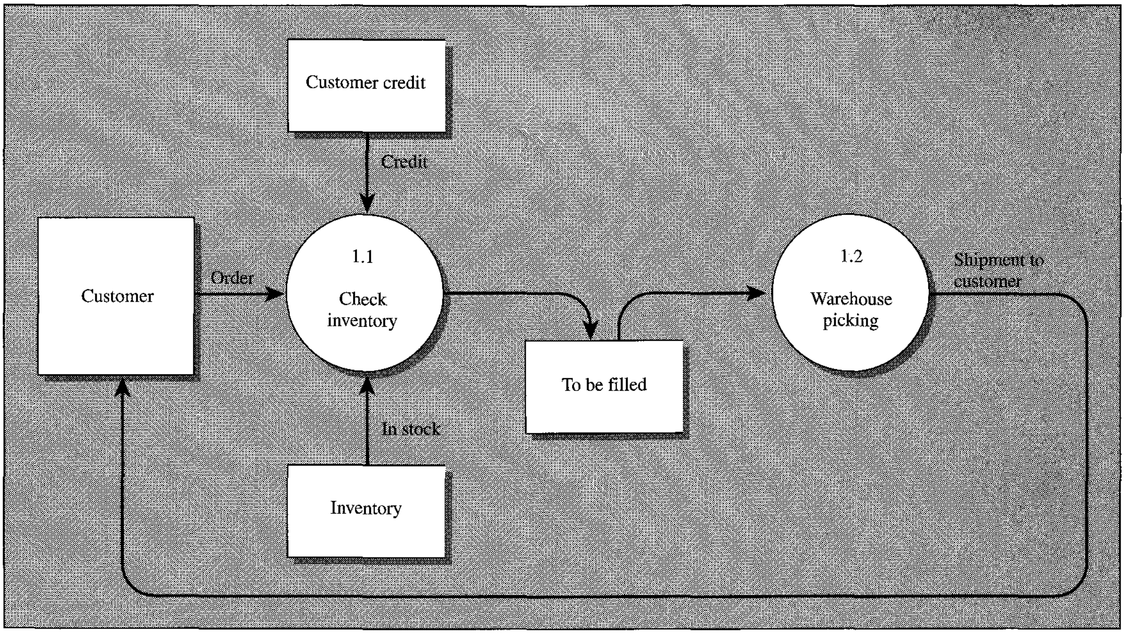


FIGURE 15-5
The next level of detail.

feasible as the customer will look elsewhere for the program rather than wait. However, it is important to reorder when stock is low or entirely gone. If we need more merchandise, an order must be placed with a supplier. There is also a path from warehouse picking to the reorder process if the inventory records do not exactly match the warehouse contents. Here one wants to check the warehouse carefully and then reorder if in fact there is nothing in inventory.

Figure 15-7 adds more detail to the reorder process and includes an accounts-receivable process. We see that the firm must check in merchandise when it is received from suppliers and that the goods are eventually placed in inventory. Accounts receivable are important if the firm is to stay in business! You must send an invoice to the customer with the shipment of goods and create a receivables record.

It would be possible to expand Figure 15-7 further, but the diagram is beginning to get cluttered. At this point, the designer would probably take each process and treat it as a subsystem for further explosions. For example, it would be possible to treat the accounts-receivable process as a subsystem and generate several pages of greater detail on how the firm creates and processes receivables.

This example illustrates what we mean by design and logic. The managers of this company are creating the various information flows and processing steps in their

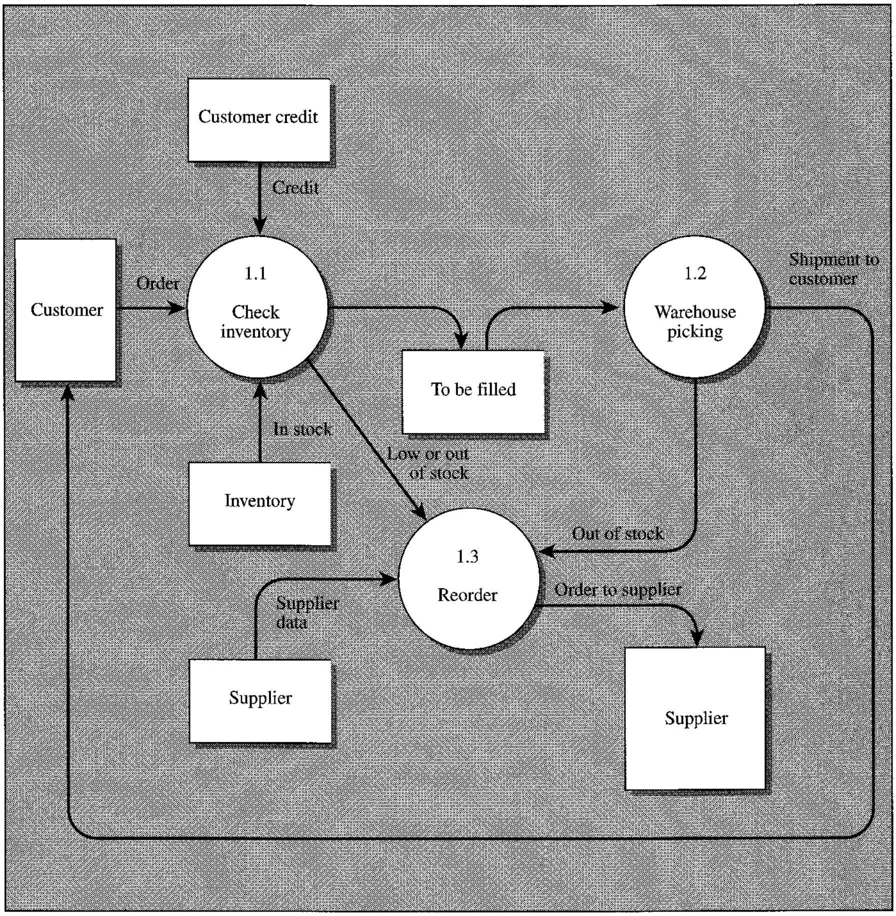


FIGURE 15-6
Reorder plan.

new firm. They must design different order-entry procedures and identify the trade-offs among them. For example, they may choose to have customers submit orders

- On paper
- By fax
- By telephone with a clerk filling out a paper order or entering the order directly in a computer
- Via the Internet
- Any combination of these options

In making this choice, the managers might trade off factors such as cost, customer service, and development time.

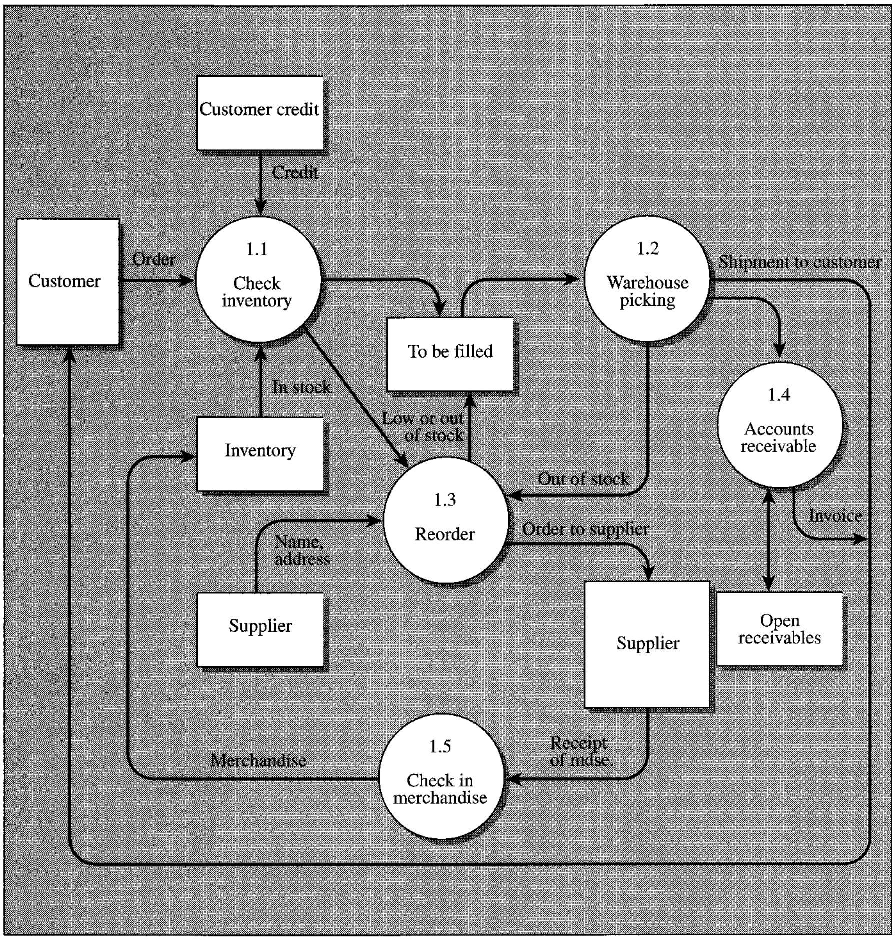


FIGURE 15-7
Receipt of goods and accounts receivable.

When the managers decide, for example, to install a toll-free telephone number and have order-entry personnel enter orders directly in the computer, they have designed one part of the system. If managers want customers to order electronically from the Internet, they are also specifying one part of the system's logic. When the managers identify the questions the clerk is to ask the customer and what he or she is to type in the computer, they are designing the processing logic. They could decide to identify the customer by phone number or by zip code, last name, and first initial. Based on this input the system would retrieve data about the customer (if he had ordered before) such as his complete address. Design is the process of creating this new information system.

Object-Oriented Design

There is great interest in a conceptual approach to programming and systems analysis called **object-oriented analysis.** This approach to design is tied very closely to programming: software becomes a collection of discrete **objects** that incorporate data structure and behavior. An object is a representation of some real-world thing and a number of specific instances of that thing. For example, we could define a Ford Explorer as an object. Objects encapsulate attributes and services; this Explorer has four doors and four-wheel drive. The object is the Explorer, which is stored with its attributes of four doors and four-wheel drive. All objects have an identity and can be distinguished from one another.

A **class** describes a group of objects with similar properties, common behavior, and common relationships with other objects. The Explorer is a member of the Vehicles class. The grouping of objects into classes makes it easier to work with abstractions. The designer can think about the system at the level of the class without having to bother with individual objects in the class. There are methods or procedures associated with each class; they apply to the objects in the class and change some attribute. The same method may apply to different classes, but it may take on different forms in different classes. This characteristic of a method applying across classes, changing its implementation to match the class, is called **polymorphism.** In a conventional system, methods would be programs or routines for processing objects.

A link connects different object instances; for example, Mary Smith (an object) works for (a link) the Widget Company (an object). Links with common characteristics are grouped into an association. Based on what we have seen in past chapters, it may help to know that links and associations are often implemented as pointers between objects and classes. Objects communicate by sending messages. As a result, one object cannot directly access the object in another class, which means that objects are **encapsulated** or protected from damage from other objects. The message generally results in the execution of some method of processing that is stored with the object. Different authors describe this processing as done through methods, procedures, or services.

To build an object-oriented model, you identify the classes and objects in the problem domain. Class diagrams contain classes and show their relationships, while object diagrams show how objects send and receive messages. Over time, one builds class libraries: an objective of this approach is to reuse software. For example, a class and its objects for an inventory system might also be used in a production control system. Reuse is intended to reduce the amount of time spent and the cost of developing applications. Programmers implement object-oriented systems with languages such as C++ (C enhanced with features to support object-oriented programming), Java or Smalltalk, one of the first object-oriented languages.

As an example, assume you are to develop a system to manage corporate vehicles. The object of interest is a vehicle. There are many instances of vehicles (cars, trucks), so an object tells us something about a class of real-world things.

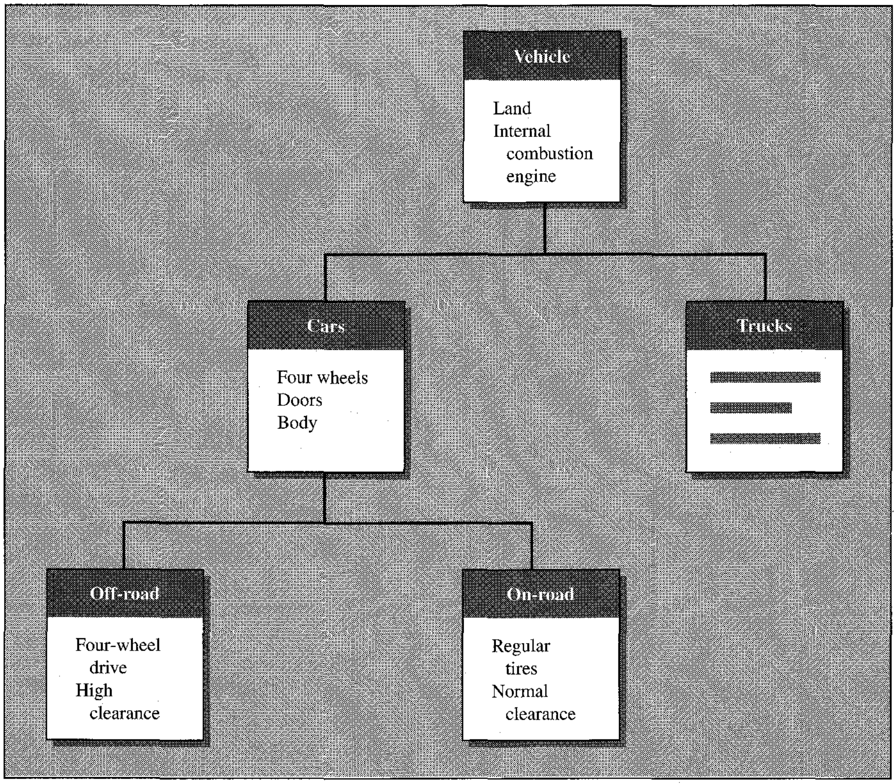


FIGURE 15-8
An object classification with inheritance.

Instances of vehicles have different attributes (wheels, engines). Figure 15-8, a classification structure for vehicles, shows that cars are one type of vehicle. We are interested in land vehicles with internal combustion engines. Within the subclass of cars are vehicles with the following attributes: four wheels, doors, and a body. Cars can be off-road or on-road. An off-road car has four-wheel drive and high ground clearance, and so on.

A very significant concept in object-oriented analysis is **inheritance.** Each instance of an object inherits the properties of its class. An instance of an on-road car, a Ford station wagon, inherits all attributes above it in the hierarchy. It is a land vehicle with an internal combustion engine, and it has four wheels, doors, a body, regular tires, and normal ground clearance.

An important characteristic of object-oriented analysis is communications through messages among different objects. These messages may be in the form of services that are performed for the objects. One example of a service is to register a vehicle and issue license plates. Repairing a vehicle is another kind of service. The message triggers a method or routine stored with the object to change some attribute

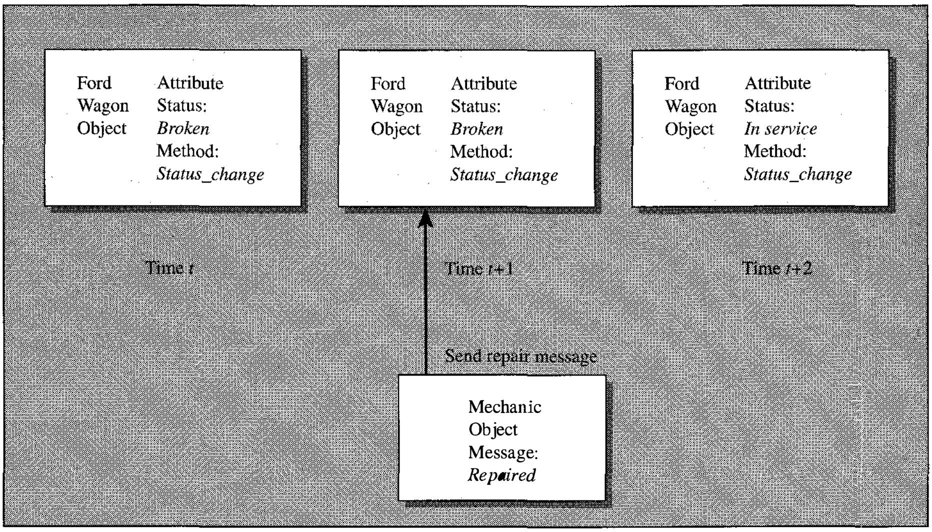


FIGURE 15-9
Message passing and encapsulation in object-oriented systems.

of the object. For example, a message from a mechanic object might say the Ford wagon attribute "status" should be changed from "broken" to "in service."

Figure 15-9 shows an example of objects communicating through a message. At time *t* the Ford wagon object is broken. At time $t + 1$ a mechanic object sends a message to the Ford wagon object indicating that the mechanic has repaired the car. This message activates a method or procedure to change an attribute of the Ford wagon object. The results of that change are shown at time $t + 2$. The Ford wagon object now has an attribute that indicates the car is in service again.

Since the routine that makes the change is stored with the Ford wagon object, it is possible to change other parts of the system without changing this object. Other objects also do not have the ability to directly modify the Ford wagon object, reducing the chance for errors. If you change some part of the system but continue to send messages in the same format as before the changes, there is no need to modify the Ford wagon and other automobile objects in its class. This encapsulation of the object and the methods for changing its attributes make it easier to change one part of a system without having an unanticipated impact on other components.

Design incorporates identifying objects, the relationships among objects, and the services that are performed involving the objects. A set of steps for object-oriented analysis adapted from Coad and Yourdon (1990) is:

1. Define classes and objects to form the highest "layer" of the analysis.
2. Proceed to define the detailed structure of classes and objects such as one-to-many relationships (very similar to entity-relationship models) and inheritance.
3. Define the methods to be performed and the messages that will trigger methods.
4. Define the attributes of classes.

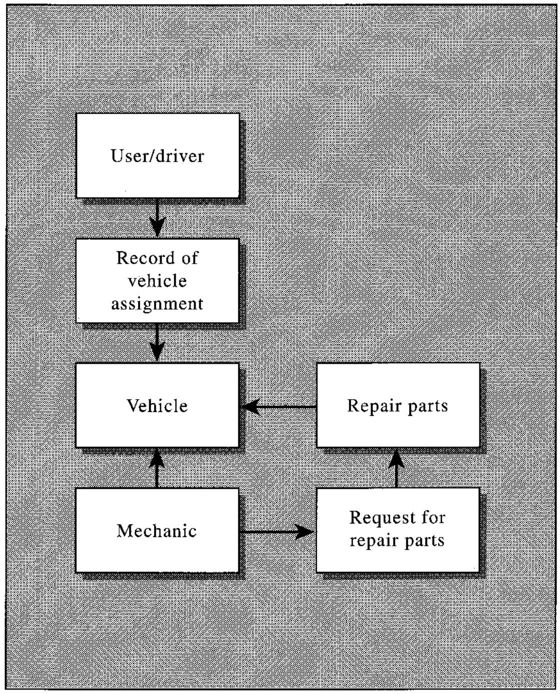


FIGURE 15-10
Object structure diagram.

There are several approaches to object-oriented design depending on the particular author one follows. There are a variety of design documents that serve the same role as DFDs in structured design. The first of these is an **object structure diagram** shown in Figure 15-10. This model identifies the object classes involved in an application and relationships between objects. The diagram can be used to show inheritance, aggregation, and attributes of objects. Figure 15-11 shows an **object interaction diagram.** We see the objects involved in recording the assignment of a vehicle to an employee and arranging the repair of that vehicle when necessary.

A **transactions sequence diagram,** sometimes called a "use case," models the possible ways of using a system. Each transaction sequence describes a service the user wants from the system. It should show what is required to complete some unit of work that is significant from the user's perspective. Transaction sequence diagrams also help develop the transaction structure diagram by showing objects that may have been omitted in the design so far. Figure 15-12 is an example of the transaction sequence invoked when a driver needs to have

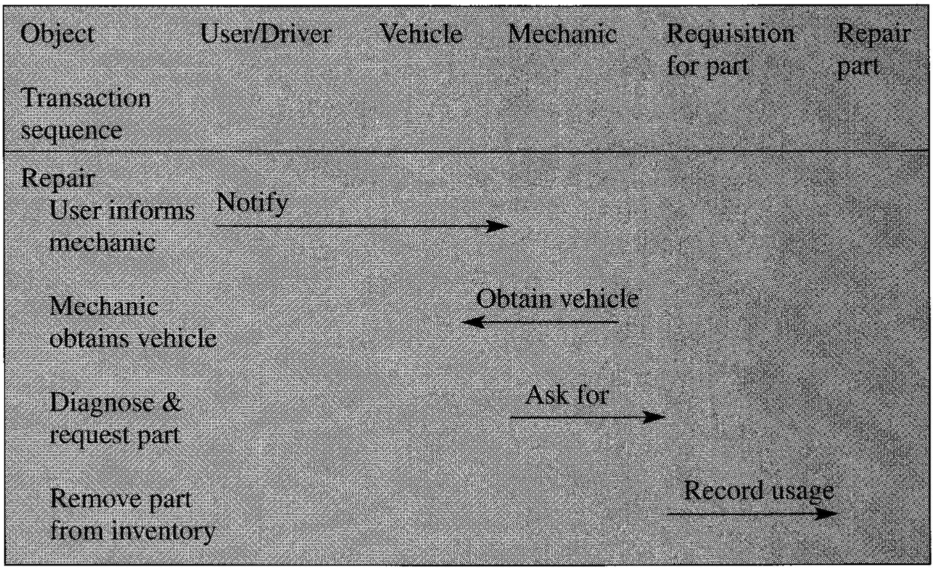


FIGURE 15-11
Object interaction diagram.

a company vehicle repaired. In the figure, the user contacts the mechanic to request a repair. The mechanic takes the vehicle and diagnoses its problem(s). He or she then requests a part from the spare parts inventory and uses it to repair the vehicle.

The final diagram we shall discuss is one that models the interaction among objects. As we saw in Figure 15-9, an object-oriented system operates by sending messages among objects. Specifying this interaction is a key part of the design process. Figure 15-12 shows the interaction among the objects in our vehicle system when the transaction is to arrange a repair of the vehicle. By specifying similar diagrams for all the objects and transactions in the system, one completes the logical design of an object-oriented system. In completing the design, Yourdon et al. (1995) also recommend developing an object life cycle diagram that shows how objects change over time. For example, a vehicle in our system changes from "broken" to "fixed," on one or several occasions. A life-cycle view would show the vehicle coming into the inventory of vehicles, a history of possible repairs and enhancements (for example, a new set of tires), and the final disposition of the vehicle.

Object-oriented analysis is relatively new. It appears very promising and is the appropriate design approach if you plan to use object-oriented programming to implement a system.

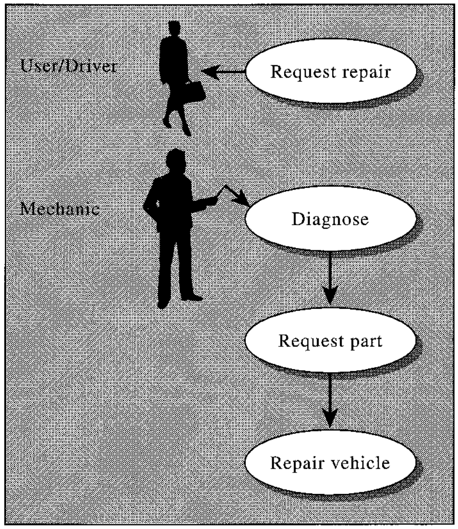


FIGURE 15-12
Transaction sequence or use case diagram.

A Comparison of Approaches

While it may not be readily apparent, structured methodologies and object-oriented approaches are quite different in underlying philosophies. There is no one standard methodology for each approach. Different authors propose different notations and design steps for both structured and object-oriented design. However, all these authors agree on certain features for each approach. Structured methodology is based on the notion of functions; programs consist of modules to meet functional requirements. Function and procedure are the primary focus of this approach, and functions or processes share data. The emphasis is on process modeling rather than on data modeling, and analysis proceeds in a top-down manner.

In object-oriented approaches, programs consist of interrelated classes of objects; data and procedures are encapsulated within the object. The analysis proceeds from the bottom up. Objects communicate with each other by sending messages to another object, which in turn, responds to the message. One uses object-oriented programming languages designed or extended to support objects, classes, and all the characteristics of this development approach such as inheritance, encapsulation, and polymorphism.

Object-oriented approaches to design are discussed extensively today, though only a small proportion of companies use the methodology. It is not clear if this approach will, in fact, provide substantial benefits until we have more experience with it.

MANAGEMENT PROBLEM 15-3

Eat-Lite is a small chain of health-food stores on the East Coast. The company has grown rapidly and is now investigating the possibility of developing an information system to help control its operations. Wendy Schwartz, the firm's founder, described the reasons. "We need to get better reports back on our sales, and we have to replenish the stores faster from our suppliers. We are out of stock too many times."

"I have used e-mail myself, and I think it could help us communicate with the local store managers—you know—make the company seem a little more personal. We could also handle sales promotions and new-product introduction using it. I also think we have to consider the Internet as a way to reach stores and customers."

Wendy talked to a number of consultants, each of whom had different recommendations for systems and equipment. The consultant that she liked the best wanted to first decide on the architecture: Should Eat-Lite try PCs in the store and a client-server architecture or think more about a midrange minicomputer at headquarters that would do most of the processing? How should store-headquarters communications be handled? Does the company want to use the Internet as its communications network or develop a private net?

Wendy was a little confused. The book she read on systems analysis and design made it sound like it's best to do the logical design of a system without thinking about the hardware on which the system would run. Why is this consultant talking so much about hardware in the first place?

CHAPTER SUMMARY

1. Systems analysis and design is an activity that requires teamwork among managers, the information services staff, and users. It is a creative and exciting process that can bring about substantial change in the organization.
2. It is important to appreciate the difference between designing an application for yourself, say, using a spreadsheet on a PC, and designing an application that will be used by a number of individuals in the organization.
3. Traditionally, we have conducted multiuser design following a life cycle model.
4. In designing applications, managers, users, and the professional designers all have important roles to play.
5. The life cycle model, while useful for thinking about design, has problems that can be addressed by extensive user involvement and influence in design and by adaptations like prototyping.
6. There are a variety of ways to collect the information that you need for design. Interviews are the most popular method.

7. Structured design techniques focus on top-down design. They employ data flow diagrams and entity-relationship models to describe a system.
8. Object-oriented design is the newest approach. It concentrates on data in the form of objects that communicate by passing messages. Objects, their attributes, and methods or procedures that act on the objects are encapsulated together.
9. The tasks of learning user requirements and determining the functions for a new system are the most difficult part of design, regardless of whether you use structured or object-oriented approaches to describe the system.

IMPLICATIONS FOR MANAGEMENT

I am constantly surprised and encouraged by the inventive applications people discover for technology. You can easily find an outlet for your creativity in designing information systems. There are standard kinds of transactions processing systems in most organizations, but even within a routine application like order entry, there are a variety of ways to execute the design. For a multiuser system, you will want to appoint a design team and be sure there are reviews of the system with management and other users. You may also have to act as the chief sponsor for a system you would like to see developed. It is important to remember that professional designers disappear into the sunset after completing a project, and users have to live with the application every day.

KEY WORDS

Champion
Class
Conversion
Data flow diagram (DFD)
Design
Encapsulation
Enhancements
Feasibility study
Inheritance
Maintenance
Object interaction diagrams
Object-oriented analysis
Object-oriented design
Object structure diagrams
Objects
Operations
Polymorphism
Preliminary survey
Prototype
Structured design
Systems analysis
Systems life cycle

Testing
Top-down design
Training
Transactions sequence diagrams

RECOMMENDED READING

Boehm; B.; A. Egyed; J. Kwan; D. Port; A. Shah; and R. Madachy. "Using the WinWin Spiral Model: A Case Study," *Computer*. July 1998, pp. 33–44.

De Marco, T. *Structured Analysis and System Specification*. Englewood Cliffs, NJ: Prentice-Hall, 1979. (An excellent book on structured design.)

Rumbaugh, J.; M. Blaha; W. Premerlani; F. Eddy; and W. Lorensen. *Object-Oriented Modeling and Design*. Englewood Cliffs, NJ: Prentice-Hall, 1991. (A detailed introduction to object-oriented design.)

Schneiderman, B., *Designing the User Interface,* 3rd ed. Reading MA: Addison Wesley, 1998. (The classic book on interfaces.)

Yourdon, E.; K. Whitehead; J. Thomann; K. Oppel; and P. Nevermann, *Mainstream Objects: An Analysis and Design Approach for Business*. Upper Saddle River, NJ: Prentice-Hall, 1995. (A book developed by Software A.G., a major database and language vendor, on how to develop object-oriented systems.)

DISCUSSION QUESTIONS

1. What are the advantages of user-oriented design?
2. What are the disadvantages for the IS staff and users of user-oriented design?
3. Would you expect user-oriented design to be more or less costly than conventional approaches?
4. What is the role of top management in building systems?
5. What type of planning for applications should be undertaken by the IS department?
6. Does a long-range IS department plan make any sense when technology is rapidly changing?
7. How should new systems development projects be charged in the organization? Should overhead, the IS department, or user department budgets absorb the cost?
8. Why have so many existing systems concentrated on information flows and transactions processing rather than decisions? What kinds of applications exist today that go beyond transactions flows?
9. What are the pros and cons of central systems development versus applications development at each company location?
10. What does a user need to know to contribute to the design of a multiuser system?
11. Develop a questionnaire for obtaining data from potential users of a system on their attitudes, expectations, and thoughts for the goals of a new system.
12. The design of information systems is best accomplished by a team. What possible conflicts might this create for other employees? How should the team structure be presented to reduce these problems?
13. If users design systems, will changes still be necessary after conversion when the system is in operation? Should as many changes be needed as under conventional design? Why or why not?
14. How can users be sufficiently involved in systems analysis and design in a large organization when there are many potential users who should be included?

15. Can top managers participate in systems analysis and design if they will also be users?
16. How can management best contribute to systems development?
17. How should the IS department's budget be divided between new applications and enhancements to existing systems?
18. Are there decisions in the operation of existing systems that users should influence?
19. What is the purpose of structured design methodologies?
20. To what extent can personnel resources be reallocated within the IS department to provide more flexibility in meeting demands for service?
21. What are the major characteristics of object-oriented design?
22. Why do many IS staff members resist making changes requested in operational systems?
23. When on a cost-cutting drive, management will sometimes dictate an across-the-board budget reduction of some number, say 10 percent. Does this approach make sense for the IS department? What alternatives are available?
24. What is the most likely reason a proposed system will be infeasible?
25. How do changes in technology, especially advances in hardware, affect the feasibility of new applications of technology?
26. Where are the largest bottlenecks in the systems life cycle? That is, where are the most problems and delays probably encountered in developing a system?
27. Compare and contrast structured and object-oriented approaches to design.
28. Is there one design approach that is best in all situations?
29. What design approach would you choose for a system to process incoming orders for a manufacturing firm?
30. What design approach would you recommend for an interactive decision support system to be used by the treasurer of a firm to manage cash deposits?
31. What are the differences in design for a multiuser system versus a personal system on a PC?

CHAPTER 15 PROJECTS

A Group Design Project

Please note that this assignment is to be completed in a group; it is very hard to do systems analysis and design alone, particularly if it is the first time you have worked on such a project. An important part of this exercise is learning to work with people on a design team who will have different ideas than yours.

In order to make the assignment a little bit more fun and to create some diversity, your first task is to choose your company and products. The firm you are "designing" manufactures and distributes a product (of your choosing). The company has its headquarters at its one manufacturing plant in Hoboken, NJ. There are three warehouses that handle regional distribution throughout the East Coast. (There is some business from other locations, but the firm's major market extends west from Boston to Cleveland and south to Washington, D.C.)

Your company obtains sales from three sources:

1. Fifteen sales representatives who call on customers: 45 percent of the orders come from this source.

2. Three 800 toll-free numbers that customers call directly to place an order: 40 percent of the orders come to the phone desk.
3. Mail: 15 percent of orders come by mail.

There are a number of problems with the way orders are now processed in your firm. First, there are no computers and there is no automation. All orders must be written on a standard order form for processing. Sales representatives mail most orders to headquarters and call in urgent orders.

Communications with the warehouses are disorganized. Two or three times a day copies of orders are faxed to the warehouses for picking. The order department phones in emergency orders. Because of all the problems in order processing, about 25 percent of the day's orders are urgent enough to be phoned to the warehouse. As a result, the warehouse staff picking orders is not scheduled efficiently.

Second, as the executive vice president said, "We are drowning in paper. Our current system was fine when we were a small company, but our volume has grown 50 percent a year for the last three years. I suspect we are losing orders; I know that our delivery time is terrible. Some customers have told us they are going to our competitors because, while our product is superior, we can't get it to them."

Third, your firm does not have the ability to learn anything from its orders. Because they are all on paper and it takes so much effort just to get the goods out, no one can look at the information the orders contain. You don't know what percentage of sales each source of orders represents; management wonders if it pays to have a direct sales force, but can't get the data to decide. All forecasting for production is done by looking at what was manufactured the previous year; there is no updating from current orders.

Your assignment is to design a new system for order processing for your company. The president feels it is important to accept all types of orders, including those by phone, fax, mail, and from the Internet. Your report should contain the logical design for a new system. Please design an order entry screen for telephone orders and a Web page(s) for direct order entry via the Internet.

You are not required to recommend hardware, but you should give some thought to hardware and software architecture. For example, are you designing a system for an airline reservations system mainframe computer or for a pocket Sharp Wizard?

Defining a System for Simon Marshall

In a previous chapter you were asked to develop a simple portfolio system for Simon Marshall Associates. The system you developed was based on a personal computer and used a database management package. Because the problem was relatively well specified, there really was no systems design.

Now, take the problem you completed and think about turning it into a working system for Simon Marshall. First, identify the objectives of a system and its potential users. Then, think about features that might be necessary for different individuals who might work with the system. Is there a need for more data than in the original problem? What kind of output will users want to have, both on the screen and in printed form?

CHAPTER 16

Building Systems: Further Developments

Outline

Focus on Change

We often seem to forget that the purpose of designing a system is to change something, the flow of information, the processing of transactions, the way people do their jobs in the organization, and so on. One of the reasons changes are so difficult is that we are dealing with abstract concepts and often invisible procedures. It is also often the case that applications with the greatest chance of transforming the firm are the most risky and the least likely to demonstrate a clear cost savings in advance. The manager has to decide whether to undertake these risky, potentially high-payoff applications.

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In this chapter, we examine the early stages of the systems life cycle, the place where users have the most to contribute. The two appendices to this chapter contain examples of structural and object-oriented design. To some extent, the old saying, "You can pay now or you can pay later," applies here. Organizations that spend time in the beginning of a development process carefully defining their requirements for the system have a much better chance of success than organizations that begin to write programs with an inadequate definition of what the system is to do. The analogy of constructing a building applies. It is very easy to move walls and other components of a building when looking at the architect's drawings. Once the building has been constructed, moving walls gets to be expensive, and you may not even have the option of making a change because of the way the building was constructed.

We begin the development process with a preliminary survey and the feasibility study. The output from these two studies is used to determine whether to proceed with the design of an information system and to select a single processing alternative if the system is approved. If a system is feasible, the analysis and design stages are undertaken, and the design team prepares detailed specifications.

SYSTEMS ANALYSIS

Analysis is the study of a problem, generally done before undertaking some action to solve the problem. In the case of systems analysis, the first task is understanding and describing existing information processing procedures in the area of the proposed new system. Many of the techniques recommended in the previous chapter can be used to document our understanding of the present processing system, such as data flow diagrams.

In many instances it will be hard to identify any organized set of procedures that represent the existing information processing system. We need to enumerate

TABLE 16-1

ANALYZING THE EXISTING SYSTEM

Decisions	
	Decision maker
	Input
	Output
	Frequency of decision
	Level of costs
Information	
	Flow
	Characteristics
	Form
	Source
	Retention
Transactions and processing	
	Operations
	By whom performed
	Peak load
	Average load
Individuals/functions	
Communications/coordination	
	Communication among units, individuals

problems and determine what motivated the suggestion that technology might help in processing information. Whether there is a well-defined system or not, we should develop the specific information listed in Table 16-1. First, we should identify decisions that have to be made and the responsible decision maker. What are the inputs and outputs, what is the frequency of the decision, and what are the costs involved?

Next, we should identify crucial information flows, including the source, frequency, and volume of information. Information can be characterized according to the decision-making framework discussed in Chapter 3. For example, we can look at the form in which data are gathered and processed, either written or verbal. If documents are involved, how many are there and what is their information content? What types of decisions are supported?

We also need to identify how information is processed as it flows through a system. Who processes the information? What are the peak and average loads? A study should identify the critical communications between organizational subunits and individuals. We need to understand what role the system plays in coordinating work flows and other activities. Finally, we should estimate the current cost of information processing.

As described in the last chapter, while structured design and object-oriented analysis are different, the kind of information above is needed regardless of which approach one takes to design, structural or object-oriented.

High-Tech Airport Woes

Probably the most perilous systems development undertaking is a high-profile application which serves the public. An airport, especially a new, expensive, and "high-tech" airport, is a good place to get into trouble. Hong Kong offers a $20 billion airport that fits this profile well. When Chek Lap Kok Airport opened, someone entered erroneous information into its main database. The corrupt data created monumental confusion that one newspaper described as "almost comic," of course, unless you were there. Flights took off without luggage, officials resorted to tracking flights using pieces of plastic on a magnet board, and airport personnel called each other on cellular phones to find out where passengers could find their planes.

Hong Kong's systems cost over $70 million U.S. and featured an array of different contractors. Seimens of Germany, VanDerLande of Holland, and Swire Engineering from Hong Kong built a baggage system to handle 20,000 bags an hour. Honeywell developed a sophisticated building management system that can assign jets to gates based on how cheaply an area can be heated or cooled. All these systems link to an Oracle database that coordinates changes among systems. EDS built the airport display system.

Someone entered incorrect data, and the display system did what it was designed to do: It broadcast the information as quickly as possible to all locations. With wrong gate or arrival time information, the airlines could not tell where to send cleaning crews, fuel trucks, baggage handlers, or passengers! There were tests of the system, one of which involved 10,000 people, but still not every employee had a chance to use the system before opening day.

It is not just the public that depends on airport systems; Hong Kong Air Cargo Terminals, Ltd. is a freight forwarder linked to the airlines. A bug in the airport system caused computers to erase inventory records. Adding to lost data were problems with computer-controlled equipment at the airport. The result was to put the company out of business for several days, reducing the supply of fresh meat and produce in Hong Kong.

If Hong Kong's airport was not enough, the new airport in Kuala Lumpur, Malaysia, suffered almost the same fate. In Kuala Lumpur, 20 different contractors built systems for 20 different airport operations ranging from baggage handling to flight information. All the systems plug into 434 miles of fiber-optic cable. The system was designed so that there is manual backup if any component fails. Unfortunately, on opening day for the airport, check-in agents typed wrong commands and then panicked when they were unable to generate boarding passes. They pressed a profusion of keys, overloading the system. The end results: Agents wrote boarding passes by hand, and flights were delayed up to 2 hours. Here, stranded cargo sitting in tropical heat soon turned to rotting refuse.

One can plan carefully and test extensively, but very large systems serving the public can expect to encounter problems. The challenge is to minimize them, provide backup, and always be able to keep functioning until someone can resolve the problem.

SURVEY AND FEASIBILITY STUDY

In this section, we present recommendations for the contents of the preliminary survey and feasibility study. Basically, each of these documents consists of two parts: the present system and an alternative. A feasibility study presents several potential alternatives and evaluates them on technical, economic, and operational criteria. We must estimate technical and operational feasibility and compare costs with benefits.

Costs and Benefits of New Systems

Management usually insists on a cost/benefit justification for a system. You will generally find that the categories for benefits differ considerably, depending on the type of system planned. For example, it is likely that strategic systems will have more uncertain benefits and will be justified by improvements in customer service, new sources of revenues, and so on. The estimates of costs and benefits for transactions processing systems are usually more certain and detailed. The firm might expect to reduce inventory balances by 25 percent, which results in a quantifiable savings in investment and handling.

The tangible and concrete benefits for some systems, particularly strategic applications, are likely not to exceed their costs. Management may decide to develop the system anyway and the cost/benefit analysis helps assess the risks involved.

In examining costs versus benefits, there are a large number of factors to consider. System costs include the following:

Development

- Systems analyst time
- Programmer time
- User time
- Possible hardware purchase costs
- Possible software purchase costs
- Possible outside services costs (e.g., system integrators and consultants)

Operations

- Computer costs
- Communications costs
- Operating staff costs
- Incremental user costs
- Maintenance costs

Development costs are the actual cost of analysis, design, and installation for the system. These costs are highly sensitive to the amount of time necessary to develop the system and are directly proportional to the number of analysts, programmers, and users, and the length of their involvement. Historically, professional estimates of the time required to design and install a system have been far too low.

When assessing total costs, we should not forget the expenses of operating a new system. A new system may require the use of part of the time available on an existing computer, an upgrade on the present system, or a new computer or network. Incremental staff in the IS department and users may be required to operate the system. Finally, there are the costs of routine maintenance and modifications. No system is ever finished; "bugs" will need to be eliminated, and users will request periodic enhancements as they work with a system.

Traditionally, benefits are analyzed from the point of view of tangible cost savings from a system. Often these savings are measured by the reduction of workers currently employed or by an estimate of the number of future employees who must be hired without the system. (It should be noted that many times, savings projected in personnel prove illusory.) Tangible savings also come from more efficient processing. For example, an inventory control system may reduce inventory balances while maintaining service levels. The firm saves the interest charges on the money previously required to finance the inventory level needed before the computer system was introduced. Today's great interest in business reengineering or business process redesign, discussed in Chapter 18, involves management looking for significant paybacks such as an order-of-magnitude reduction in costs.

Tangible cost savings can be difficult to estimate in some cases. Emery (1974) has suggested looking at the value of perfect information as providing an upper bound on possible benefits. For example, in a forecasting application, what is the maximum benefit from having a perfect forecast of sales, that is, knowing in advance exact future sales? If the cost of developing the system exceeds the maximum benefit under perfect information, the application will undoubtedly be rejected immediately. If, however, the benefits appear higher than the costs, we can make various assumptions about the impact of less-than-perfect forecasts from the proposed system.

To refine the benefits estimates, a prototype of the forecasting system could be applied using a simple computerized version of the forecast. The model could process historical data to provide an estimate of the improvements the model would produce over the existing forecasting procedures.

Not only should we look at tangible cost savings, we must also consider intangibles and unquantifiable savings. This is particularly true as we move from transactions processing systems toward operational managerial control and strategic systems, where intangible benefits are more important. Some of the technologies that we discuss to support work groups in Chapter 21 are also hard to justify using the criteria of cost savings.

We believe that technology can be used to increase revenue as well as reduce costs. Systems that give the firm a strategic advantage, such as a greater market share, are difficult to justify in advance on the basis of cost. The following list of benefits may prove helpful in this analysis (you may also want to review the discussion of the value likely to come from different types of IT investments in Chapter 3):

- Ability to obtain information previously unavailable
- Receipt of information on a more timely basis
- Improvements in operations

- Ability to perform calculations not possible before (for example, the simulation of production schedules)
- Reduction in clerical activity
- Improvements in quality and accuracy
- Improvements in decision making
- Better communications and coordination in the firm
- Improvements in customer service
- Creation of ties with customers and suppliers
- Reductions in cycle time
- Contribution to corporate strategy
- Improvements in competitiveness
- Major redesign and improvements in business processes
- A dramatic restructuring or redesign of the entire organization using IT design variables

Chapter 3 discussed some of the ways technology can add value to the organization. The categories above represent specific benefits that organizations have actually obtained from their investments in building new applications.

Many organizations use subjective techniques to determine whether a project is desirable from a cost/benefit standpoint. They argue that with uncertain intangible benefits, one still has to decide whether a system appears justified. These decision makers use their subjective feelings of what a reasonable figure would be for the benefits provided by the system. Chapter 23 offers suggestions for how to decide on undertaking a new technology initiative.

Identifying Systems Alternatives

General One of the major activities during the survey or feasibility study is to sketch possible alternatives for a new information processing system. Given the wide range of technology available, it is difficult not to be able to provide some assistance for a problem. The issue is not so much whether a system is feasible as what alternative is desirable.

During a feasibility study, a design team should develop alternatives and criteria for evaluating the alternatives. For a particular situation, a user may take the least expensive and most rapidly implementable system. In another case, a user may opt for a very comprehensive system to be custom programmed. The important point is this: As a user, insist on seeing some alternatives!

Packages For many proposed systems, an applications package offers an alternative. Frequently, large amounts of money and time can be saved by using one of these packages, though there can be a number of drawbacks. An applications package is an over-the-counter program or system of programs purchased as an end product. The package vendor tries to make the product very general. Users supply the data parameters that apply to their situation, and the package does the processing. Since computer power is becoming cheaper per computation, it makes sense in many instances to acquire a package that may use computer

MANAGEMENT PROBLEM 16-1

John Crawford is the chief technology officer for Systems Solutions, a large consulting firm that specializes in developing and installing custom information systems for its clients. Systems Solutions uses a variety of technologies to complete its assignments. It has programmed in conventional languages like COBOL and has used the package PowerBuilder and the language Visual Basic for client-server applications. Crawford has read about object-oriented design and also about object-oriented programming. He is trying to decide whether to make a major commitment to these technologies. In its Web programming, the firm uses Java among other tools, and all of its code in Java is object-oriented. It has also used C++ for developing programs for Unix systems.

Object-oriented analysis should fit better with object-oriented programming than conventional structured design. However, Crawford wonders if it is really the way of the future. "One of the objectives here is to reuse software by creating objects that can be applied in more than one place. I have read reports about such generic frameworks being offered by some vendors, and they seem to help with about 40 percent of programming. I wonder if that is enough to completely change around our approach to design."

What advice would you give Crawford? Is there an easy way to learn more about object-oriented development?

hardware inefficiently in order to have an application functioning earlier. We discuss packages extensively in the next chapter.

Organizational Impact

You should attempt to estimate the effect of each alternative system on the organization. What departments and individuals will be affected by the system, and what jobs will it change? What will happen to any employees who are replaced by a system? Does the application create new links with customers and/or suppliers? Does technology make it possible to restructure the organization or some part of it? Is part of the intent of this application to support the IT organization design variables presented in Chapter 4 to move toward a new structure, for example, the T-Form organization?

Technological Feasibility

A proposed system may stretch the capabilities of modern technology, but may be the one that provides the firm with a great advantage. The design team needs to evaluate if a new system is technologically feasible. Burlington Northern railroad developed an extensive prototype of a train scheduling system in one region of the country to provide information on technological feasibility and to estimate costs and benefits if the system was installed across its entire service area. This systemwide decision involved a capital expenditure of more than $300 million. Prototyping and testing, however, are appropriate even when smaller investments are involved.

TABLE 16-2

OUTLINE OF PRELIMINARY SURVEY AND FEASIBILITY STUDY CONTENTS

Summary
- Goals
- Evaluation of each alternative

The existing system
- Problems
- Goals of new system
- Decision considerations
- Information flow
- Processing
- Communications

Each proposed alternative
- Overview—percentage of goals achieved and benefits
- Decisions
- Information flows
- Technical (database and processing logic)
- Development effort, schedule, and cost
- Operational aspects
- Impact on the organization
- Total costs and benefits

Contents and Format for a Study

The contents of one possible format for a survey or feasibility study are outlined in Table 16-2. The summary presents a brief overview of the reasons for the study and ranks each processing alternative, including the present system, on the criteria established by a steering committee. This summary is the primary input for decision making. Existing systems should be described according to the analysis above. Finally, the report presents each alternative in detail. Here it is helpful to include a scenario, that is, a reasonable projection of how the system will actually be used, including by management, users, and IS department activities, under each alternative.

DETERMINING FEASIBILITY

At one time, the information services department usually decided what applications to undertake. As demands for service increased, problems began to develop because some user requests had to be denied. As more systems of importance to the organization developed, many IS departments felt they were placed in a difficult situation if forced to choose among competing applications. The IS department is not in a position to decide whether a system is feasible or which processing alternative should be chosen if a system is to be developed.

Selection Committee

One answer to the problem of choosing information systems is to convene a selection committee of users, other managers, and IS department personnel. When

TABLE 16-3

SOME POTENTIAL CRITERIA FOR EVALUATING ALTERNATIVES IN PROJECT SELECTION

Contributions to strategy
Tangible and intangible benefits
User satisfaction
Percentage of needs met
Maximum potential of application
Costs of development
Costs of operations
Timing of costs
Timing of benefits
Impact on existing operations
Development time
Time to implement
Resources required
Probability of success
Probability of meeting estimates

representatives of various functional areas are included, each department is able to see why certain decisions are made. The selection of applications alternatives seems less arbitrary under these conditions. With management guidance, the committee can select applications and processing alternatives consistent with functions currently emphasized in the organization.

SELECTING AN ALTERNATIVE

In this section, we assume that management has decided to undertake the development of a technology initiative and that the task now is to choose an alternative for implementation. The organization is committed to investing in this project; the task is to decide how to develop the application, for example, through custom programming, a package or outsourcing.

For the purposes of discussion, we also assume that a **selection committee** exists to choose an alternative for implementation. The first task of the selection committee is to agree with the information services department on the number of alternatives for a single project and how the alternatives should be developed. As an example, suppose one user department has proposed an inventory control system. The alternatives might include (1) doing nothing, (2) purchasing a packaged program from a vendor, and (3) building a custom system. Each of these alternatives for an inventory control system meets some percentage of user needs at different costs. Probably three to five alternatives for each proposed application are sufficient. However, there should always be more than one alternative for a new system. Selecting the first alternative (doing nothing) is equivalent to deciding that a new system is infeasible.

The next step is for the committee to agree on a set of criteria to be used by the information services department in evaluating each alternative. Table 16-3 contains examples of possible criteria, although the set of criteria will be unique for each organization. The set of criteria should be as complete as possible so that no important evaluation factors will be overlooked. However, the selection committee should avoid enumerating too many criteria, or the data collection and processing requirements for evaluation will become a burden. Each criterion should be measured on a common scale of, say, 1 to 7.

Once the criteria are determined, it is necessary to develop **weights** that indicate the relative importance of each criterion in arriving at the applications selection decision. It is unlikely that all committee members will regard each criterion as equally important. Some method will have to be used to weight the criteria for different individuals. Approaches to this process range from simple rank-ordering schemes to partial and paired comparisons. The weights are of paramount importance to applications selection because they reflect the priorities of the selection committee. The committee, of course, cannot expect conditions to remain constant. Shifts in management policies and users' needs necessitate revisions to weights over time.

If the recommendations above are followed, the selection committee should be in a position to review a series of alternatives for the application. Each alternative should be evaluated on the criteria established by the committee. Consider the example in Table 16-4. In this hypothetical decision problem, the **selection committee** is considering either an applications package or a custom-developed inventory system.

The first column in the table lists the criteria agreed on by the committee and the information services department. The second column contains the weights assigned to each criterion by the committee. The remainder of the table contains the scores for each alternative as evaluated by the IS department.

There are several ways to arrive at a decision given this information. One approach is to work toward a consensus among committee members. In this example, the applications package would probably emerge as the preferred choice because of its high ratings on the important criteria of percentage of user needs met, development cost, and probability of success.

As conditions change, the committee can modify the weights to reflect new priorities. Also, criteria can be dropped and/or added to reflect new circumstances.

TABLE 16-4

APPLICATIONS SELECTION EXAMPLE

Criterion	Weight	Package	Custom-developed system
Percentage of user needs met	0.35	75%	90%
Cost of development	0.20	$42,000	$90,000
Cost of operations	0.10	$10,000	$ 7,000
Staff to develop	0.15	1	3
Probability of success	0.20	0.95	0.75

The major advantage of the recommended approach is that it forces an objective evaluation of several alternatives for each proposed application and provides a consistent but flexible framework for making decisions on applications.

UNDERTAKING SYSTEMS ANALYSIS

If a system is feasible and one alternative is chosen for development, the next stage is a detailed systems analysis. There are few guidelines on the depth of analysis required when the design team examines present information processing procedures. All aspects of the present processing method must be understood and documented, and the analysis should identify key decisions as well as flows of data.

The design team must decide where to place the "boundary" on its studies. An expansive boundary may be appropriate, but a design team is well advised to take steps slowly in order to outline a manageable task. It is too easy to expand a simple processing problem into a huge system. What initially looks like an order-entry process turns into an accounts-receivable and production-control system, because eager designers expand the boundaries of the problem into other areas.

The designers should document their understanding of present procedures with reports and memos. Data flow diagrams or object-oriented documentation should be constructed and reviewed with users who are not on the design team. When satisfied with its understanding of the present processing procedures, the design team should hold a "walk-through" with all users involved as a final check on the analysis.

UNDERTAKING SYSTEMS DESIGN

The most creative part of the systems life cycle is the design of new alternatives for processing. Although these ideas were sketched in the preliminary survey or feasibility study, the design team has to develop them in far more detail now. For example, in the previous section we chose a packaged program for inventory control (see Table 16-4). Suppose instead that we selected the custom-developed system for development. The information in the feasibility study is general. The details of that system must be designed before programming can begin. What equipment is required? What are the screen formats, the database design, and the kind of queries and transactions to be processed?

Results of the Design Process

The results of this study should be complete specifications for the new system. An example of rough specifications can be found in Appendix A to this chapter. In structured design we usually begin by specifying the desired output. How does the user interact with the system? Then it is necessary to determine what input is required to produce this desired output. A comparison of input and output identifies the data that must be maintained in the database. Next, we consider processing. How are the input data transformed and used to modify the database? How often

MANAGEMENT PROBLEM 16-2

The top management of Eastern Bank and Trust has an "executive office of the president." The highest four officers of the bank, including the chairman of the board, the president, and two executive vice presidents, meet together to make all major decisions. This committee approves the budget for the information services department and also decides on new applications.

Because of pressing business, decisions related to information systems are often postponed from one meeting until the next. The budget director for the IS department indicated that he waited in the reception area for four meetings before his budget presentation was reached on the agenda.

The budget director's major objective is to have the IS department's budget approved with as few questions as possible. The budget includes the funding for major systems development projects for the coming year. Therefore, approving the budget also involves selecting the major new applications.

The members of the management committee are very dissatisfied with the current approach to selecting information systems projects. They admit that no project has ever reached the feasibility study stage and been rejected. The managers indicate that they are not really making decisions but are just ratifying the proposals of the IS department.

How can the bank solve this problem and develop a more effective project selection procedure? Why is this management committee not working well for decisions about information systems?

do data have to be updated? How are the input and the contents of the database processed to produce the desired output? Also, at this point the design team should specify manual procedures for other activities associated with the system.

For object-oriented design, the process will be different; it follows the description and generates the design documents shown in the last chapter. In particular, the design team needs to identify familiar business objects associated with the application. Examples of a business object are a customer, a supplier, an invoice, a product, or a service. You need to identify classes into which you can group the objects along with attributes that describe them. The actual processing of information takes place through message passing so it is necessary to delineate the key messages that travel between objects. Transactions sequence diagrams or "use case" scenarios help describe the new system.

GENERAL DESIGN CONSIDERATIONS

Today's design environment is complex. While we would like the design to be independent of the underlying technology, that is really not possible. If you are designing a new application for a **client-server platform,** the options available will be different than if you are developing a system that must include legacy applications on a mainframe.

Client-Server Design

The dominant architecture today is client-server. Design for this platform is complex because there are so many components involved, including clients, servers, networks, user interfaces, and usually a database management system on the server. Object-oriented design approaches are popular in the client-server environment. The professional designer views this environment as consisting of four layers: the application, the server, the client, and the network.

The application is what interests you as a user. The application uses the client's user interface to present information and the database on the server to extract and update information. Typically, about 75 percent of the program code will end up on the client for running the user interface. The professional designer is also concerned with sizing the server. How much capacity will be needed to provide service to all the clients that might simultaneously make requests of the server?

Because so much of the processing takes place on the client, and the client generally sits on a user's desktop, client-server development is well-suited to extensive user input in the design process. The user wants to select what appears on the client's screen to initiate data queries and display. Generally the client will run a windowed, graphical user interface (GUI) like Windows 98, and the application should look consistent with this overall interface.

As an example, consider the client-server platform developed by a major investment bank for its brokers. This network features Sun Workstations and servers, all running Unix. The client part of the system provides the user with a number of windows that contain real-time data from the stock and bond markets. The user can also display a client's portfolio in a window, and the sales assistant can access another window that runs the legacy mainframe systems that are necessary to update client information. There are multiple servers for this client—the Sun servers for market data and information, and the mainframe systems that act as servers for transactions processing information—which are important for the broker and sales assistant.

Graphical User Interfaces

The graphical user interface, as found in all windowing systems, has become the interface of choice for users. Virtually any system designed for modern hardware and software will feature a GUI. Designers are faced with a number of challenges in developing this kind of interface.

1. The interface must be simple and it must be easy to learn and remember for the infrequent user. The user should not have to go through a lengthy relearning process.
2. The interface should be fast and efficient for the frequent user and should not create awkward transitions or the need to move frequently from keyboard entry to the pointing device.

There are a number of guidelines for developing this kind of interface:

- Try to make the screen look like a familiar physical object; for example, a calculator should look like a physical calculator. When the user clicks on a button, the result should mimic pressing the key of a real calculator.
- Try to make the interface consistent across all applications. It also helps to make the interface consistent with the windowing operating system interface and with popular applications that the user already knows how to use.
- Remember that the user is in charge of the windows and the interface should feel natural to the user.
- The mouse (or **pointing device**) is the primary mode for input, not the keyboard. The user will manipulate objects on the screen directly by clicking on them.
- Use modal tools, that is, tools the user can click on to change subsequent mouse actions. An example would be a drawing program where the user clicks on a line tool to draw a line or a circle tool to draw a circle with the mouse.
- The interface should be intuitive enough that, with the assistance of on-line help, the user does not have to revert to paper documentation about the application (most users will not open the documentation anyway).

The major objective of the designer is to create an interface that feels natural and intuitive to the user, a difficult task. Firms like Microsoft have usability laboratories where subjects unfamiliar with software are observed trying to use it so designers can learn what is intuitive. The same approach makes sense for developing custom applications. Create a prototype, and let users work with it before choosing a final design.

Designing Web Sites

The rapid adoption of the Internet has led to a new industry for Web site design. Companies develop this capability in house or contract Web site design to any number of companies offering design and hosting services. (A Web site host runs a Web site for a client on its own host computer.) Developing a Web site is like any other design task: It is a human, creative endeavor. In Chapter 12 we saw examples of a number of Web designs. Which one do you think was best? What features made it more appealing than the others?

There is no science of Web site design, but various experts offer guidelines. One place to look for ideas on designing Web sites is the Web itself. As of this writing, a helpful guide could be found at Yale's Center for Advanced Instructional Media (http://info.med.yale.edu/caim/manual/contents.html).

Web sites are graphic, so the suggestions above apply for good graphical user interfaces. A major characteristic of Web sites is the vast amount of content they may contain. Companies like IBM have thousands of pages of material on the Web; navigating and finding what you are looking for becomes a challenge and a major consideration in design. The Yale site describes four models for organizing information on a Web site for easy access, shown in Figure 16-1. The simplest scheme is sequential: one page leads to the next. This treatment might be appro-

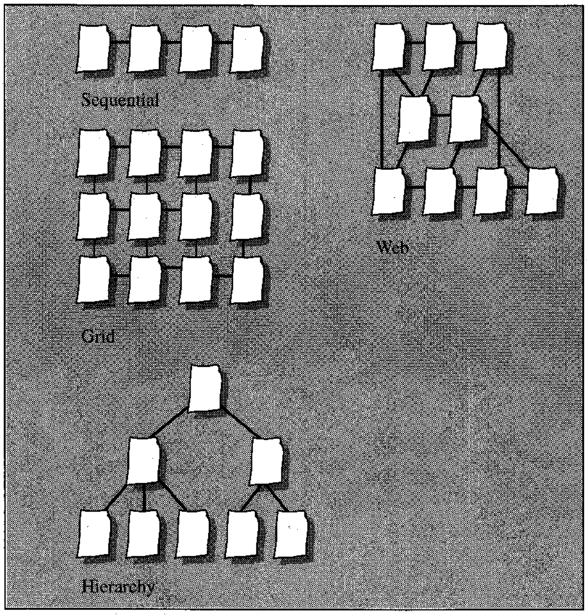


FIGURE 16-1
Web site organization.

priate for a chronological presentation or a series of topics in which each page goes into further detail. A grid is appropriate when one wants to correlate two variables, such as a time line versus a series of standard categories. The pages in a grid should have a uniform structure of topics and subtopics, generally with no hierarchy of importance. One might organize medical records into a grid.

Hierarchies are a popular way of organizing information; users are familiar with this representation and find it easy to navigate among the pages. A hierarchy models many different kinds of information, from the points on an outline to a family tree of products. The most free-form organization is a web in which one can reach a number of different pages from any location. Webs are good for small amounts of data and for experienced users. Large webs can be difficult to navigate and can easily confuse the user.

There are many different guidelines for site design beyond the basic organizational structures suggested above. Most of the recommendations are based on a particular individual's tastes in design, often with feedback from user reactions to sites. Some of these recommendations from IBM (http://www.ibm.com/ibm/hci/guidelines/design/affinity.html) are:

- Keep the site simple; do not confuse the user, but make it easy for him or her to find each function.
- Give users a lot of control over the interface; do not expect them to follow a given series of steps.

- Try to provide a familiar interface; take advantage of what the user already knows about the subject to design pages that match his or her experience.
- Make objects and their controls obvious; try to use symbols and icons that the user will have no difficulty understanding. A good example is the trash can icon for deleting material.
- Make actions reversible; be sure that there is always a way to go back or undo an action so that users will be encouraged to explore the site.
- Make all actions accessible all the time; the user should not be prohibited from using a function just because he or she has chosen another one.
- Keep users out of trouble; the responsibility for protecting the user lies with the designer.
- Where feasible, allow users to customize the interface to make it more convenient for them to use.

There are many more guidelines like this. Given the large number of Web sites on the Internet, one viable design strategy is to find several sites that appeal to you and your users, and adopt them as a model for the design of a new site.

The Input Bottleneck

In the past few years, the trend in information systems has moved toward collecting data as close to its source and as automatically as possible. The objective of this philosophy is to eliminate data transcription wherever feasible, thus avoiding errors and reducing the time required to enter the data into the computer. The ultimate in automatic data collection, of course, is sensors attached to the input of a real-time system, such as the computer monitoring of a hospital patient. In most commercial computer systems, a popular **source-data collection** technique is to use a terminal and/or scanning technology. EDI also reduces the amount of input required for many business transactions. The Internet can often be used to get customers to key information into your systems rather than having your own employees undertake this task.

Bar coding is extremely popular. Parts in production, finished goods, pieces of merchandise, videotapes, and library books can all be tracked by using bar codes and their readers. There are also a number of firms that use hand-held terminals or PCs. United Parcel Service drivers use an electronic clipboard to record shipment data. Federal Express drivers use a hand-held device to read bar codes on packages, then upload this information to computers that track shipments. A number of pen-top personal computers are available, and we expect to see more direct entry by marking forms and printing information.

Image processing involves scanning a document and either storing it on a magnetic disk or "burning" an image of it on an optical disk. This type of input and storage is well suited to documents that do not change. A large brokerage firm images stock certificates that customers send in for transfer to another name or other processing, as described in detail in Chapter 18. The firm must keep a record of these certificates and should handle them as little as possible. By imaging the certificate and its accompanying documentation, various departments in the firm can

MAGEMENT PROBLEM 16-3

John Washington is the manager of sales for Farway Manufacturing Company, a firm specializing in the manufacture of lawn and garden supplies. The firm's products are sold in hardware stores and nurseries throughout the world by a large field force of sales representatives.

Currently, Farway is involved in the design of a new order-entry and sales information system, and John is the user in charge of the project. The design team is in the process of choosing a method for data input and is divided over which alternative would be most desirable.

One group in the firm favors the use of a personal digital assistant (PDA) or notebook computer. Each sales representative would use a radio or cellular modem to communicate orders directly back to the factory. The representatives would have to key in orders instead of checking off the items ordered on a form.

A second group that is uneasy about the technology has proposed continuing with the same familiar order form. All changes would take place at the factory and would not be noticed by the sales force. When the orders arrive at the factory, operators would group them into batches of 50 and enter them on-line to the computer. This alternative features the advantage of batch error control combined with immediate feedback as the data are entered.

John is trying to determine what criteria to use in deciding between these alternatives for input. Which alternative sounds best to you? How should John resolve this deadlock in the design team?

retrieve all the necessary information about the certificate and the transaction from a terminal while the certificate remains safe in the vault. The image is represented as a series of dots (called pixels) and is not stored as characters as you would find in a word processing program. If you want a computer to process the data on an image, you must convert the thousands of pixels that represent each character to a standard character code like ASCII.

Handling Errors

A well-designed system handles errors; that is, it corrects the errors or notifies someone of them and continues producing valid output. It is not unusual to find more than half the instructions in a program devoted to error detection and handling. Users on the design team should be aware of input-error possibilities and should design procedures to minimize their occurrence and any adverse effect on the organization.

As an example, consider an order-entry application in which the sales force sends a completed order form to the factory. In the factory, clerks place a day's receipts of orders in a batch and add the number of pieces ordered to provide a total. Then an operator at a workstation enters the information from each order. First, the operator types in the customer number and the computer retrieves and displays the customer's name and address; the operator checks the computer-retrieved data against the order. If there is an error, the operator corrects the account number and continues. Each item on the order is keyed in, and the computer checks to see if the item numbers are legitimate. For example, is style 3245 made in blue? Various totals are computed on the order as a further check. For example, all the items entered from the CRT can be added and the total compared with the total manually computed on the order. A listing of the day's orders with a batch total should correspond to the manual batch total computed for the orders before they are entered into the system.

If the company gave notebook computers to the sales force to prepare their orders and then transmit them electronically, you would still need to perform error checks. Designers would create an editing program on the notebook computer to catch some errors at input and would look for others when accepting the electronic orders in the order entry system. What errors would you try to catch at each stage?

Backup

In addition to error controls during processing, we must consider the availability of backups. An **audit trail** is necessary; that is, there must be some way to trace transactions through a system from input to output. In an on-line system, one reason for keeping a file of transactions is to make sure there is an audit trail.

In **fault tolerance,** the critical features of a computer are duplicated, both in hardware and software, so the failure of any part does not cause the computer to fail. Tandem (now a part of Compaq) and Stratus both make fault-tolerant computers. These machines have found a market for high-volume transactions processing applications such as those at the major stock exchanges.

COMPUTER-AIDED SOFTWARE ENGINEERING

You may have drawn the conclusion after reading this far that systems analysis and design is a very labor-intensive process. The people who bring automation to the organization have almost no automation to help in their work. **Computer-aided software engineering (CASE)** is an attempt to automate as much of the design process as possible (see Figure 16-2).

There are two areas where CASE has been applied, sometimes called "upper" and "lower" CASE. Upper CASE applies to the early stages of the design process, tasks like undertaking systems analysis and drawing data flow diagrams (DFDs). Lower CASE focuses on the later stages in the design cycle, such as automatically turning system specifications into working computer programs. The basic idea is that the power of PC-based workstations can be used to facilitate systems analysis and design. Today few examples of CASE tools are fully integrated, which means they offer all the features imaginable in such a tool and cover both upper and lower ends of the design cycle.

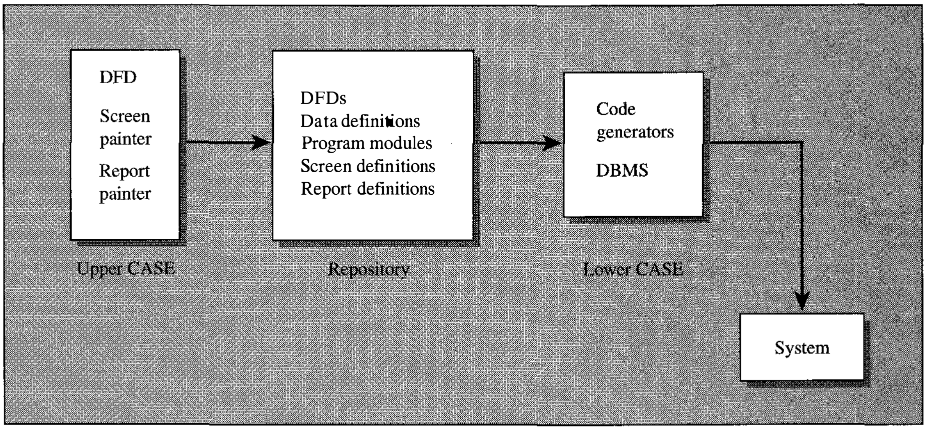


FIGURE 16-2
A CASE approach.

Upper CASE

There are a number of tools found in different CASE products to help in the early stages of analysis and design, including the following:

Diagramming tools. These tools, which help build DFDs, are the most frequent components of CASE products. Structured design has a variety of rules about how DFDs are to be constructed, and some of these products strictly enforce the rules.

Screen and report generators. These products can be used to quickly prototype a report by entering columns or fields on a screen. They are similar to the report-generating features of some PC database management systems (DBMSs). Sometimes they provide the ability to generate computer code to produce the report or input screen.

Repository. This is a huge database for storing everything about a system, including database design, DFDs, and more.

Lower CASE

Lower CASE analysis and design tools include:

Code generators. These are programs that produce other programs based on specifications created earlier in the design process.

Code restructurers. There is much poor code in existence. These products take, for example, COBOL programs and convert them to structured programs to facilitate maintenance.

More recently, CASE tools facilitate object-oriented analysis and design. Sometimes these features are added to an existing CASE system that is already based on structured design concepts. Since object-oriented design is often associated with client-server technology, some of the tools generate code for client-server platforms. For example, one product generates PowerBuilder code, a client-server development language from Sybase.

We have seen the tremendous amount of manual labor involved in designing technology-based information systems. What will CASE do to design? Will it eliminate the designer? It is unlikely that designers will become obsolete. CASE tools aid the designer just as PC spreadsheet packages aided a large number of individuals who perform calculations on paper spreadsheets.

CASE tools should make it easier to develop examples of screens and reports, and show them to users; feedback during development can come more quickly. To the extent that CASE tools reduce programming time and facilitate changes to a system, they should reduce the total time required for the systems life cycle. The task of developing programs in the future may require less skill. In fact, it is very likely that for a large number of systems, the analyst will be able to generate program code using a CASE tool, bypassing the programmer altogether.

The crucial bottleneck in developing new applications is systems analysis and design. Tools like CASE that support the designer will help to make building systems more productive. It is the lack of productivity, the lengthy time required to develop systems, and the budget overruns that make many users and managers dissatisfied with information services. Designers need to experiment with and adopt whatever tools help solve these problems. It is unlikely that you will use a CASE tool, but you may be involved in acquiring and implementing such a tool in your firm.

Is Rapid Application Development a Solution?

CASE is aimed at improving the systems development process; it has not been the panacea its developers originally promised. James Martin, however, has incorporated CASE into an approach he calls, "rapid application development," or RAD. The basic idea is to use powerful software tools and CASE to respond rapidly to users with prototype applications. The approach requires heavy involvement of those who will use the system, often through a series of joint application design (JAD) workshops. Users and executives explain their needs to designers who use CASE and other tools to respond rapidly with a prototype solution. The user must respond in turn with feedback and modifications. The tools involved can include fourth generation languages, code generators, expert system shells, and of course, a CASE system to integrate all of the tools into one environment for the developers.

There have been improvements in developing new systems over the years. However, no one has found a way to get the kind of productivity seen in the manufacture of electronic devices. Developing an application still involves considerable human labor, whether it involves a custom system, a package, an Intranet, or a desktop application. Techniques like rapid application development can help, but they have not resulted in orders of magnitude improvements in design as yet.

WHAT IS CONVERSION EFFECTIVENESS?

Conversion effectiveness (Weill 1990) is defined as "the organization's success in converting IT into useful outputs." In his original study, Weill measured four components of conversion effectiveness, including top management commitment, experience with IT, user satisfaction, and turbulence of the firm's political environment. While these items undoubtedly influence the conversion of the IT investment into a successful project, there are many more factors that influence success. My list includes the following, and you can probably add others:

- Size and scope of the project
- Amount of unknown technology involved
- Project management
- Support and encouragement of managers, and their sponsorship
- The urgency of the problem/opportunity addressed by the technology
- Norms in the organization
- User commitment and involvement
- Technical development environment
- Quality of the IT staff
- Strength of the project team
- Level of expertise of participants
- Type of technology employed
- Type of application
- Amount of custom code written
- Nature of packaged software included
- Use of external consultants
- Degree of understanding between users and developers
- Presence of a project champion
- Senior management involvement
- Amount of organizational change required
- Threat to existing personnel and vested interests
- User's views of the quality of the system

There are many variables that partially determine conversion effectiveness. A failure on any one of the items listed above can doom a project *even if every other aspect of development is successful.*

Estimates for the probability of successful conversion are the responsibility of IT staff members, consultants, outsourcing staff members, and other professionals with experience in the field. These individuals, given the nature of a proposed IT investment, should be able to estimate the probability of conversion success. They will base this estimate on their own past experience, the kind of technology the project requires, the capabilities of those working on the project, and other factors like those listed above that their experience suggests influence project success.

For a manager, understanding that an IT investment does not automatically result in a successful outcome is very important. If you believe that organizations in general do not receive an adequate return from investing in technology, one reason

IT Mismanagement Sinks a Brokerage Firm

Fidelity Investment Co. had to close its London office following a series of computer problems. In one month the firm received more than 1000 customer complaints about a faulty system that led to the late bookings of dividends and other problems. U.K. market regulators, also swamped with complaints, forced Fidelity to stop taking any new customers or offering new services. They also fined the firm over $300,000 for failing to install a new computer system and train its employees. As a result of these problems, the unit lost $60 million in one year. The closing will affect 260 positions, but Fidelity will try to absorb the personnel elsewhere. Fidelity had 40,000 accounts in London.

We do not have enough information to know if Fidelity's problem arose from a systems design problem or not. However, this incident shows the seriousness of system problems of any kind. For many companies, the technology is intertwined with basic operations and customer service. Management at Fidelity did not know or did not understand the seriousness of its problems. Fidelity is not alone; Oxford, a U.S. health maintenance organization, has been in serious financial difficulties due to inadequate management planning for technology. Systems analysis and design is a crucial part of understanding the way a business works; after all, many organizations can be viewed as collections of systems. Ignoring IT can be a major management mistake!

may be their failure to successfully convert the investment into working applications. With a knowledge of the things that can go wrong, a capable manager may be able to increase the probability of a successful conversion.

CHAPTER SUMMARY

1. Systems design is one of the most creative activities in modern organizations. Information technology offers the opportunity to radically reshape work processes and even the organization itself.
2. Unfortunately, design is a labor-intensive task that requires a great deal of tedious effort.
3. Remember that professional systems designers never use the systems they design. You use the systems that are designed by analysts, whether they work for your company or for an external consultant. Therefore, you should try to understand the objectives and functions of any new IT application that affects your responsibilities.
4. It is important to have more than one alternative to consider when making the decision to invest in a new application of technology.
5. We recommend the use of a selection committee to evaluate proposed alternatives for an IT investment. The committee should develop a series of criteria for evaluating proposed alternatives and a procedure for making a choice.

6. Systems analysis involves understanding present processing procedures, whereas design involves creating new ways to apply technology to improve information processing.
7. Users are likely to be most heavily involved in the first part of the systems life cycle, in defining the system prior to actual programming.
8. The client-server is the most popular platform for design today; a design team must determine what tasks will be assigned to the client and to the server, and must develop the user interface for the client.
9. Today user interfaces are mostly graphical. The design of these GUIs requires great care and experimentation.
10. Web site design is one of the newest and most exciting areas for IT innovation.
11. The user needs to be concerned with reliability and backup for critical applications.
12. The concept of conversion effectiveness is important in understanding some of the risks in developing new technology applications. Whether or not the firm receives a return on its IT investments depends heavily on its success in converting an investment into a working application.

IMPLICATIONS FOR MANAGEMENT

One of the worst-kept secrets in systems development is how labor intensive and time consuming the process is. Almost anyone who has worked on a development project will tell you that the project took more work and more time than anticipated. While there are CASE tools and structured approaches to design, no one has figured out how to automate the process of requirements definition—figuring out what the system is supposed to do. There is a saying that "The devil is in the details," which applies nicely to systems development. If you want technology to assist you in improving some business process, you have to identify exactly, in excruciating detail, the logical steps in the process. Even if you plan to purchase a package, you have to know what the system is supposed to do so you can see if the package meets your needs.

KEY WORDS

Audit trail
Client-server platform
Computer-aided software engineering (CASE)
Conversion effectiveness
Fault tolerance
Pointing device
Selection committee
Source-data collection
Weight

RECOMMENDED READING

Deng, P.; and C. Fuhr. "Using an Object-Oriented Approach to the Development of a Relational Database Application System," *Information and Management.* 29, no. 2 (August 1995), pp. 107–121. (The basis for the example in Appendix B of this chapter.)

Dewitz, S. *Systems Analysis and Design and the Transition to Objects.* Boston: Irwin McGraw-Hill, 1996. (A systems analysis and design text that tries to bridge the gap between traditional design and object-oriented design.)

Dos Santos, B. "Justifying Investments in New Information Technologies," *JMIS,* 7, no. 4 (Spring 1991), pp. 71–90. (An interesting discussion of the future consequences of investing in IT today and a suggestion for how to compute the value of this option.)

Weill, P. *Do Computers Pay Off,* Washington, D.C.: ICIT Press, 1990.

Wu, S.; and M. Wu. *Systems Analysis and Design.* St. Paul, MN: West Publishing Co., 1994. (A straightforward book on systems development.)

DISCUSSION QUESTIONS

1. Why should you be interested in seeing a number of alternatives for a proposed IT initiative?
2. What are the major sources of frustration in selecting applications?
3. What problems arise if the information services department is in charge of the design and makes unilateral decisions?
4. Why collect data where they originate?
5. What is the concept of conversion effectiveness? Why is it important?
6. In your opinion, what kind of technology has the most pleasing user interface?
7. Can systems design be described as a science? What is scientific about it? What characteristics make it appear to be an art?
8. What are the major components of a client-server application?
9. What is the drawback for users in serving on a selection committee and/or a design team?
10. What other approaches to selection of information systems project alternatives can you suggest?
11. What kinds of things can go wrong in developing an application?
12. Suggest a mechanism for deciding which enhancements to existing systems should be undertaken. How does this problem differ from selecting new applications? How are the two decisions similar?
13. Why present multiple alternatives in preliminary surveys and feasibility studies?
14. How do projects already under way influence decisions on undertaking a proposed application?
15. How can you find out what applications packages might be available as a possible source of processing in a proposed system?
16. How should risk be considered in evaluating proposed alternatives? What are the risks in systems analysis and design?
17. What is an audit trail in an information system? Why is such a trail of transactions necessary?
18. What is the role of the server in a client-server system? The client?
19. How can you determine what size the server should be for an application?
20. Is it possible for technology to eliminate paper reports?
21. What contribution can the user make to a preliminary survey and feasibility study? How can the use of this information lead to biased recommendations?

22. Describe guidelines for designing a graphical user interface.
23. What other creative tasks are there in the organization in addition to the design of new information systems? How do they differ from this activity?
24. What are the prospects for automating systems design tasks? Where could automation be fruitfully applied in the systems life cycle?
25. Design a procedure for developing criteria and assigning them for selecting alternatives for an application.
26. Does a system have to use the most modern technology to be successful? Why or why not? Are there disadvantages to utilizing the most up-to-date technology?
27. How can a manager increase the probability of successful conversion of an IT investment into an application?

CHAPTER 16 PROJECT

Systems Design Problems

1. One of the most common applications is payroll. Many organizations have custom-designed payroll systems, and many service bureaus offer packages to compute an organization's payroll. The logic of the payroll process is common across many organizations.

   Usually a file contains data about each individual who is on the payroll. An example of the data to be included in setting up this database for employees would be as follows:

Name	Medical plan
Number of dependents	Pension
Marital status	Employee number
Deductions	Wage rate
Union dues	Social Security number
Hospital plan	

   On a periodic basis, such as weekly or monthly, input is necessary to trigger computation of the payroll and production of a check for each employee. At minimum, this weekly input would have to include the following:

   Employee number
   Regular hours worked
   Overtime hours worked
   Sick leave
   Special deductions

   Once the system is run on a periodic basis, checks should be produced along with various accumulations for different year-to-date categories. The computer program would subtract all deductions and withhold funds for tax purposes. Also normally included in the output would be a payroll register. On an annual basis, the computer system would produce W2 forms and the summaries of earnings and taxes withheld from wages for tax purposes.

a. Design (i) the input screens to be used to place a new employee on the payroll file and (ii) the screens to be completed for each employee for a payroll.

b. List the file contents and approximate field sizes for the payroll file. Do not forget to include year-to-date totals.

c. Draw at least two levels of data flow diagrams for the payroll system.

d. Describe the modifications necessary for the system to automatically wire a check to the employee's bank if the employee so elects and to include a notice to the employee.

e. Design the file maintenance and change screens necessary to alter information about employees.

2. Most organizations, whether manufacturing firms or service organizations, have some kind of accounts receivable. Accounts receivable was one of the first applications undertaken by many firms when computer systems were acquired. Service bureaus also offer accounts-receivable packages for sale or rent. Originally, most accounts-receivable packages were typically batch applications. Today we would expect to find on-line input and payment processing.

Consider an on-line accounts-receivable system. An accounts-receivable transaction is generated by the shipment of a product to a customer. An operator at a PC enters the following information:

Order number
Shipment number
For each shipment:
  Product code
  Quantity
  Date
  Shipping costs
  Special shipping mode
  Special discounts
  Comments

The program accepting this input responds with the customer's name and address when the order number is entered. It also prints the product descriptions, the price extension, and the total invoice cost.

The customer receives the statement and sends in payment for one or more invoices. The next task is for an operator to enter the payments and to match them against outstanding invoices. The operator enters the invoice number, the total payment, and exceptions to indicate partial payments for items on an invoice that are not paid.

In addition to the printed invoices, invoice register, and monthly statements, the system provides an accounts-receivable listing, a daily cash balance, and exception reports for invoices that were partially paid or not paid at all. There would also be a function to allow inquiry concerning payment history. Of course, as with any system, it is necessary to establish new customers. The new customer information has to include the following:

Account number

Name and address

Credit payment terms

Normal shipping mode

a. Design the database, including customer, shipment, and invoice tables.
b. Describe the overall flow of data for the system.
c. Design the screens for data input and inquiry.
d. List the edits and controls necessary in this system.

3. Sales reporting can be a very important application. Often, data for sales reports come directly from shipping and/or invoicing systems in the organization. At a minimum, this application requires a customer file including customer number, geographic code, shipment date, order number, item number, quantity shipped, and price.

From these data it is possible to generate an output sales report. This report might be summarized by product, product type, region, or salesperson.

a. Design an inquiry system for a client-server platform that would answer questions interactively concerning customers or products. Also design several screens for users to access with browsers on an Intranet to retrieve sales data.
b. Assume that historical data are available on sales for the past 10 years. What kind of forecasting system would you design for this organization? What would be your considerations in choosing a forecasting system?

4. The manufacturing or production function in an organization includes many activities, such as materials acquisition, production scheduling and control, work-in-process inventory control, and finished-goods inventory control.

One way to start the manufacturing process is with the preparation of a bill of materials. A bill of materials lists all the components necessary to manufacture a product. Usually the input that is provided is the number of new products identified by product number and quantity. The output from this system is a list of subassemblies and the quantity required. That list contains all the parts needed to manufacture the particular product.

a. Design the database for a bill-of-materials processor.
b. Describe the logic of a program to display the number of parts needed given orders for products.
c. Assume that the input to the bill-of-materials processor contains both the product and the shipment date. Design a system to produce a report on products that must be manufactured by a given due date.
d. Design several screens for the company's Intranet to provide production and inventory information throughout the firm.

5. A budget is a fundamental managerial control tool in an organization. In setting up budgets, minimal input includes an account number, the type of account, a description, and where a control break is to be taken to add up the totals for each account. Then, for each budget cycle, input is provided on the account number, the budgeted amount of money, and the actual money spent. The output from such a system is the budget report. It shows the account, the description, the budgeted amount, the actual amount, variance amounts, and usually percentage totals as well. Design a database for a budget application, and describe the format of a budget report. Should the budget be available on an Intranet?
6. Technology is used extensively in the retail industry, particularly for supermarket checkout operations. In these systems, a scanner reads the universal product code (UPC) on items sold in the store. A midrange computer in the store contains a file with the UPC numbers and the current prices. As items are scanned, their prices are read from the file, and the entire cost of the grocery order is computed.

   All during the day, the computer in the store maintains a record of items sold. In the evening, the data can be transferred to a central computer to update master records, which represent sales and, more important, inventory balances. These inventory data can then be used to restock the supermarket so that it is not necessary for store personnel to place formal orders with the warehouse.

   Such systems were designed to speed the checkout process and to ensure more rapid response for the resupply of grocery products.

   a. Design the database for the local grocery store and the database for the central host computer.
   b. Develop a backup plan that will become operative if the computer in the supermarket fails.
   c. What reports could be generated from the system for use by store management? What kind of queries will managers make?

Designing a Distributed Client-Server System: The Hardserve Case Study

This case study describes the design of a distributed system for Hardserve, a company that specializes in the wholesale distribution of merchandise to retail hardware stores. Hardserve buys goods from manufacturers and stocks them in a warehouse. Retail hardware stores order merchandise from Hardserve, which then ships it from inventory. Hardserve has usually been the first choice for retail stores trying to find an item, but if Hardserve does not have the goods requested by the retail store, the store will go elsewhere. The company's objective is to design a new system for its stores and the central warehouse. The case presents a preliminary survey and then sketches specifications for the Hardserve system.

Goals

We have identified the following goals for a system.

1. Reduce inventory levels while maintaining a desired level of customer service.
2. Reduce the reorder cycle time for the local stores: Get replenishment stock to local stores two days faster.
3. Improve management of seasonal and slow-moving items.
4. Capture sales data so purchasing can analyze trends and stock the proper merchandise.
5. Smooth the operations of the local stores by improving customer service and reducing paperwork.

THE EXISTING SYSTEM

Problems

The existing system is illustrated in the flowchart of Figure A-1. At the present time we have manual processing of papers and an old inventory control package running on our warehouse computer. For some items we tend to overstock from fear of running out, and in others we miss a reorder point and incur a stockout. Purchasing hears from the warehouse when a particular item has reached a reorder point on the computer file. This reorder point is set by the warehouse manager's experience. We also have no real sales forecasting because we do not track which items are moving. Accounting analyzes the physical inventory, and at the end of the year, purchasing looks at what items have sold. By that time it's too late for the data to do any good.

Decision Considerations

We have identified the following crucial decisions in our business:

1. What should be ordered for each new season?
2. What should be reordered during the season and when?
3. How much should be reordered each time?
4. What items should be dropped from inventory?
5. What and when should the local store reorder?

Information Flows

Current information processing is shown in Figure A-1. The warehouse computer indicates when physical stock has dropped below the reorder point and sends a report at the end of the day to purchasing. The purchasing agent either reorders the item, if it is not on order, or expedites it if an order has already been placed. At the end of the season, the purchasing department analyzes purchase orders and estimates what will be needed for the next season. Decisions on the reorder amount are based on the purchasing agent's negotiations with the supplier. Approximate volumes of orders and other related data are given in Table A-1.

A DISTRIBUTED SYSTEM

Systems Design

A local-store client PC, using bar coding and a wand for reading data into the computer, automates as much of the store's interaction with customers as possible and reduces store paperwork. The local-store PC places orders to a warehouse server through a communications link, dramatically reducing local-store inventory replenishment. At the warehouse, we streamline processing.

With orders coming electronically, the warehouse system can consult inventory records and prepare "picking lists" almost instantaneously. The system also uses an economic-order quantity to suggest reorders to purchasing. The

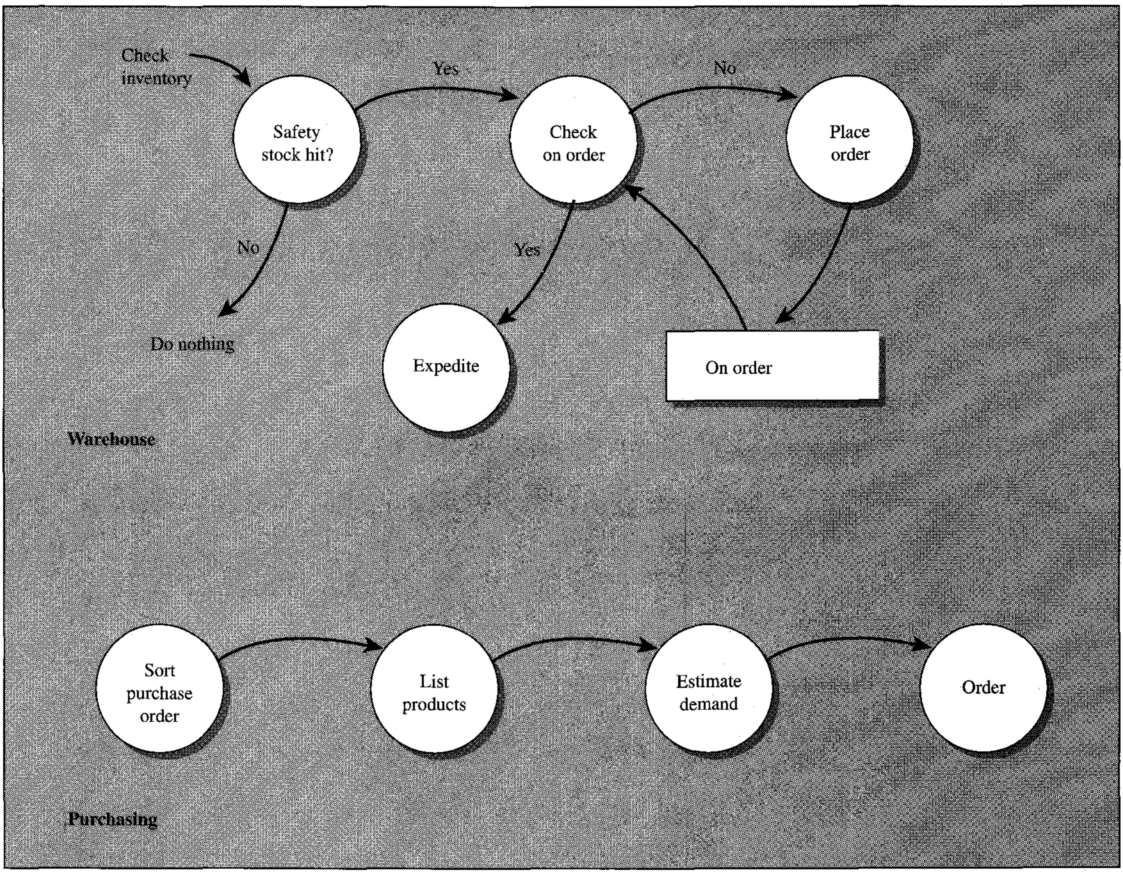


FIGURE A-1
Flowchart of the existing system.

amounts of paper involved in placing a purchase order and in receiving the purchased goods have been reduced.

The rest of this discussion presents some preliminary design specifications for this system. For this design, to provide a little variety, we are using a modification of the data flow diagrams (DFDs) introduced in Chapter 15. The rounded rectangle for processing in the DFD is replaced with a circle to produce the "bubble charts" found in this example.

Figure A-2 is labeled a level 0 diagram, though in structured design that designation officially belongs to something called the context diagram. Figure A-2 is a pseudo-context diagram since it has two "bubbles"—one for the store and one for the warehouse. In this example, using the two process symbols makes it clear that we are designing two systems that must interface closely with each other.

TABLE A-1

APPROXIMATE MONTHLY VALUES

Average number of orders	
January	4,100
February	6,700
March	7,800
April	8,400
May	5,400
June	4,600
July	5,000
August	5,100
September	6,200
October	9,500
November	10,100
December	8,200
	81,100

Average orders per month: 6,758
Maximum orders per day: 500
Average orders per day: 311
Average number of items per order: 5.1

As the diagram shows, the hardware-store system includes a manager and sales, payables, and inventory clerks. In fact, these roles may actually all be played by one or two people. The sales clerk uses the system to check merchandise out at the "cash register," which is a personal computer with a bar-code scanner. The inventory clerk uses the PC to scan the bar codes on new inventory items as they are received from the Hardserve warehouse. The store system also accumulates a summary of payables for the payables clerk. Since the store purchases its goods from the warehouse, there is only one major payable.

The store PC, then, keeps track of the inventory in the store. It subtracts sales at the cash register from inventory and adds the receipt of new items and customer returns to the inventory. The store system checks its files each day at the close of business to determine what items need to be reordered from the warehouse. It sends these reorders to the warehouse, as shown in Figure A-2.

The warehouse system is very similar to the store system in that it maintains an inventory, too. The warehouse system interfaces to several systems. It sends a record to the existing Hardserve accounts-payable financial system, because the warehouse buys from a number of vendors and has a significant payables function. The warehouse system also includes the purchasing function, since the warehouse must purchase all of its supplies from different vendors. Finally, the warehouse system helps run the warehouse by creating picking slips for workers to use in filling the orders to be sent to the local hardware stores.

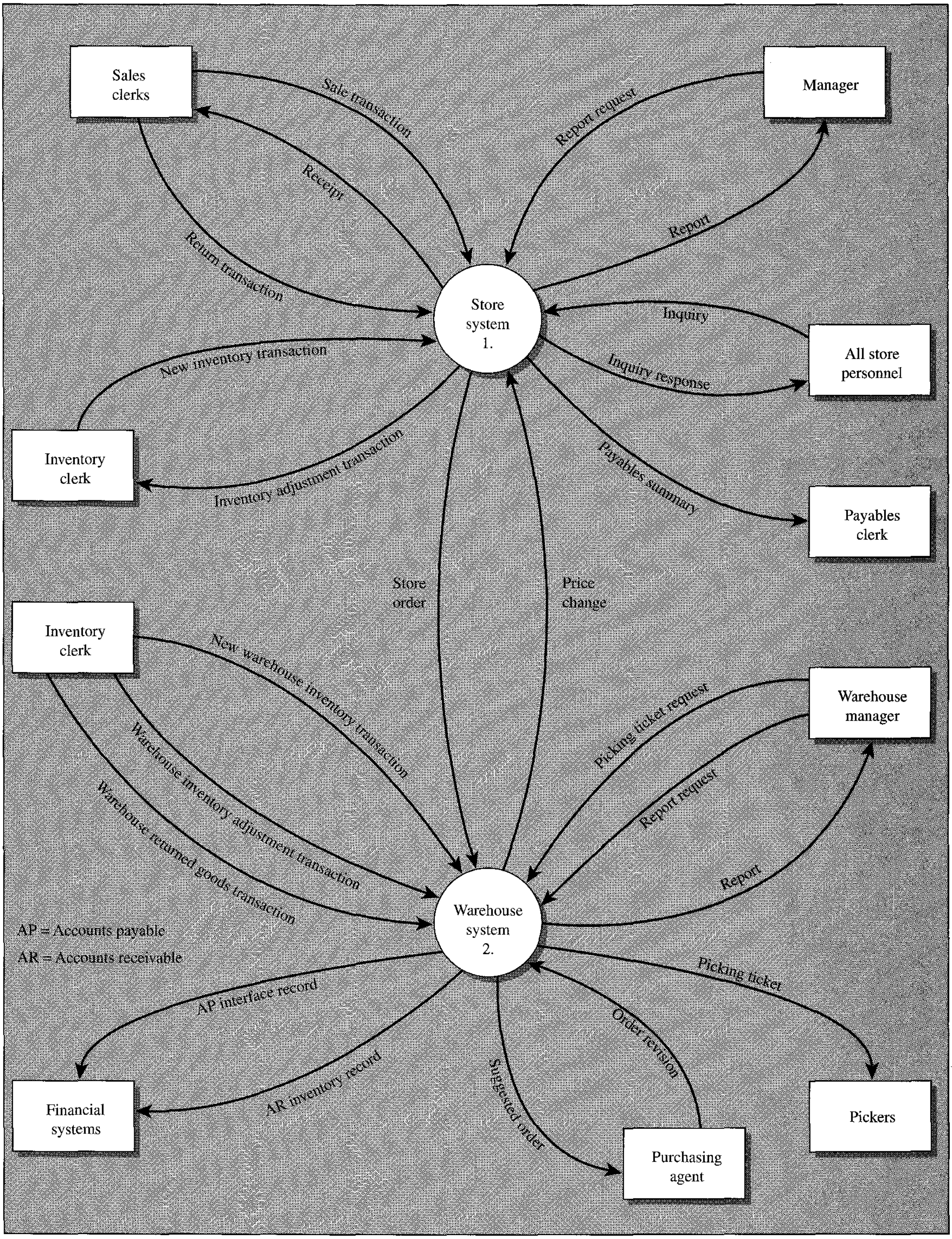


FIGURE A-2
Diagram 0—pseudo-context diagram. (AP: accounts payable and AR: accounts receivable)

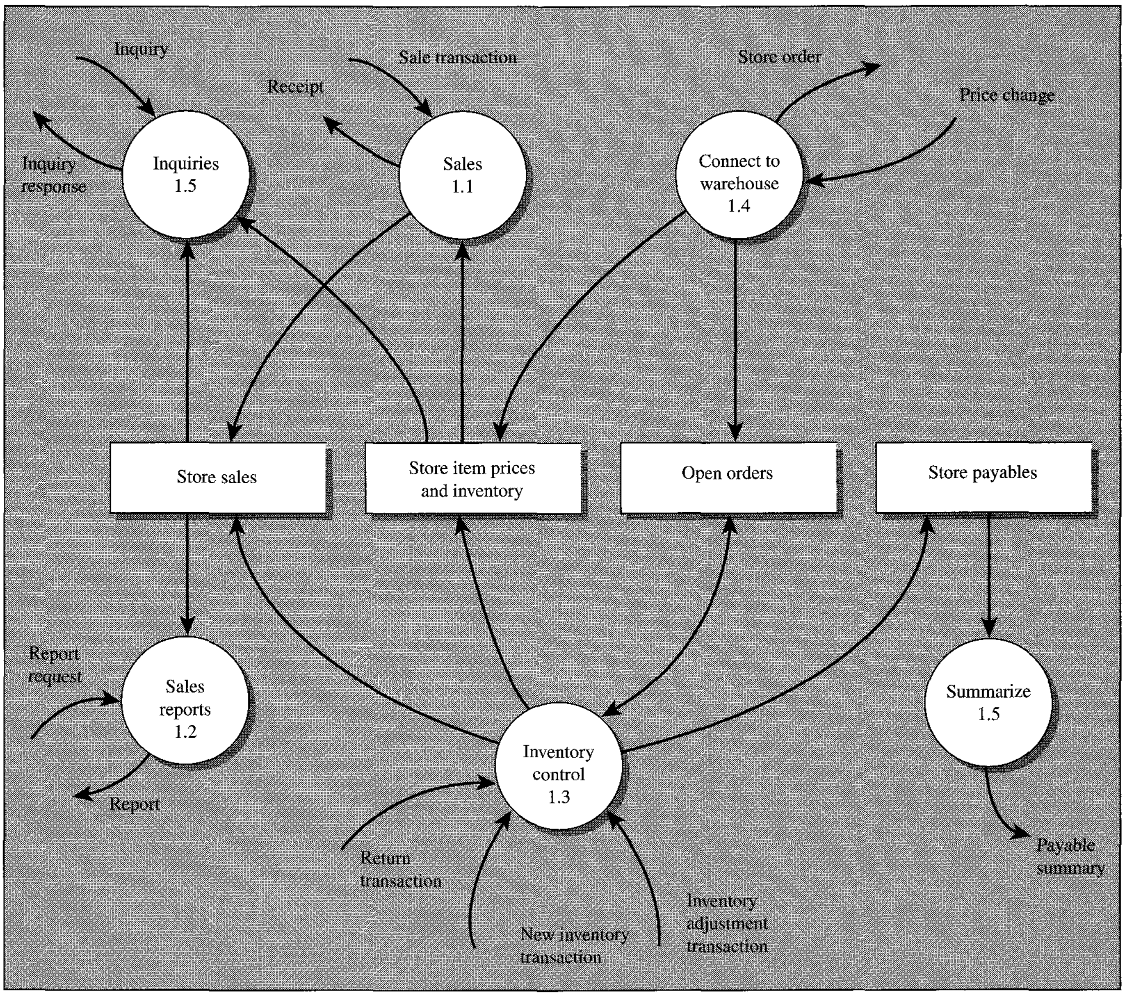
System Specifications

What kind of hardware is needed to support this system? The systems designer will generally seek advice from hardware and software experts in the organization building the system. For Hardserve, the general architecture is fairly simple. Each store will need a minimum of one PC and the warehouse will need a larger server to keep track of inventory.

Systems Overview: The Local Store

Figure A-3 shows the local-store system. The most important processes are sales (1.1), inventory control (1.3), and connecting to the warehouse (1.4). For

FIGURE A-3
Diagram 1—local-store system.



the sales function, the design team is looking to various optical reading devices, such as wands, that read the universal product codes (UPCs) on merchandise. The designers have to survey the warehouse and check stores to see how many products have bar codes. If too few are coded, Hardserve might print codes and apply them as it receives merchandise to be placed in the warehouse.

The inventory control process must keep an accurate "book" or file of the items in local-store inventory. As inventory is received from the warehouse, this process adds it to the store file: Store item prices and inventory. The same logic is followed if a customer returns merchandise to go into inventory. There may be inventory adjustments. It is likely the store will take a physical inventory at least once a year and adjust the book inventory to conform to the physical. When there is a return transaction, the inventory process also should update the store sales file. As merchandise is received from the warehouse, the inventory control process updates open orders to reflect the receipt and posts data to the store payables file.

The local store may wish to view various reports about its sales on a daily, monthly, and year-to-date basis. Designers will also have to consider the level of detail desired by store owners. For example, some users may want to see sales by product class while others want sales of individual products. The designers also have to determine if the reports need to show last year's sales to date as well.

Process 1.4 directs the store's PC to dial the warehouse so the local store can transmit reorders to the warehouse. This process consults the store item price and inventory file to determine what items have reached their reorder point; it then places an order for the item. Process 1.4 posts each day's order to the open orders file so the merchandise can be checked off when it arrives.

Sales

Figure A-4 is a level 1.1 diagram for the sales process. During the day when customers are in the store, the sales screen will probably be "up" most of the day. The user will scan purchases, the scanner converts the UPC to a product number, and the local-store computer looks up the price of the item in an item price file. The computer calculates any extension (the clerk can type a number to indicate multiple purchases). If there is no UPC on the item, the clerk keys in the item number and the price and quantity. For example, it is unlikely that individual fasteners like nuts and bolts will have UPC numbers on them.

The computer must reduce the inventory count in the store (process 1.1.1) by the amount of the sale, and post sales to the sales file (process 1.1.5). After entering the last item, the computer calculates the sales tax and prints a receipt for the customer. The designers are also looking into the possibility of having the local-store computer automatically dial a credit authorization number for customers who are using credit cards. The computer could then print the sales receipt to be signed by the customer for the credit card charge as well.

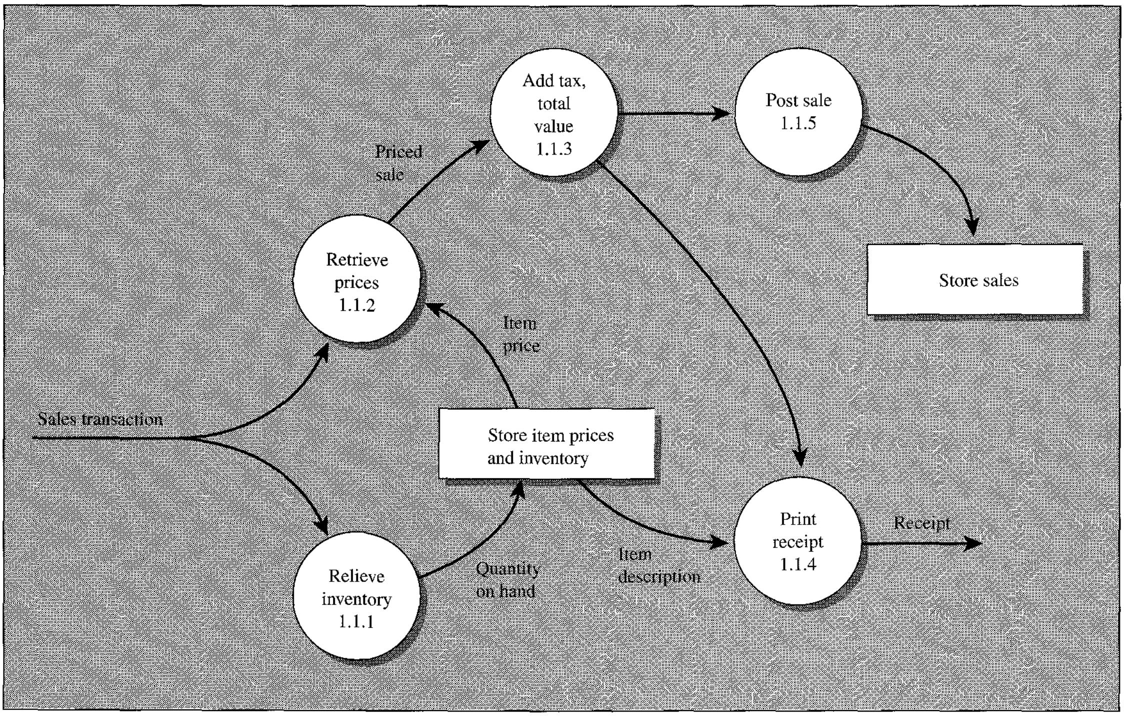


FIGURE A-4
Diagram 1.1—sales.

Inventory Control

Inventory control is one of the major functions of the system. Figure A-5 shows the next level of detail for inventory control. When merchandise is returned, the store sales file and the store item prices and inventory file must be updated. An inventory adjustment transaction updates the latter file.

Process 1.3.1 shows what happens when inventory is received from the warehouse. Three files are affected. The system displays a screen to be used in scanning input items. The Hardserve warehouse prints shipment labels corresponding to orders so that the local store can scan items as they are received. The computer must update a file of store open orders and the store item prices and inventory file to reflect the receipt of goods. The user must enter any discrepancies between what was ordered and what was received (for example, the warehouse may only be able to send six of an item when the store ordered twelve). Finally, the process updates the store payables file. The inventory receipt process is shown in another level of detail in Figure A-6. Similar DFDs are needed to provide additional detail on an inventory returns and adjustments.

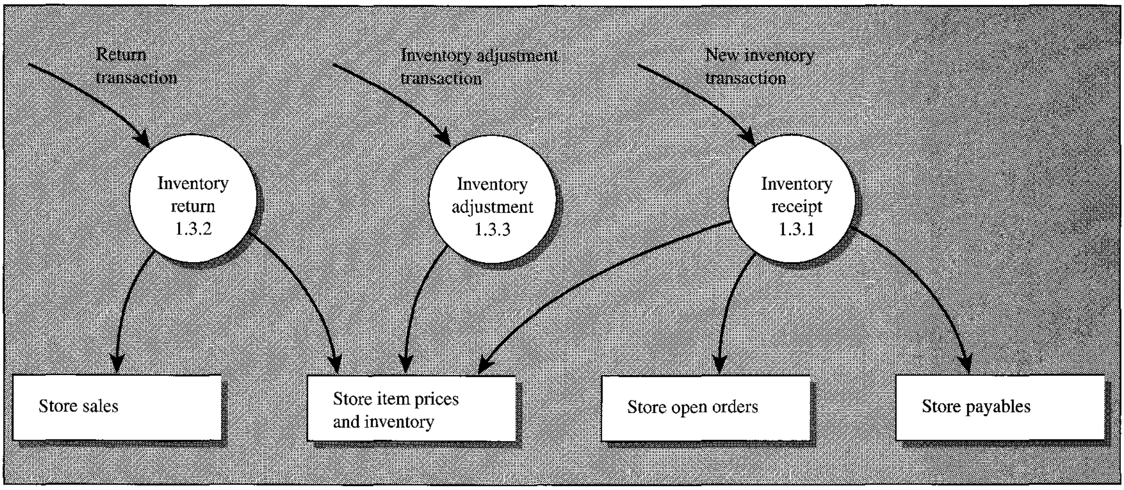


FIGURE A-5
Diagram 1.3—inventory control.

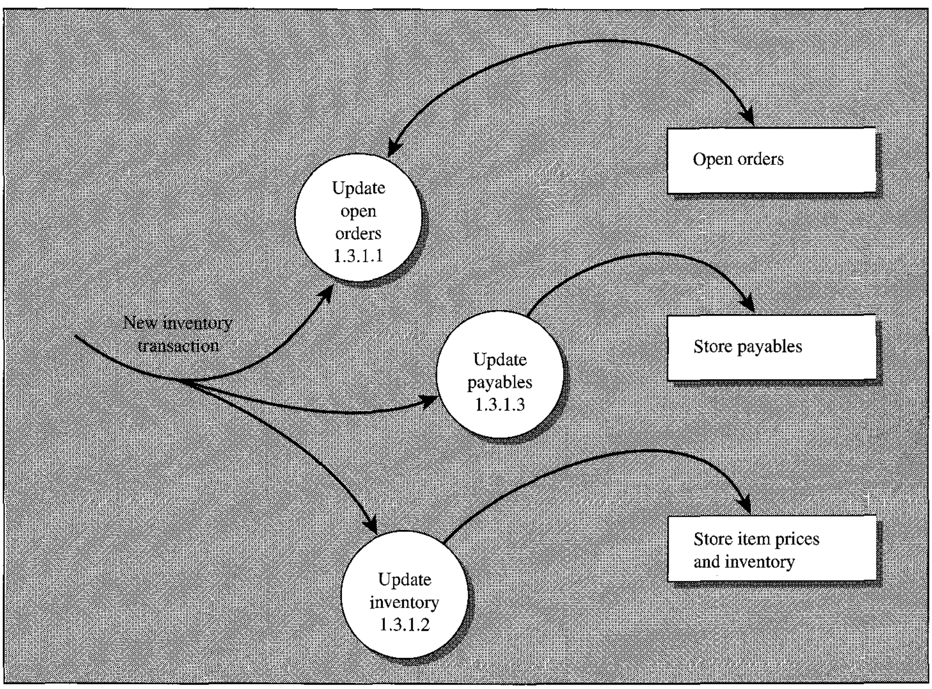


FIGURE A-6
Diagram 1.3.1—inventory receipt.

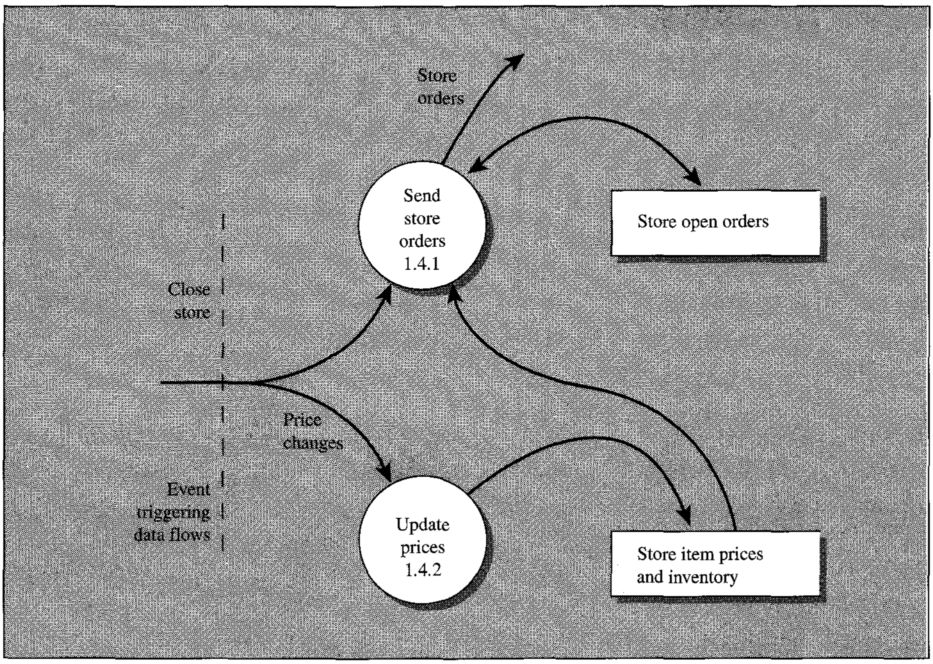


FIGURE A-7
Diagram 1.4—connecting to the warehouse.

Although not shown on Figure A-6, the check-in procedure for receiving merchandise will also probably require the ability to key in a receipt because the warehouse may not be able to print scannable labels for each item received.

Connecting to the Warehouse

Figure A-7 shows the process for connecting to the warehouse. In this case, the external event of closing the store results in the connection. Process 1.4.2 accepts price changes from the warehouse and updates prices in the store item prices and inventory file. Process 1.4.1 scans this file and sends the orders to the warehouse while updating the store open orders file.

The process of transmitting orders is shown in more detail in Figure A-8. Process 1.4.1.1 looks at inventory balances and reorder points and the reorder quantity in the store item prices and inventory file. If the quantity on hand for an item is less than the reorder point, the process generates a store order by posting the item to the store open orders file. Process 1.4.1.2 reads the store open orders file and transmits the order created today to the warehouse.

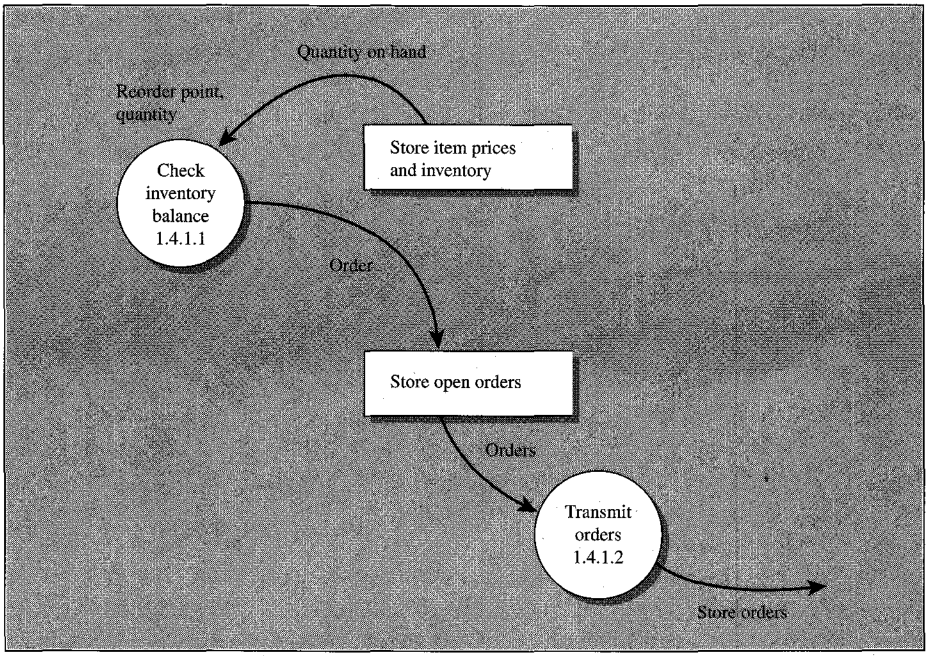


FIGURE A-8
Diagram 1.4.1—sending store orders.

Inquiries

Figure A-9 shows the logic for making inquiries. The user can display any field from the inventory record on the screen and inquire about prices and the quantity of an item on hand. The user may want to inquire about items that are on order. The response to this query shows both on-hand and on-order quantities. Finally, the user can inquire about sales. (There is a sales reporting screen, but this query is intended for a short response for a few items rather than a comprehensive report.)

Systems Overview: The Warehouse

The warehouse system is very similar to the local store system. Figure A-10 (on page 453) contains a second-level diagram for this system. This diagram shows the major functions of the warehouse system including picking stock, sales reporting, inventory control connecting to the local stores, and purchasing goods.

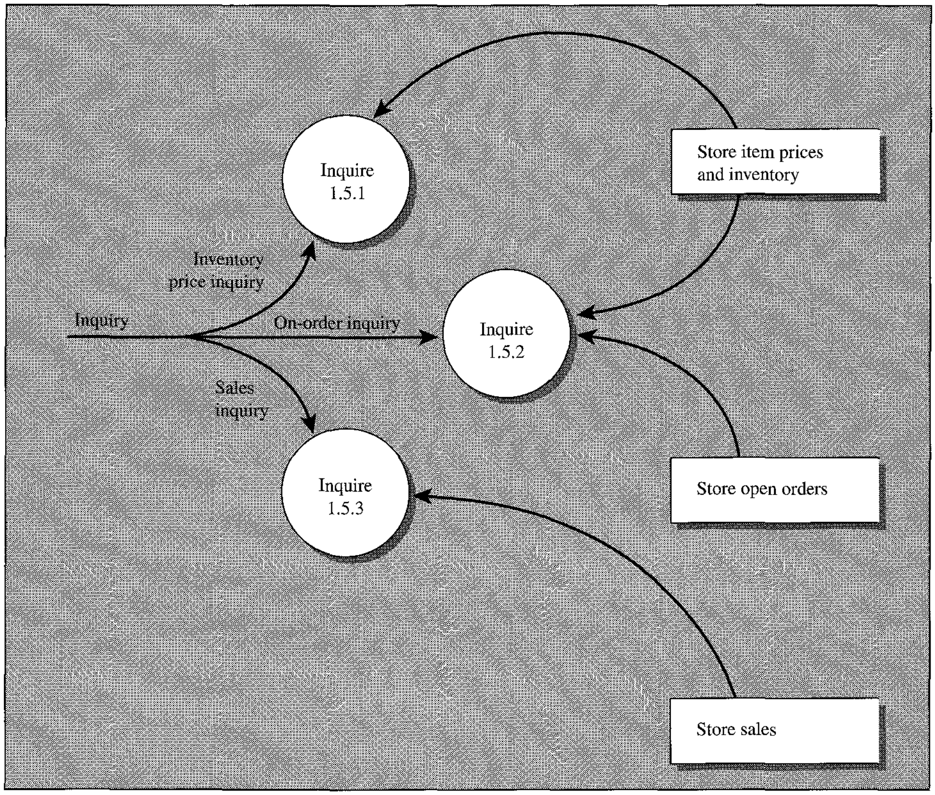


FIGURE A-9
Diagram 1.5—inquiries.

Filling Orders

An important role of the computer for the warehouse is to see that local-store orders are filled and shipped the day after they are received. (During busy seasons sometimes an evening shift picks orders and the merchandise arrives at the store in the morning following data entry the night before.)

As orders come in from the local stores, the warehouse server posts them in the order received to a warehouse file of local-store orders (Figure A-11). When the warehouse manager is ready for another batch of orders to be picked, the manager enters the number of orders he or she wants to generate. The system chooses that number of eligible orders from the picking file, and process 2.1.2 checks each item ordered against the warehouse item price and inventory file. If the item is out of stock, the system prints a notice on the order-filling form. The system does not need a backorder capability because the local-store system will reorder again,

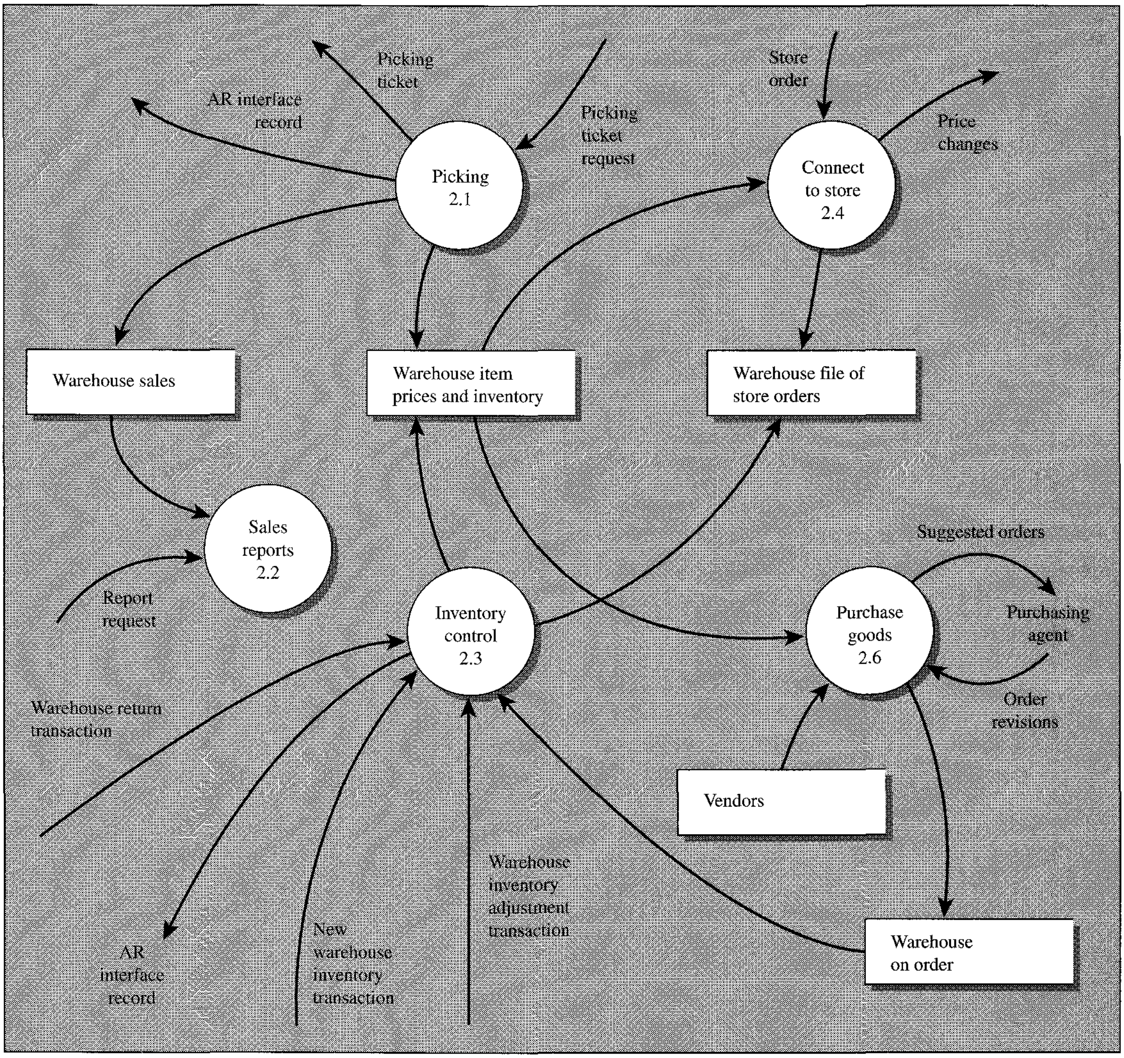


FIGURE A-10
Diagram 2—warehouse system.

since its quantity on hand will be below the reorder point if no merchandise is shipped from the warehouse to replenish the inventory.

Process 2.1.2 reduces the inventory to reflect the planned shipment of the item and creates a filled-order form, which is sent to process 2.1.3. This process generates a picking list and sorts it into the sequence in which merchandise is

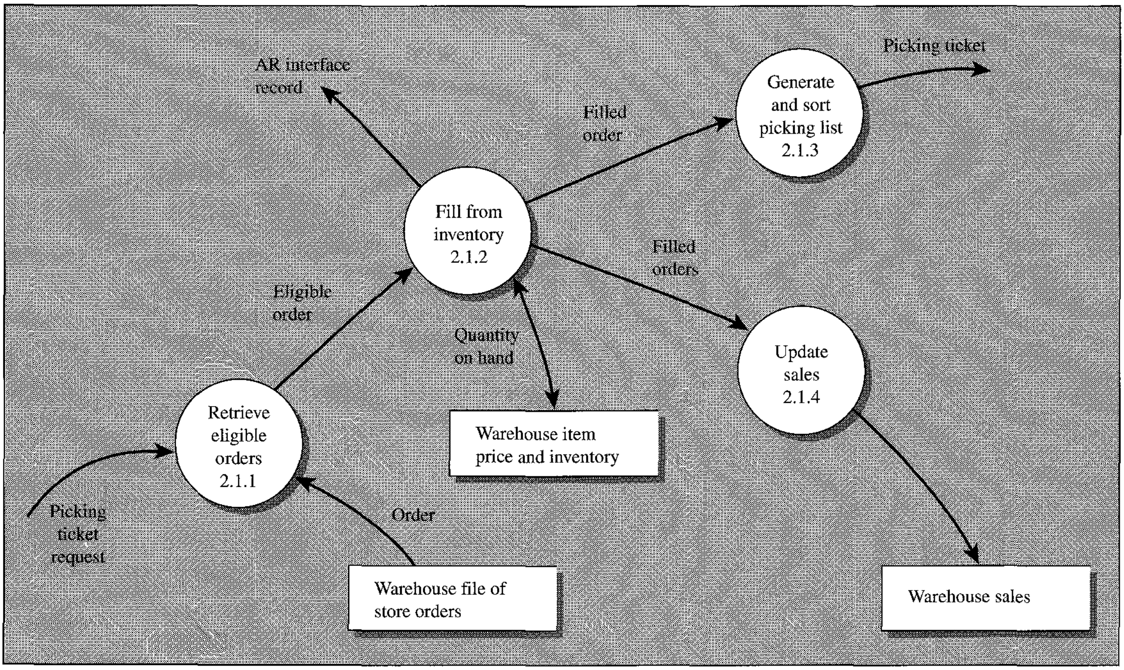


FIGURE A-11
Diagram 2.1—warehouse picking.

stored in the warehouse. As a result, the stock picker does not have to retrace his or her steps, but can move down a row in the warehouse in one direction and fill the order.

Process 2.1.4 updates warehouse sales while the order-filling process creates an accounts-receivable interface record. Sales to the local hardware stores represent a receivable account for the warehouse.

Purchasing

Figure A-12 shows diagram 2.6 with more details concerning purchasing. Process 2.6.1 is triggered by a purchase agent who wants to review inventory. The process scans the warehouse item prices and inventory file to determine items for reorder. The logic is similar to the processing of the store file. Instead of actually making the order, process 2.6.2 creates a suggested purchase order that is reviewed by the purchasing agent. Process 2.6.3 modifies the suggested order to create the final order that goes to a vendor. The purchasing agent may be able to take advantage of a special offer or have some other knowledge that the system lacks, so human review is important.

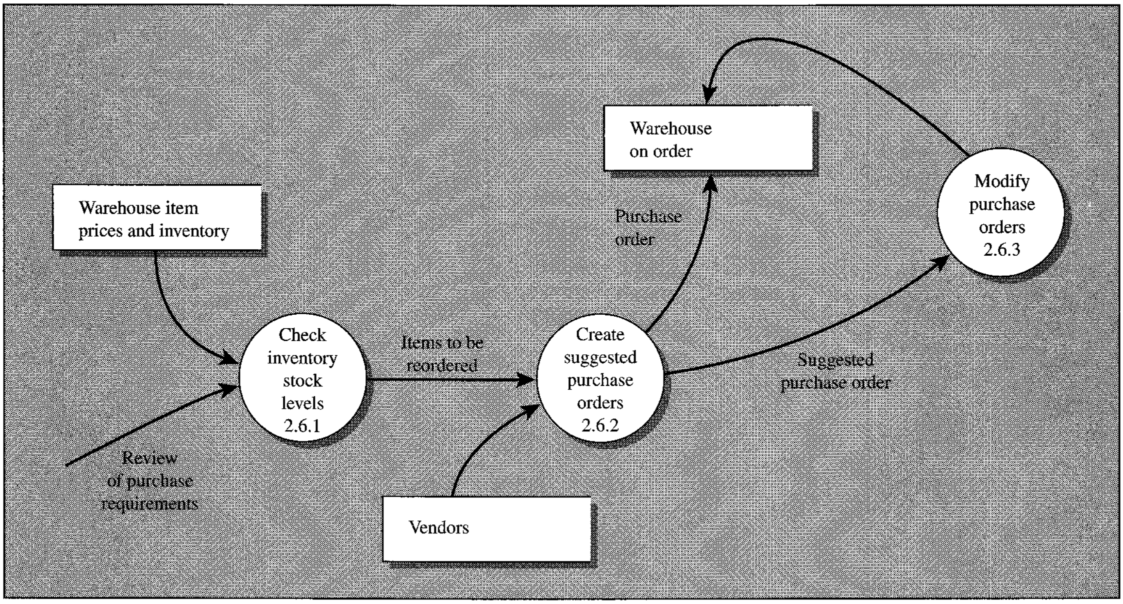


FIGURE A-12
Diagram 2.6—purchasing.

Other Processes

The remainder of the warehouse processing is quite similar to store processing and is not repeated here.

The Database

The data flow diagrams combined with a description of a database provide an important set of specifications for a system. Figure A-13 is an entity-relationship (ER) diagram for the store system.

In Figure A-13, the relationships appear on the lines connecting the entities. The arrows also indicate the nature of the relationship. A one-to-one relationship occurs when one entity is associated exactly with one other. For example, one receipt causes one payable and there is one payable for each receipt, so the lines connecting these entities have one arrow.

There can also be 1-to-*m* (many) relationships. One order contains many different order items so the line connecting order to order item has a double arrow pointing to the order item and a single arrow pointing to the order. Finally, there are *m*-to-*m,* or many-to-many, relationships. There can be many items on a sale and many sales of an item; double arrows point to each entity.

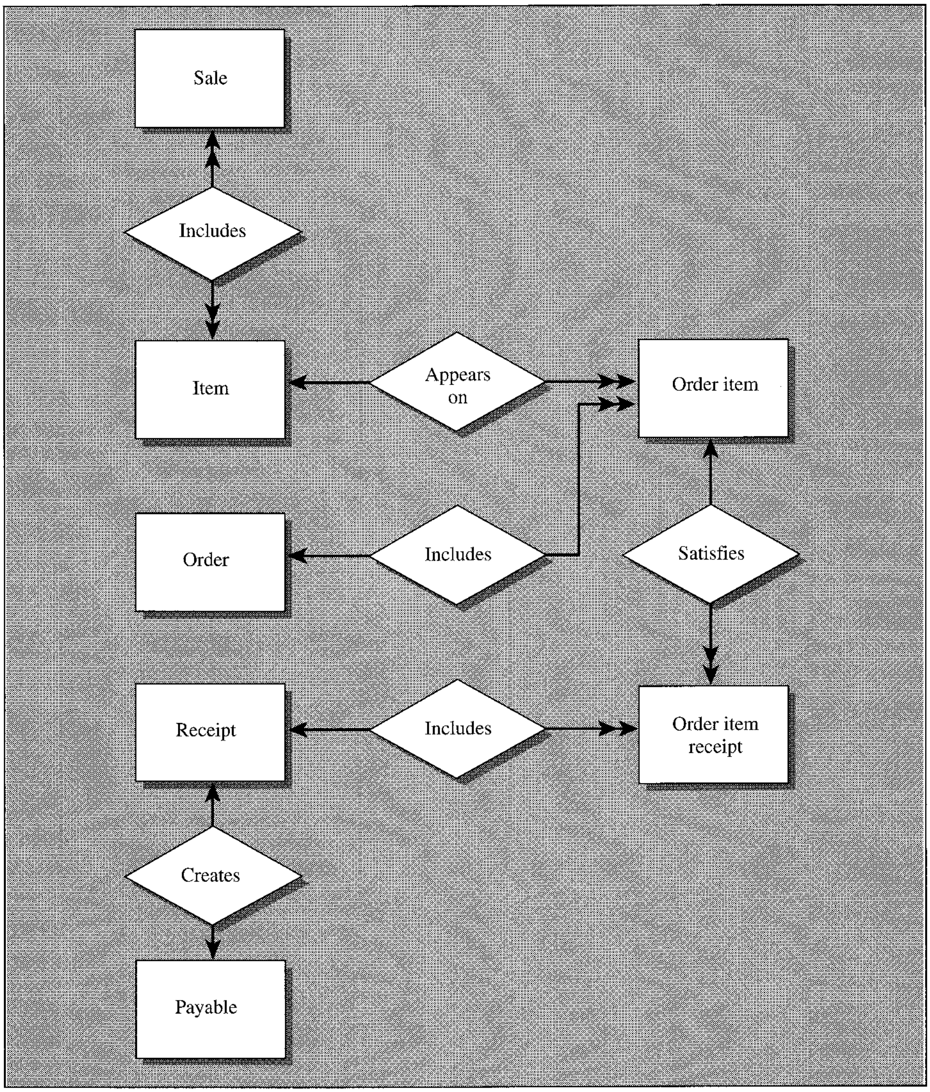


FIGURE A-13
Entity-relationship diagram of store system.

Figure A-14 (on page 457) is a rough-draft ER diagram of the warehouse system. Here we use the convention of single and double arrows to represent 1:1, 1:n, etc. relationships. Can you refine this diagram until it resembles Figure A-13?

Table A-2 (on page 458) contains the preliminary contents of the data items for the files in the local-store system. At this point, no particular data structure or database model is specified. Later, as the design team refines the specifications,

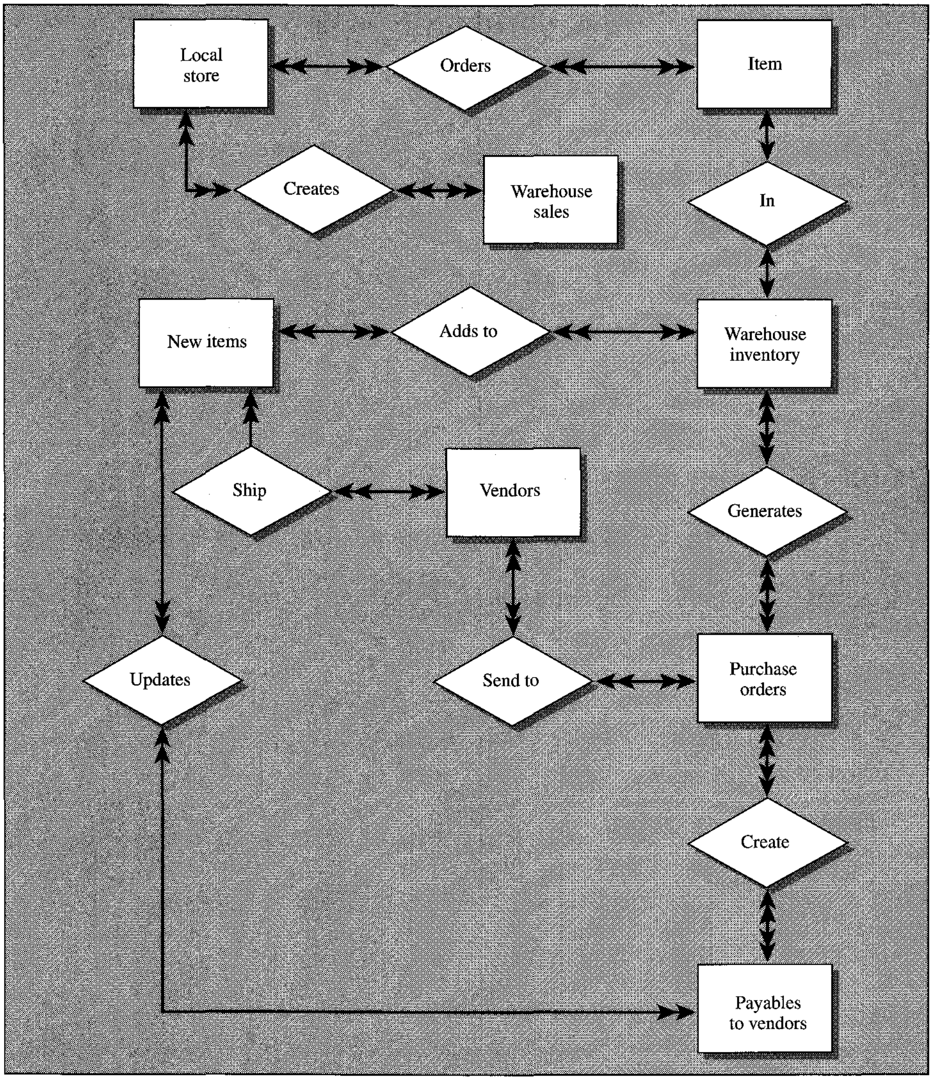


FIGURE A-14
First-draft entity-relationship diagram of warehouse system.

they will address the question of data models. If the team decides to use a packaged database management system for a PC, they will have to adopt its structure for these files. Note that a number of the files imply repeating groups. For example, an on-order file contains an order that is likely to contain a number of individual items. In Table A-2 we do not list repeating groups because that is a function of the data structure chosen. If we use a relational database, the order number might be repeated with each item number on the order.

TABLE A-2

PRELIMINARY FILE CONTENTS

File	Field	Size	Type	File	Field	Size	Type
Store sales	Item number	8	A	Warehouse	Sales last year		
	Sales this year			sales (cont.)	January	12	N
	January	12	N		.		
	.				.		
	.				December	12	N
	December	12	N				
	Sales last year			Warehouse	Item number	8	A
	January	12	N	item price	Description	50	A
	.			and inventory	Units	5	A
	.				Unit price	10	N
	December	12	N		Quantity on hand	10	N
					Reorder quantity	10	N
Store item	Item number	8	A		Reorder point	10	N
price and	Description	50	A		Warehouse location	15	A
inventory	Units	5	A				
	Unit price	10	N	Warehouse	Store number	8	A
	Quantity on hand	10	N	file of	Order number	8	A
	Reorder quantity	10	N	store orders	Order date	6	A
	Reorder point	10	N		Item number	8	A
	Store location	15	A		Quantity on order	10	N
Store open	Order number	8	A	Warehouse	Item number	8	A
orders	Order date	6	A	vendor file	Vendor number	8	A
	Item number	8	A		Vendor address 1	30	A
	Quantity on order	10	N		Vendor address 2	30	A
					Vendor address 3	30	A
Store	Order number	8	A		Vendor city-state	30	A
payables	Order date	6	N		Vendor zip code	10	A
	Payable amount	12	N		Vendor rating	30	A
Warehouse	Store number	8	A	Warehouse	Order number	8	A
sales	Item number	8	A	on-order file	Order date	6	A
	Sales this year				Item number	8	A
	January	12	N		Item cost	10	N
	.				Quantity on order	10	N
	.				Shipping instruct.	30	A
	December	12	N				

A = Alphanumeric field N = Numeric field

Input and Output

The design of the PC menu for the local store, input screens, query forms, and printed reports is left as an exercise for the reader.

Summary

In this case we have seen the results of a tremendous amount of work on the part of a Hardserve design team. They have developed a conceptual model of a client-server system that has two parts: the local store and the Hardserve warehouse. The team has specified the major functions that each system has to perform and the interfaces among the two systems. There is a preliminary database specification and ideas on the menus the user will see in the local store. There is more work to be done, but this would certainly be a good place to have an all-day review session with users to be sure they understand and approve of the major choices reflected in the design to date.

APPENDIX B

An Object-Oriented Example

This appendix presents an example of a systems design following the object-oriented methodology described by Deng and Fuhr (1995). The application is for a hypothetical hospital that the author describes as a medium-sized nonprofit organization. The hospital's objective is to provide high-quality health care while minimizing cost to patients. The hospital wants to replace its batch processing system with an on-line system that will handle tasks such as patient registration, billing, inquiries, the tracking of medical staff, laboratory results, and patient treatments. After a lengthy study, the hospital identified 10 basic functions for the hospital containing 22 total processes. A model resulting from this effort is shown in Figure B-1.

OBJECTS AND CLASSES

A key activity in object-oriented analysis is to identify objects and group them into classes, and then into superclasses. The designers fully define classes by indicating their purpose, the tasks when called upon, and any collaboration with other objects to perform a task. Table B-1 shows a list of candidate classes after the elimination of redundancies. Table B-2 shows related classes grouped into superclasses. A class must have a purpose, that is, a definition of what it is as shown in Table B-3.

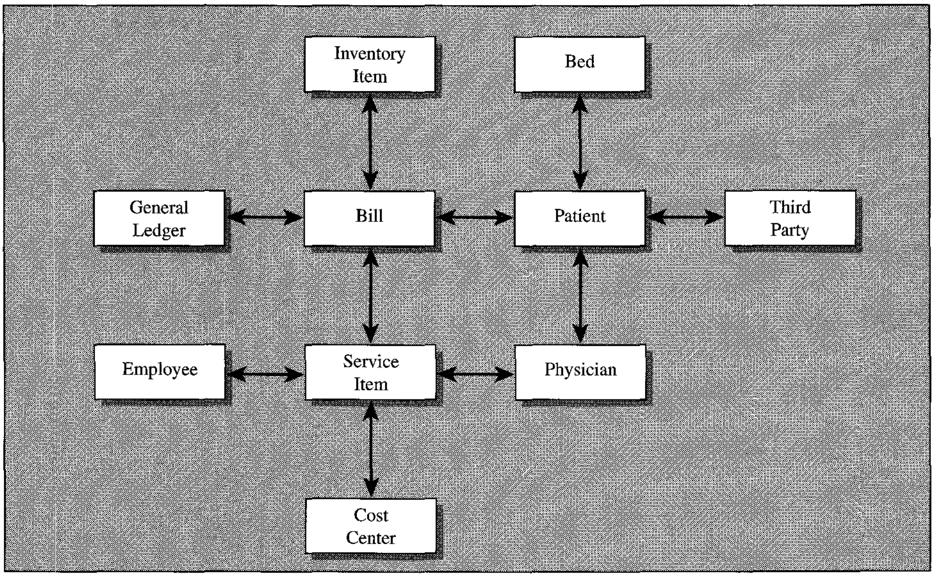


FIGURE B-1
Enterprise model of the patient care administrative system.

TABLE B-1

CANDIDATE CLASSES AFTER ELIMINATION OF REDUNDANT CLASSES

Patient Name	Physician Name	Room (Location)
Treatment	Patient Record (Patient)	Physician Identification
Patient Bill	Insurer	Patient Balance
Patient Service	Service Charge	Date Admitted
Expected Date Discharged	Date Discharged	Physician Specialty
Room Accommodations	Patient Address (Contact Info.)	Patient Identification
Patient SSN	Room Identification (Location)	Room Phone Ext.
Main Menu	Physician Phone Ext.	Third Party (Insurer)
Patient Information Display	Patient Bill Display	Patient Treat. Display
Room Utilization Display	Services Display	Physician Info. Display
Phone (Contact Info.)	Patient Procedure (Treatment)	Service Identification
Patient Home Phone	Patient Charge	Patient Contact Info.
Room Location		

TABLE B-2

SUPERCLASSES IDENTIFIED DURING THE EXPLORATORY PHASE

Superclass	Classes	Superclass	Classes
Display	Main Menu Patient Information Patient Billing Patient Treatment Physician Information Service Information Room Information	Identification	Patient Identification Patient SSN Physician Identification Service Identification Location Identification
Phone	Room Phone Ext. Physician Phone Ext. Patient Home Phone	Name	Patient Name Physician Name Insurer
Charge	Patient Charge Service Charge	Date	Date Admitted Expected Discharge Date Discharge Date

Remember that in object-oriented design, objects pass messages back and forth to initiate processing. The next step is to identify the role of each class and show the operations an object in the class must perform upon receipt of a message. Table B-4 shows the roles for each class. Then the designers identify interactions between classes or their collaborations. You might view this activity as defining the first part of a message by identifying the receiving object without yet defining the detailed flow of control and data involved in a message.

At this point, the designers develop detailed messages for each class. They document this work with graphs of each class hierarchy, a graph of class interactions, and the messages supported by each class. It is also necessary to identify what inputs from other classes are needed for a given class to perform its tasks. Note how this design is similar to a client-server environment where one class (a client) requests some kind of action from another class (server). This demand and supply relationship is shown in Table B-5 where numbers in parentheses indicate what the client requests from the server. As an example, the class Patient Name is required for the classes Patient Information Display, Patient Bill Display, Patient Treatment Display, Room Utilization Display, and Patient Bill. The Patient SSN will send a message to the Patient Name class.

TABLE B-3

PURPOSE OF EACH CLASS

Class	Description and purpose of class
Patient Name	First, Middle Initial, Last Name identifying patient
Physician Name	First, Middle Initial, Last Name identifying physician
Treatment	Procedure physician performed on patient
Patient Bill	Patient charges for services rendered at the hospital
Insurer	Third-party agency for cost coverage
Patient Balance	Amount patient owes for a particular service
Patient Service	Service/item a patient has received at the hospital
Service Charge	Default amount that is charged a patient for a service
Date Admitted	Date patient was admitted into the hospital
Expected Date Discharged	Expected date patient will leave the hospital
Date Discharged	Date patient was discharged or released to coroner
Physician Specialty	Specialization or title of physician
Room Accommodations	General/specific room characteristics
Patient Identification	Unique number identifying patient (SSN can change)
Patient SSN	Patient social security number
Physician Identification	Unique number identifying physician (SSN can change)
Room Phone Ext.	Four-digit extension for rooms that have a phone
Main Menu	Entry menu of patient care administration system
Patient Treatment Display	Entry/query screen for patient treatment (from main/info)
Physician Phone Ext.	Four-digit extension for physicians who have a phone
Room Utilization Display	Entry/query screen for room information (from main/info)
Services Display	Entry/query screen for services information (from main menu)
Physician Information Display	Entry/query screen for physician information (from main menu)
Service Identification	Unique code identifying type of service
Patient Home Phone	Home phone number to reach patient/immediate family
Patient Charge	Amount patient charged for service (may be different from default service charged)
Patient Contact Information	Mailing address, city, state, and zip code of patient
Room Location	Unique room number identifying a particular room
Patient Information Display	Entry/query screen for patient information (from main menu)
Patient Bill Display	Entry/query screen for patient billing (from main menu/info)

TABLE B-4

ROLES OF EACH CLASS

Class	Roles of class
Patient Name	Identify patient
Physician Name	Identify physician
Treatment	Provide medical/surgical care to patients
Patient Bill	Inform patient of charges incurred and balance due
Insurer	Identify agency for partial/full payment of patient bill
Patient Balance	Accept/display balance due for service rendered
Patient Service	Accept/display service rendered Provide service/item to patient

(continued)

TABLE B-4—CONTINUED

Class	Roles of class
Service Charge	Accept/display default service charge for service Display default charge when adding patient billing record
Date Admitted	Accept/display date
Expected Date Discharged	Accept/display date
Date Discharged	Accept/display date
Physician Specialty	Accept/display specialization Query doctors for particular specialization needed for a patient
Room Accommodations	Accept/display accommodations Provide specific options for patient care bedding
Patient Identification	Accept/display/validate unique identification
Patient SSN	Accept/display/validate unique SSN Inform third-party agencies of SSN for identification
Physician Identification	Accept/display/validate unique identification
Room Phone Ext.	Accept/display phone extension
Main Menu	Present user with choices Determine when and what user responded to
Physician Phone Ext.	Accept/display phone extension
Patient Information Display	Present user with choices: (add/edit/delete/view/query/search/help) (treatment/billing/room) Determine when and what user responded to View/maintain patient information records Validate/update corresponding room information if patient assigned to a location Validate patient not assigned to multiple rooms or occupied rooms
Patient Bill Display	User choices: (add/edit/delete/view/query/search/help) Determine when and what user responded to View/maintain patient billing records Return to main menu if selected from main menu Return to patient information if selected from there
Patient Treatment Display	User choice: (add/edit/delete/view/query/search/help) Determine when and what user responded to View/maintain patient treatment records Return to main menu if selected from main menu Return to patient information if selected from there
Room Utilization Display	User choices: (add/edit/delete/view/query/search/help) Determine when and what user responded to View/maintain room information records Validate patient not assigned to multiple rooms Return to main menu if selected from main menu Return to patient information if selected from there
Service Display	User choices: (add/edit/delete/view/query/search/help) Determine when and what user responded to View/maintain service information records
Physician Info. Display	User choices: (add/edit/delete/view/query/search/help) Determine when and what user responded to View/maintain physician information records

TABLE B-5

MESSAGE REQUEST AND PROVISION BETWEEN CLIENT AND SERVER OBJECTS

Class (Client/Server)	Message	
Patient Name	1.	Identify patient (35,36,37,38,41)
Physician Name	2.	Identify physician (40)
Treatment	3.	Provide medical/surgical care to patients (37)
Patient Bill	41.	Inform patient of charges incurred and balance due (36)
Insurer	4.	Identify agency for partial/full payment of patient bill (35,41)
Patient Balance	5.	Accept/display balance due for service rendered (36,41)
Patient Service	6.	Accept/display service rendered (36,39,41)
	7.	Provide service/item to patient
Service Charge	8.	Accept/display default service charge for service (36,39)
	9.	Display default charge in patient charge when adding patient billing record (36)
Date Admitted	10.	Accept/display date (35)
Expected Date Discharged	11.	Accept/display date (35)
Date Discharged	12.	Accept/display date (31,35)
Physician Specialty	13.	Accept/display specialization (40)
	14.	Inform, through query, those doctors with a particular specialization needed by the patient (37)
Room Accommodations	15.	Accept/display accommodations (38)
	16.	Provide specific options for patient care bedding
Patient Identification	17.	Accept/display identification (1,3,5–7,10–12,19,26,28,30,41)
	18.	Validate that patient identification is unique (35)
Patient SSN	19.	Accept/display SSN (1,4–7,10–12,41) Validate that patient SSN is unique
	20.	Inform third-party agencies of SSN for identification (41)
Physician Identification	21.	Accept/display identification Validate that physician identification is unique (37)
Room Phone Ext.	22.	Accept/display phone extension (38)
Main Menu	23.	Present user with choices Determine when and what user responded to
Physician Phone Ext.	24.	Accept/display phone extension (40)
Patient Information Display	35.	Present user with choices: Determine when and what user responded to View/maintain patient information records Validate/update corresponding room information if patient is assigned to a location Validate patient not assigned to multiple rooms or occupied rooms (23,36,37,38)
Patient Bill Display	36.	Present user with choices: Determine when and what user responded to View/maintain patient billing records Return to main menu if selected from main menu Return to patient information if selected from there (23,35)

(continued)

TABLE B-5—CONTINUED

Class (Client/Server)	Message	
Patient Treatment Display	37.	Present user with choices: Determine when and what user responded to View/maintain patient treatment records Return to main menu if selected from main menu Return to patient information if selected from there (23,35)
Room Utilization Display	38.	Present user with choices: Determine when and what user responded to View/maintain room information records Validate patient not assigned to multiple rooms Return to main menu if selected from main menu Return to patient information if selected from there (23,35)
Services Display	39.	Present user with choices: Determine when and what user responded to View/maintain service information records (23)
Physician Info. Display	40.	Present user with choices: Determine when and what user responded to View/maintain physician information records (23)
Service Identification	25.	Accept/display identification Validate that service identification is unique (41,8, 9,39)
Patient Home Phone	26.	Accept/display phone number (35)
	27.	Reach patient/immediate family if emergency
Patient Charge	28.	Accept/display charge (41,36)
	29.	Display default service charge when adding record (36)
Patient Contact Info.	30.	Accept/display contact information (41,35)
Room Location	31.	Accept/display room number (38) Validate that number is unique

Table B-6 contains the "signatures" for the patient care system. Message passing among clients objects and server objects is controlled by the signature. It specifies the type of parameters and objects that the class can receive and send.

Creating Subsystems

A subsystem combines classes and superclasses into an efficient grouping for implementation purposes. The main menu structure is shown in Figure B-2; it has six choices or subsystems for patient care information. (Dotted lines show data flow relationships between two subsystems in the figure.) Figure B-3 (on page 468) shows the main menu screen. Physicians treat patients, so the treatment subsystem is accessible through the physician subsystem. Similarly, patients receive service charges in the form of a bill, so the billing subsystem is accessible through the service and patient subsystems. (These two subsystems appear on a pull-down menu of the Patient command on the main menu bar in

TABLE B-6

SIGNATURES OF EACH CLASS

Class	Signatures
Patient Name	Get_PatientName(Text)
Physician Name	Get_PhysicianName(Text)
Treatment	Get_Treatment(Text)
Patient Bill	PrintBill(Text) returns (Boolean)
Insurer	Get_Insurer(Text)
Patient Balance	Get_PatientBalance(Currency)
Patient Service	Get_PatientService(Text)
Service Charge	Get_ServiceCharge(Currency)
Date Admitted	Get_Admitted(Date)
Expected Date Discharged	Get_ExpDischarge(Date)
Date Discharged	Get_Discharge(Date)
Physician Specialty	Get_PhysicianSpecialty(Text) Query_Physician(Text) returns Physician Info. Display
Room Accommodations	Get_RoomAccommodations(Text)
Patient Identification	Get Patient(Integer) Validate_Patient(Integer) returns (Boolean)
Patient SSN	Get_PatientSSN(Integer) Validate_PatientSSN(Integer) returns (Boolean)
Physician Identification	Get_PhysicianId(Integer) Validate_PhysicianId(Integer) returns (Boolean)
Room Phone Ext.	Get_RoomPhone(Integer)
Main Menu	Display_MainForm(Text)
Physician Phone Ext.	Get_PhysicianPhone(Integer)
Patient Information Display	Display_PatientInformation(Text) AddPatientRecord(Boolean) EditPatientRecord(Boolean) DeletePatientRecord(Boolean) ViewPatientRecord(Boolean) QueryPatientRecord(Boolean) SearchPatientRecord(Boolean) HelpPatientRecord(Boolean) Validate_RoomNumber(Integer) returns (Boolean)
Patient Bill Display	Display_PatientBilling(Text) AddPatientBillRecord(Boolean) EditPatientBillRecord(Boolean) DeletePatientBillRecord(Boolean) ViewPatientBillRecord(Boolean) QueryPatientBillRecord(Boolean) SearchPatientBillRecord(Boolean) HelpPatientBillRecord(Boolean)
Patient Treatment Display	Display_Treatment(Text) AddTreatmentRecord(Boolean) EditTreatmentRecord(Boolean) DeleteTreatmentRecord(Boolean) ViewTreatmentRecord(Boolean) QueryTreatmentRecord(Boolean) SearchTreamentRecord(Boolean) HelpTreatmentRecord(Boolean)
Room Utilization Display	Display_Room(Text) AddRoomRecord(Boolean) EditRoomRecord(Boolean) DeleteRoomRecord(Boolean) ViewRoomRecord(Boolean) QueryRoomRecord(Boolean) SearchRoomRecord(Boolean) HelpRoomRecord(Boolean)
Services Display	Display_Service(Text) AddServiceRecord(Boolean) EditServiceRecord(Boolean) DeleteServiceRecord(Boolean) ViewServiceRecord(Boolean) QueryServiceRecord(Boolean) SearchServiceRecord(Boolean) HelpServiceRecord(Boolean)
Physician Info. Display	Display_PhysicianInformation (Text) AddPhysicianRecord(Boolean) EditPhysicianRecord(Boolean) DeletePhysicianRecord(Boolean) ViewPhysicianRecord(Boolean) QueryPhysicianRecord(Boolean) SearchPhysicianRecord(Boolean) HelpPhysicianRecord(Boolean)
Service Identification	Get_ServiceId(Text) Validate_ServiceId(Text) returns (Boolean)
Patient Home Phone	Get_PatientPhone(Integer)
Patient Charge	Get_PatientCharge(Currency) Display_ServiceCharge (Currency)
Patient Contact Info.	Get_PatientContactInfo(Text)
Room Location	Get_RoomNumber(Integer) Validate_RoomNumber(Integer) returns (Boolean)

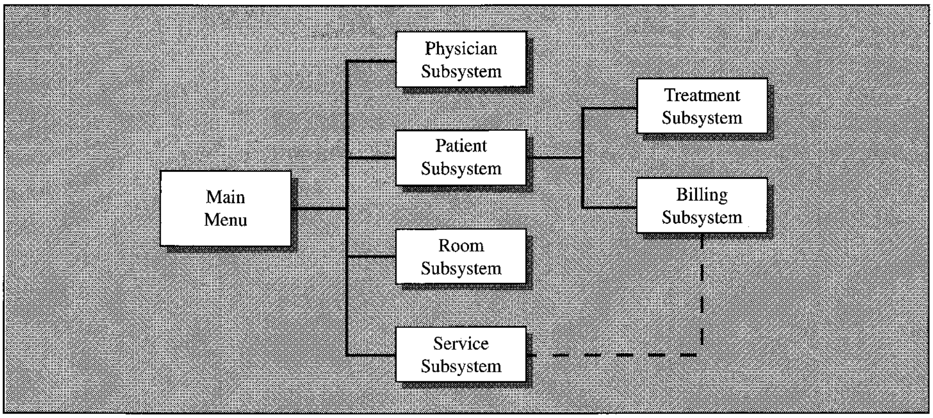


FIGURE B-2
Structure of the main menu.

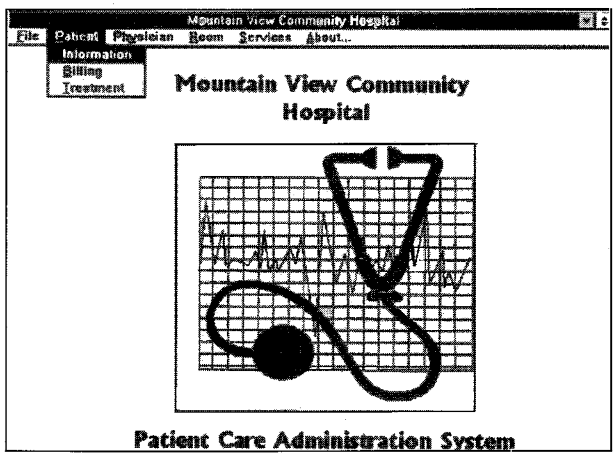


FIGURE B-3
The main menu screen.

Figure B-3.) In Figure B-4 the structure of the patient subsystem that displays the information is shown on the right side of the figure. Figure B-5 is a sample screen from the patient subsystem.

Other subsystems include one for the physician, which shows his or her specialization for patient treatment. The room subsystem shows room location within the hospital, phone extension, and the type of accommodations. The purpose of the service subsystem is to keep track of services performed by the hospital staff. The billing system shows each patient's original bill and the remaining balance. A treatment subsystem records services performed by physicians.

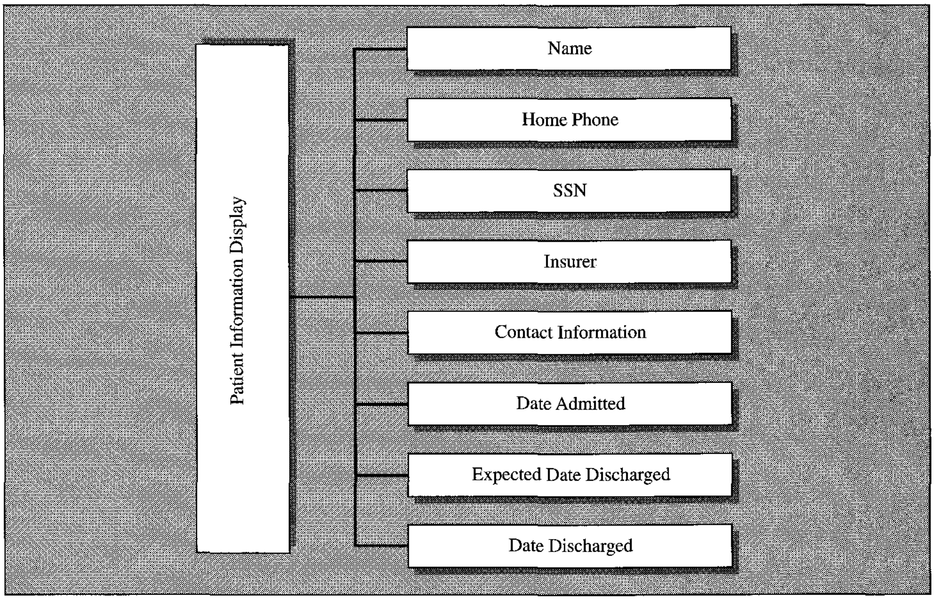


FIGURE B-4
Structure of the patient subsystem.

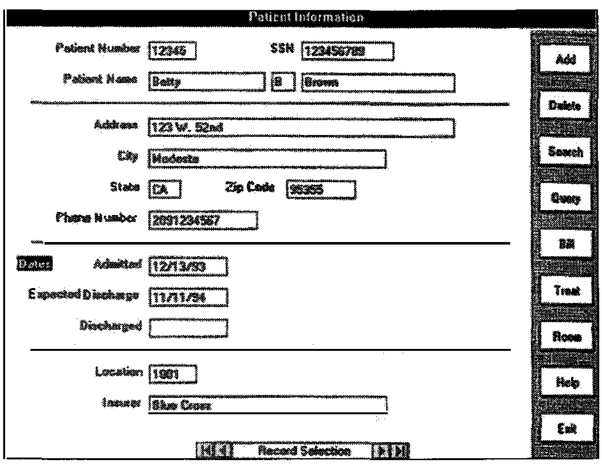


FIGURE B-5
A sample screen of the patient subsystem.

Observations

Object-oriented design is an approach that uses objects, classes, and messages to model processes in the real world. Objects can be both clients and servers in performing their roles. This approach to design is well suited to a client-server hardware and software platform, an increasingly popular architecture.

CHAPTER 17

Enhancing the Life Cycle: Packages and Other Nontraditional Techniques

Outline

Focus on Change

Applications that change the organization carry a lot of risk. Through nontraditional techniques, the manager can reduce some of these development risks. Of particular interest are techniques that reduce the time required to develop an application. Opportunities to undertake a new strategy, adopt a new business model, or respond to a competitor require a fast response. Development cycles of years are inadequate in these situations; the organization needs a way to deploy new technology in time to make a difference.

•

There are a number of problems with developing custom applications by following the systems life cycle. First, a great deal of time usually elapses before the user comprehends all the features of a system. It is very difficult to understand specifications. Usually it takes a significant period of time to progress from specifications to the first tests seen by the user. If the user did not understand the specifications or did not conceptualize all the features of the system, it might be more than a year from the time the application is first discussed until its characteristics become known through test results. In addition, the development of custom systems is associated with cost and budget overruns, particularly during the programming and testing phases. Today, with high levels of competition and rapid competitive response as the norm, most managers want results in a matter of months, not years.

In this chapter, we discuss a number of enhancements to the life cycle. The topics in this chapter are discussed in independent sections; however, you should not conclude that they are in some way exclusive. It is quite likely that you will develop a prototype using a high-level design tool. The prototype itself might turn out to provide a set of specifications for evaluating different packaged programs. All of these approaches are potentially interrelated and likely preferred to following the traditional steps in the systems life cycle.

FOR WHOM ARE THESE APPROACHES INTENDED?

It is easy to read the material in this chapter and think that it is relevant only to an information services professional. Why might you take an interest in the topics discussed here? First, it is likely you will end up developing some of your own solutions to information processing problems. Depending on the IS staff to meet all your processing needs often takes too long, and there are sometimes not enough IS staff members to answer all your requests.

Throughout the text we stress that companies are moving toward client-server architectures. You and other managers will be the clients using PC-based workstations to access data located on servers. Who will write programs for the client to use once it accesses the data? You may be very fortunate to have someone in the organization to create these programs, but it is more probable that you will develop your own programs using packages and high-level development tools.

Second, as a manager and user of systems, you want systems development to proceed quickly and successfully. The approaches described here can help reduce uncertainty in development and can increase productivity. You may want to insist on seeing a prototype of a proposed system. In fact, you may want to develop that prototype yourself to illustrate your vision for a new system.

Does anyone follow the systems life cycle? The systems life cycle has always illustrated the general approach designers take to developing systems. A working designer would not draw a lot of the distinctions in the life cycle but would think about the design while doing an analysis of the existing system. At some point, a team decides that a system was well-enough specified for programming to begin. The alternatives to a traditional approach of analysis, design, and programming discussed in this chapter alter or replace this series of steps. They are adopted to take advantage of advances in technology and to overcome some of the time and cost problems of the traditional life cycle.

HIGH-LEVEL DESIGN TOOLS

The need to improve productivity in developing systems has led to the development of new tools for building applications. The first of these languages appeared in the 1970s and became known as **fourth-generation languages (4GLs)** to contrast them with third-generation compiler-level languages like COBOL. These languages are often called **nonprocedural** because the programmer does not have to specify procedures in detail as with a third-generation language. Nonprocedural languages have commands at a higher level than languages like COBOL or C. A nonprocedural language may simply interpret a series of commands entered by the programmer and do what they indicate, such as sort records, summarize them on a field, and print a report.

One popular fourth-generation language is FOCUS. This language is able to create and manipulate databases. FOCUS is available on a variety of systems from PCs to mainframes. Its developer has created software routines so that it can serve as a central access point for data stored in a number of different **database management systems (DBMSs).** These languages have evolved into high-level system building tools such as PowerBuilder, a product designed for the client-server environment. Other higher-level design tools exist for developing applications for Intranets and the Internet.

Users of these very **high-level languages** report impressive benefits. An electronics firm programmed a new order-entry system using the fourth-generation language NATURAL in less than half the time it predicted would be necessary had COBOL been used instead. In addition, users are pleased because working at a high level makes it easy to make changes to the system. Users feel that the programmers working on order entry are the most responsive group in information services because they respond so quickly to change requests.

The major drawback associated with 4GLs is performance. Some firms found these languages are sufficiently less efficient than compiler-level languages so so as not to be useful in a heavy transactions processing environment. However, Morgan Stanley, a major investment bank, successfully rewrote its entire back-office system using NATURAL for processing all its routine transactions. On balance, a fourth-generation language appears to be a good approach for increasing responsiveness in development.

A Competitive Advantage through Micromarketing

The Target store on the eastern edge of Phoenix sells prayer candles, but no child carrier bicycle trailers. The Target store 15 minutes away in the affluent town of Scottsdale sells trailers, but no portable heaters. Heaters are located in the store in Mesa, 20 minutes away. If all of this sounds confusing, it makes sense to Target, a 623-store discount chain owned by Dayton Hudson Corporation.

Target is a master at "micromarketing," a high technology approach to customer service. The idea is to tailor merchandise in each store to its customers. Target has experienced rapid growth following this strategy. The average store has increased sales by 7 percent and Target has had an 11 percent increase in operating profits.

Buyers for the stores no longer believe that the best purchase is a large purchase. They may have to buy smaller quantities of tailored products. Buyers were convinced that they needed different merchandise in different stores as Target's sales of local team logos reached $100 million in the early 1990s. Some suppliers have to provide specialized products.

Micromarketing requires a large investment in information technology and takes sophisticated systems to stock thousands of different items in each store. The process starts with a computer-driven planning process in which buyers create merchandise assortments to fit the racial, ethnic, and age features of different groups of customers. Planners match the merchandise to the community profile, and local store managers refine the model based on their knowledge of local tastes. Target feeds actual sales data into the system to generate sales and profit tallies for each square foot of space. These results are used to allocate space to different products.

Information technology allows companies to deal with incredible levels of detail and complexity; it enables a store like Target to practice micromarketing.

GENERAL PACKAGES

We introduced packages in Chapter 14. In this chapter, we want to explore their use to speed development. There are a number of general packages in common use today, such as spreadsheets and database management systems, that offer an alternative for developing an application, especially for a small number of users working with PCs. Spreadsheet packages include the ability to record **macros,** a sequence of keystrokes which can be played back automatically. In addition to actually recording keyboard input and replaying it, elaborate macro languages exist for several spreadsheet packages. Microsoft has adopted a strategy of interfacing its office products to Visual Basic, a quite powerful programming language. Thus, from within an Excel spreadsheet, a user can execute macros written in Visual Basic.

Because Visual Basic and other macro languages are so powerful, you can develop extremely sophisticated applications using these general packages. One of my faculty colleagues uses an Excel spreadsheet to contain pictures of the students in his class and Excel macros to retrieve a picture and biographical information about each student. The disadvantage of these packages and their macro languages is that they are at a much lower level of detail than the commands typically used to build a spreadsheet. As a result, developing an application with these tools is a lot like programming, something that most users try to avoid.

Another general package that makes a great development tool is a database management system. Vendors of packages like Access and Oracle designed them for a range of uses and users. You can develop a simple application working directly with relational tables, doing each operation and updating information yourself. You can also use the languages with these packages to create input forms, update tables, and generate output automatically for a user who knows little or nothing about relational databases. The further you get into custom development, however, the more the tasks involved look like conventional programming.

DEDICATED PACKAGES

A package is one solution to the problems of custom systems design. We usually think of packages as software, but an increasing number of vendors sell both software and the hardware on which the software is run. Thus, a package can be thought of as a problem solution that is partially or completely ready to implement. The use of a package can dramatically reduce the time required to install a system by saving both design time and the effort devoted to programming. We can expect to spend far more than the cost of the package by the time it is installed, and it is unlikely that the package can be purchased one day and fully utilized the next!

It is important to realize that we are talking about dedicated packages in this section. The **dedicated package** is designed for a specific problem and is far less general than, say, a spreadsheet package. For example, a dedicated package for accounts receivable can be used for a variety of accounts-receivable operations, but that is all. It is useless for accounts payable or general ledger. With a dedicated package, you are buying much more of a custom solution to your problem; it is much less general and flexible than a package like a spreadsheet processor.

Advantages of Packages

There are a number of advantages to packages:

1. A package should require less total development time, since detailed programming specifications are not needed, and less programming than with a custom system.
2. In total, a package should result in lower costs, though it is not always clear that costs are lower by the time one learns how to use the package and makes modifications to it.
3. A package often has functions or extra features not found in a custom design.

MANAGEMENT PROBLEM 17-1

Jane Rollins runs a small investment firm that manages securities for a number of corporations and individuals. For example, Jane has her own stocks in two entities, one as an individual investor and the other in a trust established for her by a relative.

Each of the entities may own any number of different shares of stock. As shares are bought and sold, an exact record of the lot of stock, the number of shares, and the price at purchase and sale must be maintained. In addition, the bookkeepers at the firm must post all cash and stock dividends to each entity's records each time dividends are received.

All this processing is currently accomplished with ad hoc spreadsheet and database programs that staff members developed on their PCs. The staff is able to keep up, though it can take more than a week after quarterly dividends to finish posting. Closing the books at the end of the fiscal year and producing reports for the firm's accountants take a great deal of time and work. Also, it is not easy to answer Jane's questions when she asks about various entities' stock holdings, for example, how much AT&T stock is managed in total across all accounts.

Jane feels that she must use new technology to help her manage the business. "I have resisted change as long as I can, but I think we have to do things better." She is uncertain, however, on the alternatives. There are portfolio management programs available, but she has some unique requirements. She has a small number of very wealthy clients, so she needs a system that has a lot of room for holdings.

"Several that I have looked at are too small—they concentrate on large numbers of clients with modest holdings. I don't want to continue to develop spreadsheets myself or hire someone."

What advice can you give her on using technology in the firm?

4. If the package has been used in other locations, many of the programs included in the system have been debugged or at least run successfully in an operational environment.
5. From the standpoint of user understanding of a system, a package usually provides the opportunity to see in operation what one is purchasing before committing to its acquisition.

Disadvantages of Packages

While there are a lot of advantages to packages, there are some counterarguments that raise questions about this approach:

1. A package may not include all the desired functions.
2. As a result, many packages have to be modified before they are acceptable to users. Modification is difficult; it requires changes to existing code and may

be possible only through the vendor. Changing existing code can be expensive and is likely to introduce errors in the system. As with any programming endeavor, modifications also take time, reducing some of the benefits expected with a package from reduced development time.

3. To avoid making major changes in a package, you may elect to change procedures in the organization. Such changes are not always easy to accomplish and can be disruptive to the firm.
4. You become critically dependent on vendor support for the software. If the vendor is not viable, you may be left with software and no way to support it, that is, to have errors corrected, receive new versions, training, and so forth.
5. The package may not run on the kind of computer you would like to have. The package may necessitate the purchase of hardware, and that system may not be compatible with your existing hardware or overall plan for information processing in the organization.

Package Design

The vendor aims at producing a program that can be used in a large number of organizations. How can this generality be built into a system? There are four strategies:

1. The software includes a lot of input parameters or tables. For example, a manufacturing package must have tables to fill in the capabilities of each work center. The input tables and parameters allow each user to tailor the system to the environment.
2. Different **modules** are provided for different situations. Assume that a company is selling a registration package for universities. There must be a module to handle grades. The vendor might have separate modules depending on the type of grades used—A through F, 100 to 0, and so on. It is unlikely that the same institution would use more than one grading scheme so the appropriate module is included for each customer.
3. The vendor may expect the organization to change its procedures to use the package. Often it is pointed out that a small procedural change in the firm is cheaper than the alternative of program changes. For packages that address very similar applications across companies or industries, the organization might seriously want to consider making some of these changes.
4. The vendor may plan for custom tailoring and modifications for each customer. With this in mind, the package might be offered with a very flexible report writer so the desired reporting formats of each customer can be developed when the package is installed.

Some combination or even all of these approaches may be followed for any given package. Whenever a package is to be installed, the more dedicated it is to a given application, the more input will be required by users to describe their organization and environment.

Modifications may turn out to be the largest expense of the package, depending on how much programming is required. Some package vendors will not sell their source code; only the machine language is provided. Under these circumstances, we are totally dependent on the vendor to make any needed modifications. Are modifications that run 20 to 50 percent of the cost of a package justified? In one situation, the manager of a warehouse could not fill orders with the procedures included in a package. The package had to be modified. Otherwise, he could not use a procedure followed for a number of years of allocating products to preferred customers while shipping only orders completely filled by available stock.

Regardless of whether the vendor, an in-house programming staff, or some third party makes package modifications, there are precautions that should be taken to try to minimize future problems. One good strategy is confining modifications to certain modules. All changes should be carefully documented, with comments on the modified programs and external documents detailing the changes. Most packages go through continual revisions and improvements. If changes are made and not noted, the organization will be unable to install new versions because the staff will not know what modifications to make to keep the new version compatible with custom changes in the prior version.

A Classification Framework for Packages

The dedicated packages described above are generally easy to identify. They are devoted to solving a particular problem and cannot be generalized to another domain. A large variety of packages have been designed for different purposes and types of computers (see Figure 17-1). There is some debate as to what is a package and what is a language. We shall take a broad view and include several types of candidates for classification as a package. Packages are often developed for certain types of computers: large, midrange, or personal computers. Some experts refer to the first three categories listed below as "tools" because the user works with them to develop an application. These tools are used to develop an application in-house, as opposed to the previous alternative of a dedicated package. It is often the case,

FIGURE 17-1
Examples of packages.

Package type	Computer		
	Large →	Midrange →	PC
High-level tools	FOCUS	Oracle	PowerBuilder FOCUS (version for PC)
Systems software	DBMS	Oracle	Paradox, Access
Problem-oriented languages	SPSS, SAS	SPSS, SAS	Lotus 1-2-3, Excel, Quattro Pro
Dedicated	Accounts receivable	Garment system R/3 from SAP	Accounting

however, that the buyer has to modify a dedicated package, so it would be misleading to suggest that the dedicated package involves no in-house development.

High-Level Tools These languages and tools have statements that are at a considerably higher level than a third-generation language. These packages are not dedicated to a particular application but instead require the user to apply them to a problem. Some of the languages are designed for specific problem areas such as financial modeling, but quite a few are basically general-purpose.

Systems Software Software packages also exist that are designed for a specific purpose, such as a set of programs to provide database management or to control the interaction of a computer with terminals. These are **systems software** packages and can be quite general. DBMSs may follow the relational model, placing few limitations on the kinds of problems that these packages can solve. These programs may also be designed for just one computer or a small number of computers. Many would classify database management systems as systems software. Vendors of these packages often provide sophisticated development languages to create packages that are a lot like fourth-generation languages.

Problem-Oriented Languages Packages in this category are like higher-order languages in many respects but are aimed at a specific problem. SPSS (Statistical Package for the Social Sciences), which is used by nonprogrammers to analyze data, is an example of a **problem-oriented language.** An example of this package for Windows 98 is discussed in Chapter 9. Although a language, these statements are not difficult to learn, and many nonprofessional programmers use this package.

The popular spreadsheet packages in this category include Excel and Lotus 1-2-3. These packages make it possible to construct elaborate models and test their sensitivity to changes. Users reference cells in the spreadsheet through numbered rows and columns designated by capital letters. This ability to relate rows and columns using formulas gives spreadsheet programs their power. When data items are changed, the results for the entire spreadsheet are updated automatically. Spreadsheets are the most popular tool for building decision support systems, a type of system discussed in Chapter 21.

Dedicated Packages The last category in Figure 17-1 contains dedicated packages, systems devoted to a particular application. This group is experiencing explosive growth as more and more installations look at it first to buy before programming a custom system. This kind of package presents the greatest **implementation** challenge. There are dedicated packages for running franchise restaurants and managing production. Other examples include general ledger, accounts payable, accounts receivable, bank demand-deposit accounting, bank trust management, supply chain management, and so on.

These packages will most likely require modifications or changes in the buyer's procedures or both. They are not intended to be used as a language but are designed as an off-the-shelf substitute for a custom-designed and custom-programmed

Computers under the Hood

We have emphasized the potential of technology to dramatically change the nature of jobs. Such changes often require extensive training and may even demand a new kind of employee. As the cost of technology drops and a variety of computing devices becomes available, new areas for applications appear. Investments in technology help make high-priced labor more productive.

A good example of this kind of application comes from the General Motors Service Technology Group. This GM unit developed a service technician (no longer a mechanic) system called "Smart Mentor," to make the technician more productive. It is being tested at three Cadillac dealerships. The technician wears a small computer loaded with software to guide the technician through diagnosis and repair of a car. The technician carries the computer in a waist pouch and communicates with it through a headset. Input takes place through speech recognition, making the system very easy to use. The technician hooks a portable monitor to the bumper or fender of a car. The technician talks to the computer, which displays text, animation, and video instructions for diagnosis and repair.

In a typical exchange, the technician might say that a certain car has an electrical charging problem. The system displays a list of symptoms, and the technician indicates which ones the car exhibits. The computer diagnoses the problem, suggests tools, and displays a diagram of the area for repair. The system should help with the shortage of auto repair technicians and help them cope with the complexity of modern automobiles, especially their electrical and computer systems. GM had about 5000 pages of text in a 1965 service manual for a car; they now have 120,000 pages and soon will hit 200,000. Storing and finding repair information for the technician may be the Smart Mentor's biggest contribution.

system. The fundamental trade-off is to what extent you should (1) take the package as is, (2) pay to have the package changed, or (3) change company procedures.

Enterprise software systems like SAP's R/3 have also been discussed. These highly integrated software subsystems are the most extensive packages available. As discussed below, they are expensive, require a major installation effort, and are likely to change some of the basic operations of the firm that purchases them.

Packages have been around for a number of years, but three factors account for the increasing interest in this option for developing a system:

1. The cost of programming is rising, as are the risks of not completing a project on time and within budget. In addition, specifications and features are often compromised in a custom design, so the user ends up not getting everything that was desired in the specifications.
2. The packages themselves are getting better because many have passed through several generations of improvements.
3. The declining cost of hardware means that we can afford to run a package that operates inefficiently on the computer in order to save development time and cost.

FIGURE 17-2
The PeopleSoft home page.

An Example of a Package

SAP is one of the most successful enterprise software packages to date. The company claims to have 15,000 customers for its various software products, including 9 out of 10 Fortune 500 companies. It estimates that 200,000 people worldwide use one or more of its products, a very large number for a dedicated applications package.

The full suite of SAP products includes subsystems for production, accounting, control, sales/billing/inventory, treasury and ad hoc reporting. The original SAP system ran on mainframe computers, but its newest product, R/3, is designed for a client-server environment. The company also provides modules to facilitate electronic commerce using the Internet.

One of the major selling points for SAP is the integrated nature of its applications. A change in one application updates the database and is instantly reflected in another program. For example, if the credit manager increases a customer's credit limit, you want that information available instantaneously in order processing so that you can accept more orders from that customer. All transactions update the financial accounting records including the general ledger, balance sheet, and P&L statement.

As you might have guessed, implementing the full suite of R/3 applications is not a trivial task. The cost of implementation can be several times the cost of the software itself. SAP encourages customers to "reengineer" their processes so that they can use R/3. They discourage changes in the system, though SAP has opened R/3 to more customization compared to their earlier mainframe versions. It is safe to say today that what limits the spread of R/3 is the number of consultants who can help a firm implement the package. All the major consulting firms have "SAP Practices" to sell implementation help to clients. There are literally thousands of decisions that managers must make to "parameterize" the package.

MANAGEMENT PROBLEM 17-2

Jack Robinson manages the information services department for Sports World Manufacturing Company, a full-line manufacturer of sports equipment. He has just finished reading a proposal from one of the smaller plants for a complete inventory control and production scheduling package that runs on a local area network. The network would have to be acquired because the plant has no in-house production system at present. (There are some nonnetworked PCs in various offices.)

Robinson is concerned because his department operates a large mainframe computer that is not fully utilized. He wonders: How can I be sure that the new system will work? Is the package proven? What about the money we have invested in the mainframe? Is it wise to buy another computer given the fact that we have an underutilized system now?

Jack feels that he must respond to the request from the plant, and he is not sure what to do. He has asked for your help in defining the issues. Should his staff undertake a study to evaluate the package? He could compare the package with the use of a custom system on the mainframe, or he could look for a package with the same features that would run on the larger computer.

In addition to this request, Jack feels this is an important issue that will come up again in the future. Jack is concerned that the mainframe is "losing business" to midrange and to networked personal computers. He would like to develop a way to handle the problem when it recurs. What is your advice?

Despite the problems with implementation, SAP is an extremely successful package. The company is well on the way to establishing a software standard for processing the core transactions in an organization. Figure 17-2 is the home page for PeopleSoft, another ERP vendor.

Acquiring Packages

Choosing a package is not an easy task. First, you have an information processing problem. If it looks as though the application is dedicated, you should perform a systems analysis and design study. The study should be carried through to a high-level design for a new system containing outputs, the contents of the database, and inputs. This design becomes a benchmark against which to evaluate various packages.

In today's environment, you should not begin to look for hardware yet. Instead, it is time for research on possible packages. There are trade journals in the computer field that rank packages, and certain proprietary information firms keep listings of packages. Another good source of information is trade journals in the relevant industry. Finally, for software for personal computers, one can visit various computer stores and look at their documentation on packages.

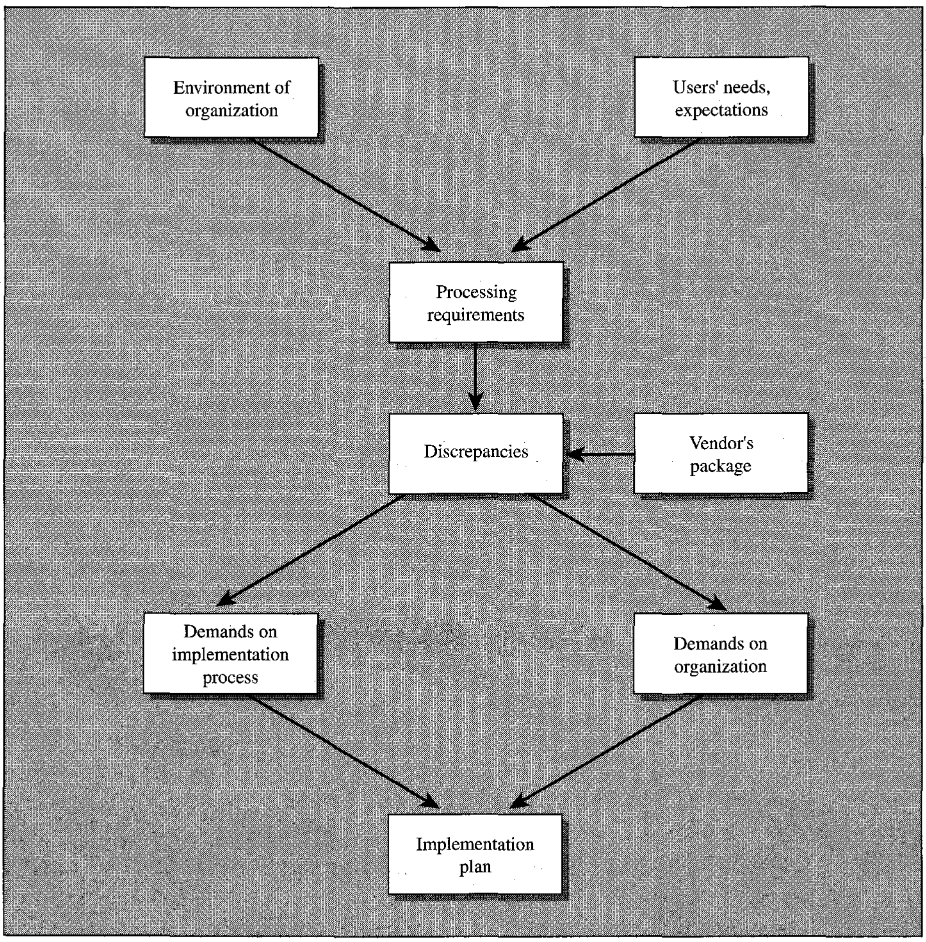
Evaluation of a package is difficult. It is important for users and the information services staff to understand the package in detail. You should be sure to see the package work and ensure that users understand what it will and will not do. Then you should estimate the extent of modifications and determine whether the package will really work in your environment.

Implementing Packages

Package implementation is not a trivial task. In certain respects it may be even more difficult than the development of a custom system. Refer to Figure 17-3, which shows a framework for package implementation. The environment of the organization, users' needs, and users' **expectations** about what the system should do all combine to create processing requirements.

The package vendor offers a solution to these requirements. It is unlikely that the package will exactly match the customer's requirements, giving rise to **discrepancies**

FIGURE 17-3
Package implementation.



A Package that Doesn't Fly

FedEx uses technology extensively in its operation; IT is key to its strategy of providing the best customer service in its industry. Every now and then, even a leader in technology has a bad day. One recent spring, FedEx implemented a package called the Optimizer, which schedules pilots to fly different routes. The package, developed by a company called Ad Opt Industries, Inc, is in use by Northwest, TWA, and UPS. It appears that the software worked as advertised, but that the human input from FedEx led to some very difficult pilot schedules.

Most airlines using such systems have very clearly defined work rules that govern the length and frequency of mandatory rest times between flights, the number of hours a day a pilot can fly, how long the pilot can be away from home, and similar conditions for scheduling. At FedEx these rules are not in a labor contract but are represented in more loosely written understandings. Lacking clear limits, the optimization program did what it was supposed to, it optimized the routes for efficiency.

Some of the resulting routes were efficient but at a great cost to the pilots. One 727 pilot found himself starting early one morning flying from Memphis to Oklahoma City. From there, the Optimizer sent him to a hotel in St. Louis, which he reached on a passenger jet. Eight hours later, he was airborne for Chicago; it then returned him to St. Louis and then back to Memphis. All of this flying took place in 27 hours. An international pilot found himself on a 12-day flight from Anchorage, Alaska, to Beijing to Memphis to the United Kingdom to Japan and then back to Alaska.

FedEx apologized to its pilots for its problems in implementing the Optimizer. However, the pilots, previously loyal to the company, thought management was trying to take advantage of a weak union. Anger at the scheduling program resulted in the company's 3500 pilots uniting behind the union and authorizing a strike vote just before FedEx's busiest period, the Christmas holidays. Buying a package does not always make implementation easier!

between the two. As an example, the customer may use eight-digit part numbers, whereas the package has provided for only six digits. During implementation, we must resolve these discrepancies, either through making changes in the organization or through special considerations in the implementation process. Finally, an implementation plan should be the result of the effort.

The vendor can help in package modification by providing flexibility in the design of the system. Database management systems to support the package, good query languages, and report generators to custom-tailor the output are all useful. Thorough documentation is very important, as is consulting help during implementation. A number of vendors also offer telephone hot lines to answer calls from users who have problems.

It may appear to users that they do not have to become involved since a developed package is being bought. In all likelihood, users will be more involved in the acquisition of a package, or at least more intensely involved over a shorter period of time, than with custom development. We must be sure that the requirements analysis is complete, that users in fact define processing requirements. The users also must understand in detail how the package works and think about it in terms of their present job environment. They must provide help in outlining the discrepancies and in deciding how they are to be resolved through changes in the package or in company procedures. There have been just as many examples of package implementation disasters as disasters with custom systems!

Conclusions

Packages are increasingly important in systems development. It is too costly to develop systems with custom programming if a package exists that will work for a given task. Most CIOs today prefer to find a package rather than develop a custom-programmed system. Remember to develop specifications on requirements at least at a high level before talking to a package vendor. It is very important to have a basis for comparing all the different packages and to avoid being swayed by features that one really does not need or want.

PROTOTYPING

The objective of prototyping is to reduce the time needed to develop requirements for a system. The traditional design approach features an analyst who

MANAGEMENT PROBLEM 17-3

Bob Harris is manager of systems development for Atlantic Manufacturing Company. This firm makes a variety of tools for home craftsmen and professional carpenters, mechanics, and other tradespeople.

Bob is reviewing a request from one of the plants for an integrated production scheduling and control system for shop-floor control. This particular plant manufactures hand tools. The tools are relatively simple, ranging from four or five parts to fifty parts in a completed tool. Although the number of parts is relatively small, the volume at the plant is quite high, and scheduling is a problem because a tool can be made in a number of different ways. The plant is the classic "job shop," as opposed to an assembly line.

Harris has just returned from a two-day professional seminar on prototyping, and he is eager to try this new approach to systems development. The request in front of him has raised the possibility of trying prototyping for the first time at Atlantic. Harris has discussed the idea with two other analysts. They, however, were quite skeptical. "The system would be so large that we would need conventional specifications and design," one advised. The other asked, "How can we build a prototype of a system this complex?"

Where do you think prototyping could be used for this suggested application?

spends time with users to elicit requirements. The analyst prepares specifications, which are given to the user to approve. Most users seem to have difficulty comprehending the specifications. As a result, it may not be until the testing stage that the user first gains an understanding of how the system will or will not work.

A **prototype** is a model of a system that will eventually be developed. Its purpose is to do the following:

1. Reduce the time before the user sees something concrete from the systems design effort
2. Provide rapid feedback from the user to the designer
3. Help delineate requirements with fewer errors
4. Enhance designer and user understanding of what systems should accomplish
5. Bring about meaningful user involvement in systems analysis and design

A prototype does not have to be real. For example, an architect's model of a building made from card stock is a representation of the building. Part of a system can be "dummied" using sample data, and output can be incomplete. The prototype may become a living specification that is constantly changed as the prototype is refined. In fact, the prototype may grow into the final system without even the development of detailed specifications!

The external appearance of the prototype must be very clear. As an example, the prototype for a transactions processing system is likely to provide a fixed set of screens that accept input from the user, process it, and possibly return output. The full logic of the system has not yet been developed, so there will be restrictions. However, there should be enough of a system present that users can understand how the final version will operate.

How to Develop a Prototype

It is important that the prototype be developed quickly and that feedback occur in a timely manner. The actual development process is likely to be a sequence of activities (see Figure 17-4).

1. The designer meets with the user.
2. The user describes the system.
3. The designer builds a prototype.
4. The user works with the prototype and critiques it.
5. The designer modifies the prototype or starts again.
6. The process then returns to step 1 or 4.

Changes here should be encouraged, not discouraged! We choose the prototyping approach because a set of system specifications is usually very abstract to the user. The prototype makes the system come alive. We want users to interact with the system and make it into what they would like to have. To accomplish the objective of rapid development, the designer will need to use one or more tools to develop the prototype.

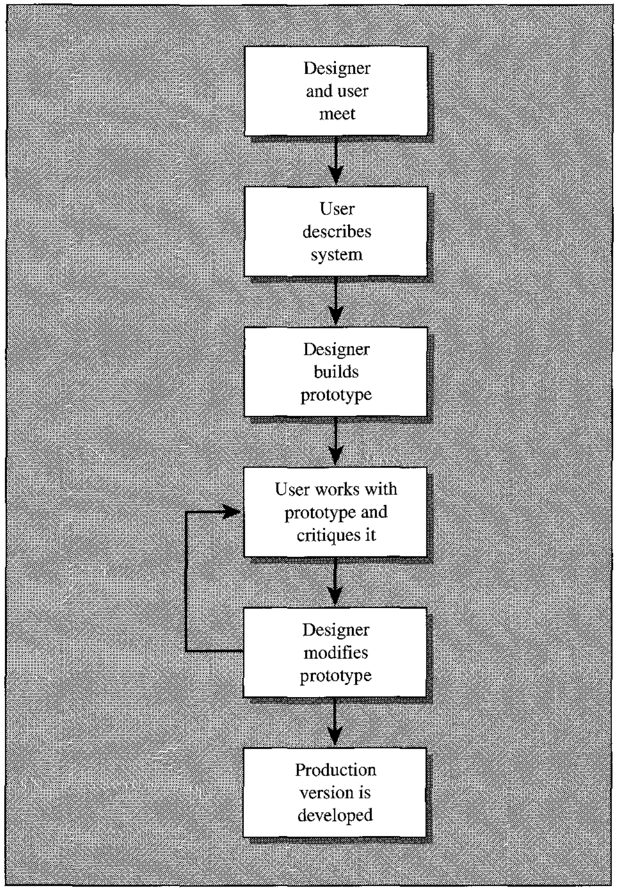


FIGURE 17-4
The prototyping process.

Software The designer can use any one of a variety of tools for developing a prototype, for example a high-level development tool (like PowerBuilder), a conventional programming language enhanced to make developing graphical user interfaces easier (like Visual Basic), or a database management system (like Microsoft's Access). These systems make the task of developing and modifying data structures much easier than is possible with most programming languages. High-level programming languages and the ability to record your keystrokes and replay them (macros) make it possible to develop prototypes quickly.

Effective programming and development tools are a requirement for prototyping. Remember that the prototype begins as a model. It does not have to include any of the editing and error-checking of a finished system. The purpose of the exercise is to show what can be accomplished, not to demonstrate that a system is complete.

An Example

The firm that developed the following system offers services throughout the world. The firm was investigating a change in its ownership. It is owned by its employees, but new U.S. legislation made some alterations potentially attractive in ownership structure. The vice chairman of the board asked the manager of the information services department to develop a small system to project the financial position of the firm several years in the future if the new form of ownership was adopted.

At first, the IS department manager simply wrote a small program in BASIC to model the plan. The output of the model formed one part of the recommendations made to the board of directors. After that meeting, at which the new plan was adopted, several managers noted the ability of the computer to forecast. One of them asked the IS department manager if it would be possible to forecast the benefits an employee would have several years in the future.

The industry is competitive, and firms frequently hire staff from each other. Because there are a variety of stock and benefit plans, it was difficult to show an employee the total value of remaining with the company. The information services staff began to work on this problem with help from different personnel and financial managers. Various formulas were programmed and the results checked by different groups until the rules were regarded as satisfactory.

The manager of the IS department had a feeling that the system would grow so he had the staff develop it using database management software. The treasurer kept most of the data needed on benefits available to each individual, and he became very interested in the system. Computing bonuses took a long time and required heavy overtime. In general, records for each employee were scattered over several files, and reports were often inaccurate. The treasurer asked that the system be made capable of maintaining all employee records and benefits. Because of the database approach and good development tools, it was fairly easy to meet his requirements. The system has evolved into a comprehensive personnel records and benefits application.

This system succeeded because it was able to grow and change over time. As users saw new features, they developed ideas for extending the application. The primary user changed from the president, who had originally requested the projection system, to the treasurer. The application had high visibility, and senior management provided extensive input.

The use of tools was also very important in the success of this effort. High-level languages, screen development aids, and a database management system made it possible for the system to evolve. In addition to intensive user involvement, the analyst working on the application listened carefully and followed the logic defined by the users. She brought the results back to them, and the managers actually debugged their own rules. By not trying to be in charge of everything, the analyst was able to develop a system with which users felt comfortable because they understood the details of how it worked.

Not every system could be developed in this manner. In other circumstances, there might be a need for concrete specifications. However, the use of prototyping to show users what the system will do should be applicable across a wide range of settings.

TABLE 17-1

A COMPARISON OF DEVELOPMENT APPROACHES

Environment	Mainframe or midrange	Client-server	Internet/Intranet	Desktop	Groupware (Chapter 21)
			Buy		
Package	×	×		×	×
Outsource	×	×	×	×	×
			Make		
Life cycle or spiral model	×	×			
Fourth-generation language	×	×			
Prototype/RAD*	×	×	×	×	×
User-developed (Chapter 20)			×	×	×

*RAD: rapid application development.

Prototyping is a very effective way to improve the requirements definition phase for a system. The approach appears to be good for attracting users to the design process and obtaining their involvement and input. Done properly, it should result in systems that more closely fit user needs and that are completed more quickly with fewer operational changes required.

A RANGE OF ALTERNATIVES

We have seen a variety of ways to develop new technology in the text. The approaches open to the manager are shown in Table 17-1. The firm may develop an application for a mainframe or midrange computer, a client-server environment, an Internet or Intranet, for a desktop user, or a groupware application (discussed in Chapter 21). The table divides approaches into "make" or "buy," with the buy option being a package or outsourcing. (Of course, in the "make" option, one might start with a package and modify it extensively.)

The ×'s in the table illustrate likely choices. For example, one might use a fourth-generation language to develop a midrange or client-server application; you would probably not find a 4GL for groupware applications. Applications developed for Internets and Intranets are generally developed quickly and are unlikely to follow a life cycle as such. A difficult task for managers and systems professionals is to determine the suitable development environment for a new application of technology and then choose an approach. The nature and goals of the application are the primary determinants of which cell in Table 17-2 is chosen.

TABLE 17-2

COMPARISON OF THE ALTERNATIVES

Pros	Cons
Higher-level languages and tools	
Very-high-level statements, claims for high productivity, ease of use, speed of development and modification	Can be inefficient in processing OLTP applications, expensive, proprietary, depend on single vendor
Package program (general)	
User often develops solutions	Can be a lot like programming
Package programs (dedicated)	
Avoid custom programming, faster implementation, debugged programs, more features than custom system	May have to change package or procedures
Prototyping	
Users see immediate results, good for motivating involvement and feedback, reduce risk of misdesign	Time to develop, cost, may be seen as slowing progress

For example, an entirely new enterprise application today suggests the use of a package and external consulting help. An idea to make the specifications for your products available to customers seems a good fit for the Internet. It is important for managers to be aware of the options and participate in making decisions about development alternatives.

CHAPTER SUMMARY

1. In many cases, management and the design team may adopt an alternative to custom development of a system following the traditional life cycle model of the last chapter.
2. The objective of alternative techniques is to reduce the time required to follow the systems life cycle and to provide early feedback to users.
3. Table 17-2 describes the pros and cons of the different alternatives and suggests that advantages from these techniques do not come for free.
4. Higher-level languages and design tools make more efficient use of human time at the cost of some inefficiencies in execution.
5. A general package program, like a spreadsheet, offers a number of tools for developing custom applications. These tools, when explored in detail, look a lot like conventional programming languages.
6. A dedicated package is designed to let the user eliminate custom programming.
7. The selection and implementation of a dedicated package is challenging. Often the organization or the package must change in order to work successfully.

8. Prototyping is an excellent way to generate user input in the design process. We recommend that, where feasible, the designer develop a prototype for different parts of any system under development.
9. The prototype may serve as a model and partial specifications for the final system, or it may evolve into the final system itself.
10. These techniques will improve the systems development process. However, they will not produce the order of magnitude improvement in development efficiency that the profession so badly needs.

IMPLICATIONS FOR MANAGEMENT

Personal computers and their associated software packages make it relatively easy to prototype all or part of a system. A prototype is the best way to focus users on what a system will do. It is much more riveting than a set of specifications on paper. One of the real problems in design is a lack of communication between the designers and the users and managers specifying the system. A prototype helps users think about how they will do their jobs with the new system. If you are evaluating packages, you will also want to see the package at work in some other company to see if it is a good fit with your environment. A "picture" through a prototype or product demonstration is worth a lot of words.

KEY WORDS

Database management system (DBMS)
Dedicated package
Discrepancies
Expectations
Fourth-generation language (4GL)
High-level languages
Implementation
Macros
Modules
Nonprocedural
Problem-oriented language
Prototype
Systems software

RECOMMENDED READING

Baskerville, R.; and J. Stage. "Controlling Prototype Development Through Risk Analysis," *MIS Quarterly.* 20, no. 4, 1996. (A helpful article describing the pros and cons of prototyping approaches to system design.)

Harrison, M. *Prototyping and Software Development.* New York: Springer Verlag, 1998. (A good introduction to prototying techniques in software development.)

Kleper, R.; and D. Bock. "Third and Fourth Generation Language Productivity," *Communications of the ACM.* 38, no. 9 (September 1995), pp. 69–79. (An interesting study of productivity and language used in a number of projects at McDonnell Douglas; there appear to be productivity advantages for 4GLs.)

Leach, R. *Software Reuse: Methods, Models, and Costs.* New York: McGraw-Hill, 1997. (A nontechnical guide to successful software reuse across the life cycle.)

Montazemi, A.; Cameron, D.; and K. Gupta. "An Empirical Study of Factors Affecting Software Package Selection," *Journal of Management of Information Systems.* 13 no. 1 (Summer 1996), pp. 89–106. (An interesting article that empirically tests factors influencing software package selection.)

DISCUSSION QUESTIONS

1. What is the primary motivation behind the use of higher-level languages?
2. How does a query language such as the ones found in DBMSs reduce programming?
3. What are the advantages of using a PC DBMS in prototyping?
4. Should you be concerned if high-level tools use the computer inefficiently? Why or why not?
5. Why are some very high-level languages called nonprocedural?
6. What are the advantages and disadvantages of using a spreadsheet package for applications development?
7. How can it be faster for a user to write a program using a high-level tool than to have a professional programmer prepare the report?
8. How is a dedicated package different from a general-purpose one?
9. Will the tools in this chapter eliminate the need for professional programmers?
10. How would you locate several dedicated applications packages for evaluation and selection?
11. Is there still a place for writing custom programs in applications development?
12. Why has the progress in developing faster and cheaper hardware been so dramatic, while productivity in systems development remains so low?
13. To what extent should users develop applications using tools like spreadsheets and DBMSs? What are the pros and cons of this approach to development?
14. What are the special implementation problems of a dedicated package?
15. Under what conditions should an organization change its procedures to use a package?
16. Why are more companies looking first at dedicated packages rather than custom development for new applications?
17. How do packages reduce development time for a system? How can packages lower costs?
18. What are all the costs associated with a package beyond the purchase price?
19. In buying a package, does one always get debugged programs?
20. Why should one insist on a demonstration of a package?
21. Why might a package not include some of the functions you want?
22. Why is a vendor reluctant to change a dedicated package for one customer?
23. Why is it important to control changes to a package carefully?
24. Why should you still develop a set of high-level specifications even if you are thinking about acquiring a dedicated package for a new application?
25. Is a large organization likely to change procedures or change a package? Why might a large firm have more need to modify a package than a small one?

26. How can a package vendor design a package to be flexible?
27. Why might the programming staff be opposed to the use of packages?
28. Is accounts receivable in every firm likely to use the same type of application? What characteristics might differ among companies?
29. What is the user's role in determining whether to acquire a package?
30. Develop an implementation strategy for R/3.
31. Why is a package a more viable alternative to a custom system today than it was 10 years ago?
32. What are the advantages of prototyping? The disadvantages?
33. How does a prototype for a computer system differ from an architect's model? How are they similar?
34. Why does a prototype need to be developed quickly?

CHAPTER 17 PROJECT

Examine Software Packages

SAP's R/3 is the most successful enterprise software package. Competitors in this market include Oracle, PeopleSoft, and Baan, to name a few. Find a company near you that has installed one of these systems and arrange to interview a senior manager and someone in the IT area who worked on the project. Try to identify the resources that the firm originally estimated it would need to buy and to install the system and also the extent to which the firm expected to change its procedures. Then ask the same questions for what really happened. How far off were the original estimates? Can you describe the changes in procedures required to install the software? What problems occurred during installation? Did the company try to make any changes to the software or have the vendor do it? How long did the entire project take? How does the actual time required compare to initial estimates? Based on your research, develop recommendations for installing enterprise software for a company.

Reengineering: Changing Businesses and Business Processes

Outline

Focus on Change

Reengineering is about change. The original idea was to "obliterate" a process rather than try to improve it. The designer asks the fundamental question: Should the organization continue with this business process? If so, how can it be dramatically improved? One hopes for an order of magnitude improvement in performance as a result of reengineering. The discussions early in the book, especially Chapter 4, suggest that you can use IT to change structure, moving toward the

T-Form organization. In this chapter you will see examples of two firms that have reengineered the entire organization rather than a single business process.

WHAT IS REENGINEERING?

In the early 1990s, one of the most popular management topics was business process redesign, or **reengineering.** Discussions of reengineering have peaked, probably because so few firms experienced success in their reengineering efforts. We shall discuss some of the factors that are responsible for success and failure in business process redesign later in the chapter.

The following is a good definition of reengineering:

> Reengineering is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed. (Hammer and Champy, 1993)

This framework has four key words:

1. *Fundamental.* Why does the firm do things a certain way?
2. *Radical.* Get to the root of a process. Look for reinvention as opposed to making superficial changes or minor enhancements to what is already in place.
3. *Dramatic.* Reengineering is not about marginal or **incremental improvements,** but rather it focuses on achieving quantum leaps in performance. Results like a 10 percent improvement are not reengineering.
4. *Processes.* Traditional design often is centered on tasks, jobs, people, and structures. Reengineering looks at a business process that is a collection of activities that takes one or more kinds of inputs and produces some output of value.

In an earlier article, Hammer described the spirit of reengineering as "obliterating" rather than automating. He argues that systems developers too often simply automate existing processes without thinking about the need for **radical change.** What does "obliterating a process" mean? Does one have to achieve an order of magnitude gain to claim a reengineering success? What are the likely impacts of a successful business process redesign effort on the organization? Figure 18-1 suggests that these characterizations of business process redesign are really endpoints on a continuum. Reengineering and radical change are on the right-hand side of the continuum; small enhancements or incremental improvements in a process fall to the left. (Possibly obliteration is off the scale on the right!)

It is very likely that the middle of the continuum represents an area of maximum work for minimum payoff. This middle ground is a place designers should avoid. One contribution of reengineering is to call management's attention to the fact that designers should concentrate on incremental improvements or the radical redesign of processes. Working in the middle ground often results in high expenditures to automate an existing, inefficient process.

If reengineering creates such dramatic gains, why would the organization ever be satisfied with incremental improvements? First, managers should always be

Enterprise Systems

There is great interest in "enterprise systems." These systems offer solutions to all the major processing tasks in an organization. They have appeal for a number of reasons: The programs are already written, they are debugged, and they can be implemented in a shorter time than writing your own software. There are, of course, a few disadvantages. First, the vendors do not like to change their code, and the customer loses some of the benefits of the packages if he or she does a lot of modification. As a result, the vendors encourage the customers to change their procedures to fit the software. These systems are large, and implementing them is not trivial; SAP has some 8000 configuration tables that must be completed to install the system for a particular customer.

PeopleSoft is another enterprise software vendor. A list of their major subsystems provides a good overview of enterprise software:

Distribution: focus on supply chain management

Manufacturing: encompasses engineering, production planning, cost management, bills and routings and production management

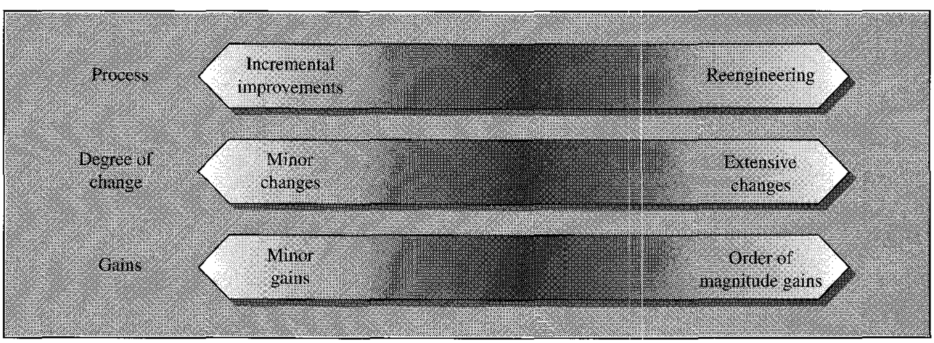
Financials: includes general ledger, payables, receivables, asset management, project management, budgets, expenses, and treasury

Human resources management: focus on personnel administration, recruitment, training, career planning, compensation, health and safety, regulatory requirements, and benefits

Enterprise software from PeopleSoft, SAP, and Oracle has been very successful as managers decide that the effort to implement the package is acceptable if it results in a comprehensive system that can be used sooner rather than later.

Do you think the installation of these systems mandates reengineering? Why or why not?

FIGURE 18-1
Avoid the middle ground.



looking at ways to improve work processes. Second, reengineering often results in dramatic reductions in the workforce and demands more work from those remaining. Management has to balance its obligation to improve processes against the firm's responsibility to its employees.

Working on the reengineering side of the continuum is risky. Changes of great magnitude may even appear to some as doing violence to the organization. When management selects reengineering over incremental improvement, it is taking greater risks in the hope of obtaining greater benefits. In fact, if one takes a more historical view, the evolution of applications systems can be characterized by on-going incremental improvements punctuated by major reengineering efforts.

WHAT IS A PROCESS?

Most of our discussion to this point has focused on the structure of the organization and how IT design variables can be used to change structures. The main contribution of reengineering for us is to focus attention on **processes** as opposed to structures. What is a process, and how is it related to structure?

One of the fundamental processes for a firm that sells a product is order fulfillment. Picture a mail-order firm in which operators take orders when customers call on a toll-free number. The order-entry department is responsible for talking to customers and entering their orders into a computer system. The sys-

MANAGEMENT PROBLEM 18-1

Betty Adams read several books and articles about reengineering. She is wondering how to apply it to her own areas of responsibility. Betty is executive vice president of Preferred Life Insurance, a medium-sized company that offers a range of life and health insurance policies, primarily to various professional associations like electrical engineers. She, like others in the company, has been concerned for some time about the rising costs of health care and the company's processing costs.

A recent study showed that a typical health claim took three weeks to process. Preferred Life Insurance plans to launch a managed care product where it contracts with doctors in health maintenance organizations. A client's primary care physician receives a capitation fee monthly, a kind of retainer. Clients pay a flat fee for health coverage. Betty thought about the plans for this kind of service and the processing that would be required. She wondered if something radical was necessary to take advantage of this kind of system where the insurance company had contracts with doctors and hospitals.

Sketch the plans for a managed care network. Can you scale your plans up to a national health program?

tem checks a "book" inventory to determine if the goods requested are available. If so, it produces a picking list for the warehouse staff to use in completing the order. If the requested merchandise is out of stock, the system notifies the purchasing department that it is time to reorder, and it creates a backorder on the system so that it can fill the order when a new shipment arrives.

This brief scenario describes the order fulfillment process, a process that cuts across at least three departments in the structure of the organization: order entry, warehousing, and purchasing. Business process redesign is likely to employ four or five of our IT design variables from Chapter 4. The radical reorganization of a process is likely to result in technological leveling as technology is used to reduce the need for multiple layers of management related to a process. Reengineering is often associated with production automation and electronic workflows as well as virtual components. It may also introduce technological matrixing in the redesigning of business processes.

REENGINEERING A PROCESS AT MUTUAL BENEFIT LIFE

One of the early examples of reengineering was at Mutual Benefit Life Insurance Company. Before business process redesign, Mutual Benefit Life (MBL) processed life insurance applications in a long, multistep process that included credit checking, quoting, rating, underwriting, etc. An application might go through 30 steps across five departments with up to 19 people involved. Typical turnarounds ranged from 5 to 25 days. Another firm estimated that a life insurance application spent 22 days in process for 17 minutes of actual work.

To redesign this process, MBL used computer networks, databases, and an expert system to make information and decision support available to employees. It created a new position called a case manager who is a *process owner.* This person acts as a case manager and has total responsibility for an application from the time it is received until a policy is issued. Files are no longer handed from one person in a chain to another across departmental boundaries. Case managers are able to perform all the tasks required to process an insurance application because they have technology to help them. An **expert system** provides advice while their PC-based workstation connects to a variety of databases and applications on a mainframe computer.

What were the results? MBL can now complete an application in as little as four hours, and the average time to turn around an application and issue a policy is two to five days. The company was able to eliminate 100 field office positions while its case managers can handle nearly twice the volume of applications MBL could previously process. It is a sad footnote that MBL's investment performance was not as good as its reengineering; the State of New Jersey assumed control of the company. One has to be able to manage all aspects of the business to be successful!

This example shows the use of **production automation** in which workstations provide the information needed for an individual to make a decision. The workstation, mainframe computers, and network create a *virtual applications processing* *work flow* for each case worker. He or she has access to credit checks, quotations, ratings, and underwriting electronically rather than physically.

REENGINEERING A PROCESS AT MERRILL LYNCH

Merrill Lynch is the largest brokerage and financial services firm in the United States with over 500 branch offices. The objective of the securities processing operation is to receive certificates from customers, perform the proper processing of the certificates, and post data to customer accounts (Lucas, Berndt, and Truman, 1996).

A very high-level process flow consists of the following steps:

1. The customer brings documents to a branch office.
2. The branch does preliminary processing.
3. Certificates are sent to a processing center.
4. The center verifies and checks the certificates.
5. The center processes certificates.
6. The center posts data to the customer's account.

Almost Reengineering

Fidelity Investments is the largest financial mutual funds firm in the US. The company has tried to revolutionize personal investing and its own operations. The company developed a huge mailing plant in Covington, Kentucky. While most firms consider the mailroom a backwater, Fidelity has managed to keep its costs low by focusing on all the details of its operations. It regards mailing as a core process for retaining customers. The company has spent over $100 million on its facility, a 188-acre office park.

The plant runs 24 hours a day, seven days a week to generate 140 million pieces of mail in a year, more than double that of Vanguard Group, its closest rival. The warehouse consists of 256,000 square feet of space. Robots retrieve prospectuses while specially built conveyor belts and carousels controlled by software move materials through the huge rooms in the center. Intercommunicating computers coordinate the process.

Fidelity stresses customer service; it promises that items requested by phone one day will be mailed the next. All requests for information one day are sent electronically at 2 A.M. to the Covington plant. Computers download the names and addresses of those requesting material into ink jet machines that address the cover page and add metered postage. Machines optically read the zip code, spray on a Postal Service bar code, sort the mail, and distribute it to different trays. About 90 percent of the mail goes directly into Postal Service trucks and to the airport, bypassing the local post office.

Is this a reengineering project? It compares favorably with the Merrill Lynch imaging system discussed in the chapter. To constitute obliteration, however, Fidelity will have to convince all its customers to use its Web site and print their own materials; then they can get out of the printing business!

On a typical day, Merrill Lynch offices around the U.S. receive some 3500 securities that need processing of some kind. What are some of the reasons for customers bringing securities to a branch office?

1. The customer has sold the stock and must surrender it so shares can be issued to the buyer.
2. A person has inherited stock and must have the shares registered in his or her name.
3. A company has reorganized and has called its old stock to issue new shares.
4. A bond has been called by the issuer.
5. A customer wants Merrill to hold his or her securities.

The Old System

The customer brings the security plus other supporting documents to the branch office cashier. The cashier provides a receipt and "batches" all the securities together to be sent for processing. Before the development of a new process, the branch would send these documents to one of two securities processing centers (SPCs), either in Philadelphia or Chicago. (See Figure 18-2 for a high-level DFD.)

The objective of securities processing at the centers was to credit the customer's account as soon as possible, certainly within the 24 hours suggested by the Securities and Exchange Commission. Because of exceptions and the possible need to contact the customer again, sometimes it was not possible to achieve this goal. A good example of problems is in the area of legal transfers when someone inherits stock. There are requirements for supporting documents like a death certificate. If the customer does not bring the documents and the branch does not catch the fact that a necessary piece of paper is missing, the securities processing center must contact the branch and ask them to contact the customer.

Because many of the securities are negotiable, the security processing centers must be extremely careful in processing. Merrill Lynch is required to keep an accurate audit trail whenever it moves a security. This requirement led to frequent, repeated microfilming of securities as they moved around a center.

To the Merrill Lynch financial consultant (FC) or broker, the securities processing task seemed to require an inordinate amount of time and lead to numerous problems. (There are some 15,000 FCs at Merrill.) The branch operations staff had to continually monitor accounts to see if securities were credited properly. FCs were forced to contact clients to obtain additional documents. There was a great deal of friction between the sales side of the business and the securities processing department.

All of these reasons plus the labor-intensive nature of processing led to a desire to improve securities processing. The most radical approach would be to obliterate the process entirely. Unfortunately, this option is out of Merrill Lynch's control. While there has been much publicity about "book entry" shares of stocks, there still are a large number of physical shares of stocks and bonds in circulation. Obliterating the process would require industry-level and government cooperation to eliminate all physical certificates, replacing them with an electronic record. This

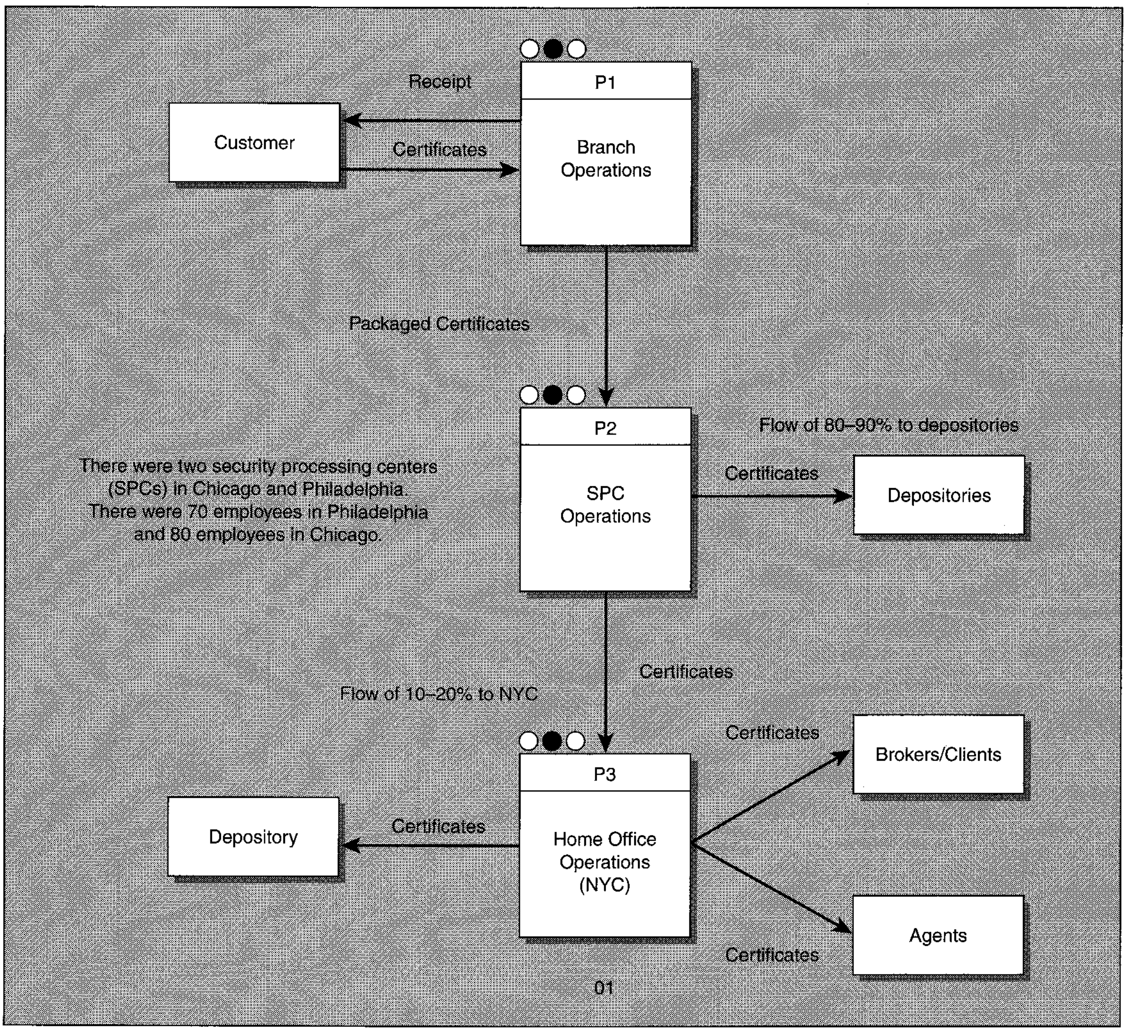


FIGURE 18-2
SPC overview.

solution would also require consumer acceptance and a massive effort to electronically record and eliminate all existing paper certificates.

After suggestions by the operations staff and extensive research, the systems group at Merrill Lynch proposed a new process using image technology to capture an image of the security certificate and related documents that accompany a transaction. The focus of the project was on work-flow redesign, not just the use of image processing. Work-flow redesign involved the closing of the two processing centers described above and the development of a securities processing department at a single site in New York (now New Jersey).

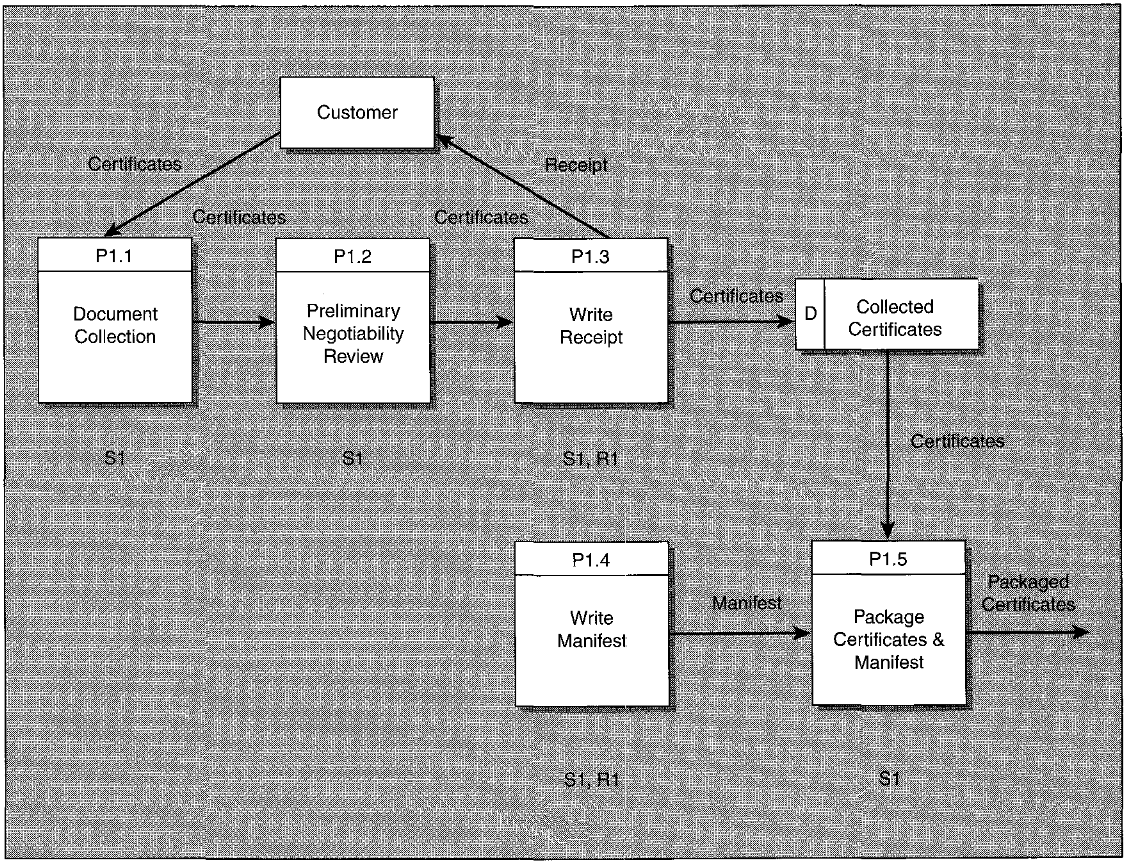


FIGURE 18-3
Branch operations.

In the old process, customers brought securities and supporting documents to a branch office or sent them to Merrill through the mail. This set of documents will be referred to as a "certificate," the terminology used at Merrill Lynch. After receiving the certificates, the branch conducted a manual review for negotiability. If this preliminary review verified that the security was negotiable, a clerk typed a receipt for the customer. If the certificates appeared not to be negotiable, the clerk told the customer what additional information was necessary to complete the transaction (see Figure 18-3).

During the day, several branch clerks accepted certificates and accumulated them. At the end of the day, a courier took all certificates to one of two SPCs in Philadelphia or Chicago. The clerks attached a manually prepared manifest to the package summarizing its contents.

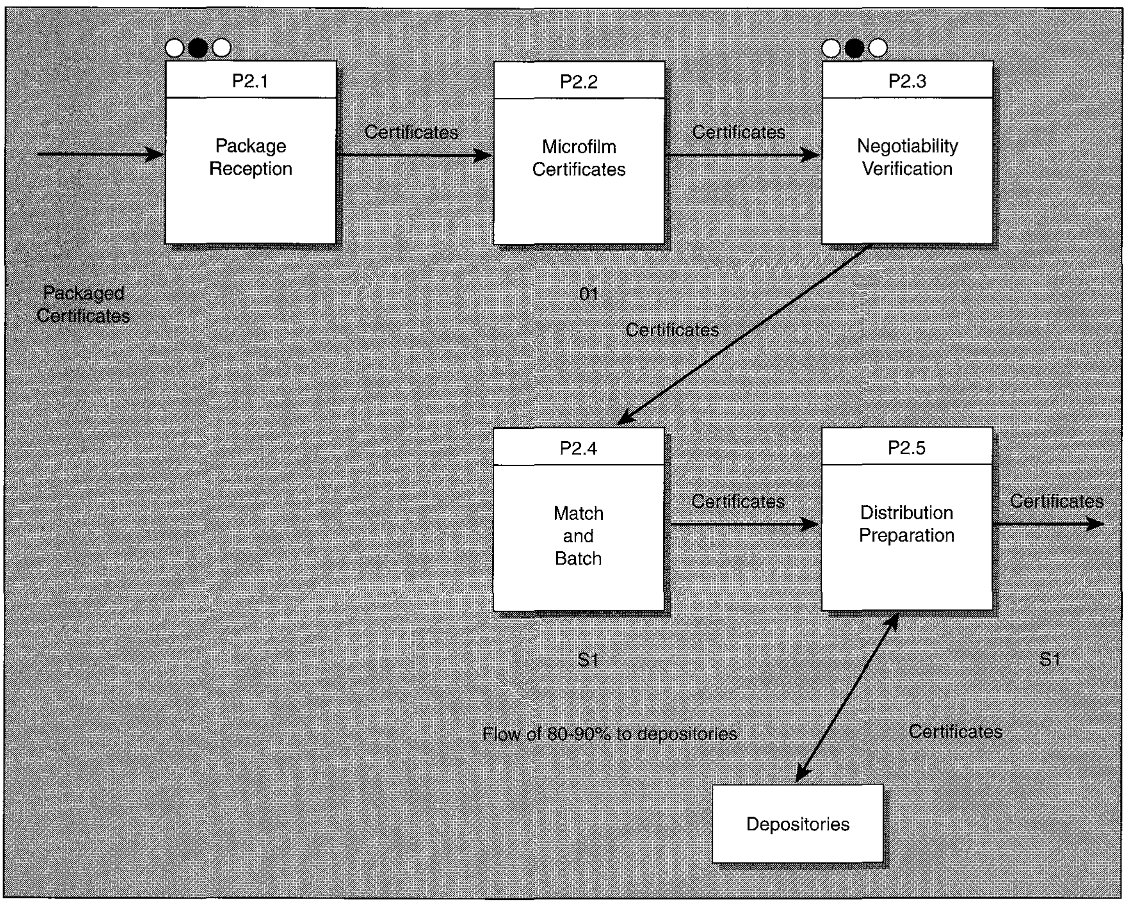
Normally the package arrived at the SPC the next day. Upon arrival, an SPC clerk inspected the package and checked that its contents matched the manifest.

The clerk contacted the branch office to resolve any discrepancies. All certificates that matched the manifest continued to the next stage in processing (see Figure 18-4).

The first step after opening the packages was to microfilm all the certificates. Next, clerks conducted a second negotiability review that is contingent on the type of transaction: legal or nonlegal. An example of a legal transaction is a stock transfer because the customer inherited the security. Regulations require that certain documents accompany the security, for example, a death certificate for the person in whose name the security is currently registered.

If further review showed the certificate was not negotiable, it was segregated. A clerk logged this status into a Merrill Lynch securities control system. Once classified as negotiable, the certificate moved to a final holding area for distribution.

FIGURE 18-4
SPC operations.



The SPCs sent 80 to 90 percent of the certificates directly to depositories. The remaining certificates were distributed to specialty departments in New York for further processing; for example, one department handles exchanges of stock necessitated by a stock split. Upon arrival at a depository or at a Merrill specialty department, the certificates were again microfilmed and staff members updated their status in the control computer system. Certificates were microfilmed yet again before consignment to their final holding area.

Why did this process entail so much microfilming? Merrill Lynch must carefully control securities and credit them to a customer's account as soon as possible. Given the volumes of paper involved, microfilming became an integral part of the control process. Merrill Lynch must also pass audits by the SEC, which checks controls on securities processing.

A New System

Merrill Lynch completely redesigned the SPC process. As in the old process, customers bring securities to a branch office or mail them to Merrill Lynch. The branch cashier conducts a preliminary negotiability review supported by an expert system (see Chapter 22). This system helps the cashier determine negotiability status. It also prints a customer receipt and generates a document control ticket that travels with the certificates. The expert posts a record of the certificate to a computer file, including a unique identifier number for the transaction.

At the end of the day, clerks package all certificates to be taken by courier to the single securities processing center in New Jersey. The system generates a manifest sheet for the package and updates a manifest file so that it contains information on the shipment.

At the SPC, the staff first wands a bar code on the package to verify receipt. Clerks check the package against the manifest; if there is a discrepancy, they update computer files and the system notifies the branch of the problem. Branch personnel have access to these files so they can check the status of processing of any security at any time (see Figure 18-5).

Negotiability must be verified in the new process, both for legal and nonlegal documents. However, the presence of the expert system in the branches reduced the number of certificates arriving without the documents needed for negotiability by 50 percent for legal documents and 75 percent for nonlegal documents.

A major technological innovation in the process was the introduction of image scanning and character recognition for certain key fields on the stock certificate. The scanning system recognizes a reference number via the bar code on the control sheet accompanying the certificates. The system uses the reference number to access the computer record which shows the scanner operator the certificates included in the transaction. The operator scans the certificates and any legal documents. At this point the images and physical certificates diverge (see Figure 18-6).

The scanned certificate image undergoes a **character recognition** procedure to turn three areas of the image into characters that can be processed by a computer

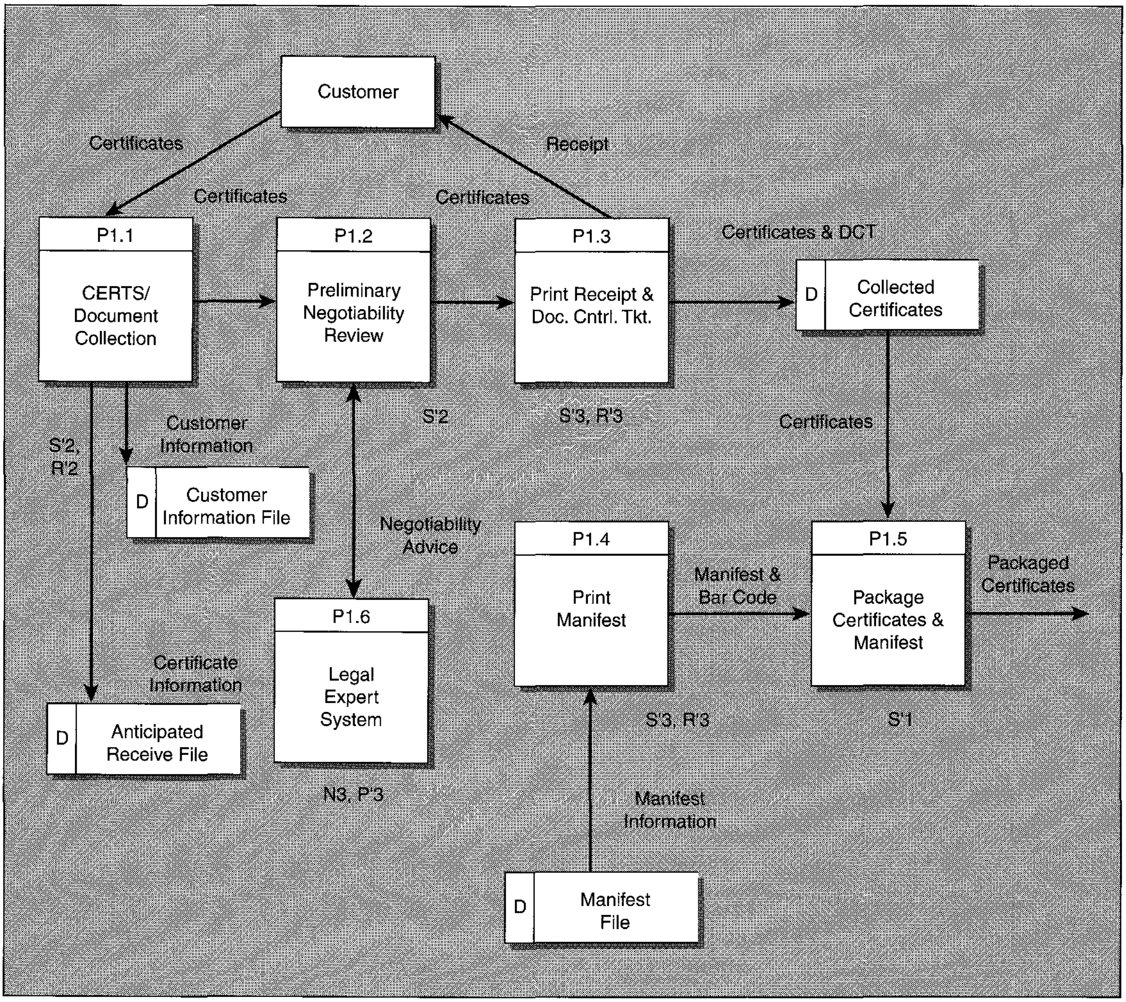


FIGURE 18-5
New system branch operations.

(see Figure 18-7). From a technical standpoint, this recognition employs a proprietary algorithm embedded in "firmware" in the imaging computer. This recognition process converts three important fields from image to character format: the CUSIP number (a unique number for each security assigned by the securities industry), denomination of the security, and the security number. These three numbers are already recorded in the computer; recognition of the imaged fields is to establish rigorous control and provide assurance that the correct documents have been scanned.

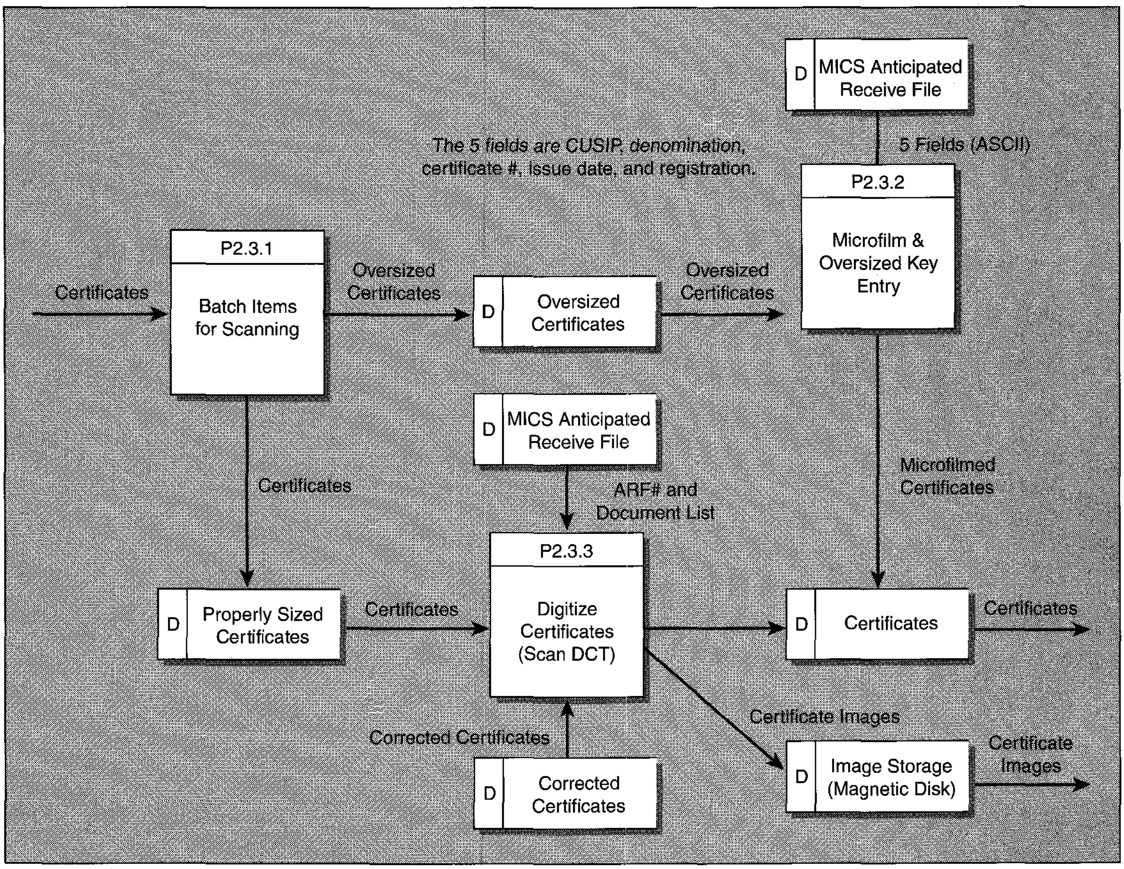


FIGURE 18-6
Image capture.

The recognition task is complicated by the fact there are no standard formats for securities. The three fields may exist any place on the security. The recognition algorithm needs to know where to look for the fields it is trying to convert. This information comes from a template database that indicates where the three fields are located on the security. Merrill has developed a template for each CUSIP and date of issue combination. The scanning computer routes any certificate whose template is not yet in the database to a workstation operator. The operator uses a mouse to draw a box around each field and the system records this location information in a new template for the security.

The system performs the image-to-character conversion by referencing the image, overlaying the template, and executing the algorithm. If the converted character fields match the same fields from the computer, the system updates the computer files to show that scanning is complete and stores the images for this

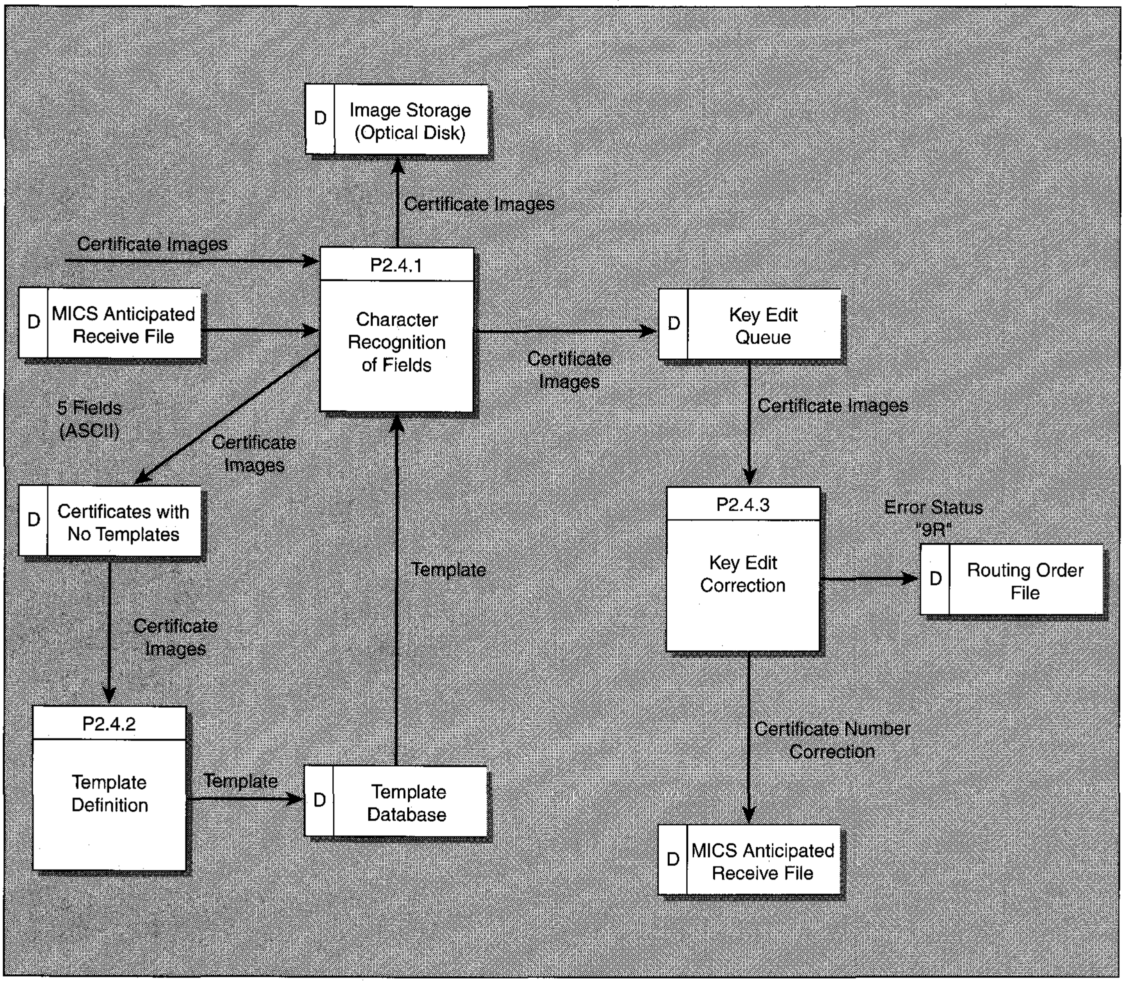


FIGURE 18-7
Character recognition.

transaction permanently to optical disk. If there is a mismatch between the converted characters and the computer record, or another nonrecognition problem, the system refers the transaction for key editing. There, operators examine the image and input data to unrecognized fields.

The staff takes the physical certificates for distribution to their final location. The system executes a procedure to provide routing orders for each certificate, and it specifies a destination box for the certificate.

When a user needs access to security information, he or she can retrieve the image of the security on a graphics workstation. There is no need to access the physical security or to hunt through microfilm records, a process that could take as long as three days with the old process.

TABLE 18-1

EVALUATION OF CERTIFICATE PROCESSING

Changes in organization structure
Elimination of two securities processing centers and the consolidation of all securities processing in a central site
Changes in work flows and functions performed
- Branch office input changes
- Branch office customer receipt
- Anticipated receipt information
- Package receipt and bar coding
- Elimination of most microfilming
- Legal negotiability work-flow changes
- Imaging operation, scanning, and key editing
- Retrieval of image rather than physical security

Interface changes
- Branch office interface
- Customer interface
- Worker interface with scanning equipment
- User interface retrieving images

Major changes in technology
- Expert system to assist branch cashier receiving certificates
- Incorporation of scanning to replace most microfilm and provide better control, including:
  - Scanners
  - Template definition
  - Key edit
  - Computer facility with optical disk jukebox
  - Retrieval of scanned documents
  - Modifications to existing control system

Impact
- Improvements in customer service
  - Better customer receipt
  - More information captured at point of contact
  - System can be queried for status of processing
  - Better control
- Certificate level control
- High-quality images compared to spotty microfilm
- Reduction from 3-day searches for microfilm to instantaneous retrieval
- Significant cost reduction
- Reduction in research time

Evaluation

Table 18-1 lists the major changes in the Merrill Lynch SPC process. The reengineering effort resulted in the elimination of two process centers and the creation of a securities processing department at a central site. The process supports major changes in tasks and work flow, beginning with the receipt of securities at a branch office. The interface to the process for all groups having contact with it has also been changed.

Technology changes include the expert system for the branch office input, scanners, a template library, character recognition from images, and optical disk storage. There have been significant increases in the level of customer service and the quality of support that securities processing provides to the branches. There is much less handling of physical securities, and retrieval time for a certificate image is nearly instantaneous. The time to research a security has been dramatically reduced: from up to three days in the old process to virtually instantaneously in the new.

The new securities processing system has had a dramatic impact on resources:

1. Reduction of occupancy from two locations to one
2. Reduction in depository fees
3. Interest savings on receivables
4. Reduction of microfilm costs
5. Savings in security services
6. Reduction in staff of 168 positions, leaving a current total of 165 (including temporary staff)

The new process required an investment of approximately $3 million. The return on the investment was calculated as a payback period of less than two years, which translates to a saving of around $1.5 million a year.

This example shows how one can execute a major redesign of a business process. Merrill Lynch used technology along with process redesign for **technological leveling** and reducing the number of processing centers and the number of managers needed to staff them. It applied information technology to automate the flow of certificates through the SPC, a form of **production automation.** The image system captures the certificates electronically, and employees in different departments can retrieve the image of a certificate in seconds without the need to visit a vault. The certificate image can be routed to any terminal capable of displaying it within Merrill Lynch, illustrating **electronic work flows.** (Subsequently, Merrill Lynch outsourced all securities handling to a third party; the simplification of securities processing has made it possible to turn over all handling of securities to a separate firm that will use electronic linking and communications to work as a partner with Merrill Lynch.)

Merrill Lynch's SPC reorganization illustrates how one can use business process redesign to make substantial changes in one part of an organization. The SPC is one area in a very large firm. Are there examples where process redesign has affected the fundamental structure of an organization?

REENGINEERING THE ENTIRE FIRM AT OTICON

Bjorn-Anderson and Turner (1994) have written about the success of the Danish company, Oticon. This firm is one of the five largest hearing aid manufacturers in the world, with approximately 1200 employees and sales of $80 million. Oticon exports more than 90 percent of its production to over 100 countries. The firm has its own research department and production facilities.

Oticon has positioned itself to be the preferred partner for leading hearing aid clinics around the world. Company headquarters are in the Tuborg industrial park to the north of Copenhagen, and there are three manufacturing facilities in Denmark and other countries.

Kinder, Gentler Tax Collection

While the IRS admits to spending $10 billion on systems that do not work in the real world, the state of Kansas has reengineered its revenue service. The process includes seven steps:

1. Mail trucks deliver returns to the processing center.
2. A machine opens and sorts returns into two groups, those with and without checks attached.
3. A person opens the returns and removes them from their envelopes, sorting them by type.
4. An operator scans the returns into the computer. Another computer scans all payments and credits and applies them to a taxpayer's account.
5. The computer notifies an operator if it encounters any problems during scanning. In addition, thousands of clerical staff members type key information from the returns into a computer system.
6. A collection agent uses information on a screen to contact a taxpayer and resolve any problems. He or she can make the correction immediately online. Programs check the arithmetic and put returns on tape for storage.
7. The agency sends letters to taxpayers notifying them of errors.

In one instance a taxpayer called and asked for an overdue refund check. A customer service representative asked for his social security number and used it to access his records on the system. The representative could see an image of the tax return and a report showing that the post office had returned the check because the taxpayer had moved. The representative asked for his new address, entered it in the system, and assured the taxpayer that the check would go out the next day. Imagine this kind of service coming from the federal Internal Revenue Service! Current IRS processing is scattered among 50 computers, most of which do not communicate with each other.

A new tax commissioner in Kansas changed not only the system but the culture as well. The idea is to treat taxpayers as customers and assume that most of them are honest. The revenue service's job becomes one of helping them understand and pay their taxes. If the agency views its role as one of helping people rather than enforcement, it expects compliance and revenues to increase. The commissioner is also working to get more people to file electronically. Imagine the number of keystrokes federal and local tax staff workers make to key tax returns for the country. If many people already key their own taxes into PC tax preparation programs, why not convince them to transmit the data directly to the revenue agency?

Given the size of the effort nationwide to collect taxes, a small amount of reengineering can save millions of dollars and provide better customer service.

The company began producing its own hearing aids during World War II. It was family owned until 1956 when new management took over and began mass production. By the end of the 1970s Oticon had reached the number one position in the world market with a 15 percent share and sales in over 100 countries. It was a leader in miniaturization for hearing aids worn behind the ear.

From 1979 through 1985, Oticon's market share dropped from 15 percent to 7 percent as competitors developed hearing aids that fit inside the ear. The company had losses in 1986 and 1987, leading the board to bring in new management.

A new president, Lars Kolind, came to Oticon in 1988. His first action was to start a cost-cutting program in an attempt to regain profitability. Kolind also changed the firm's marketing strategy. For years, Oticon stressed high-quality hearing aids, but now competitors were also building quality units. Kolind decided that the most appropriate strategy for Oticon was quality *and* customer satisfaction. Oticon focused its business on dispensers or retailers of hearing aids who were most interested in producing satisfied customers (see Figure 18-8).

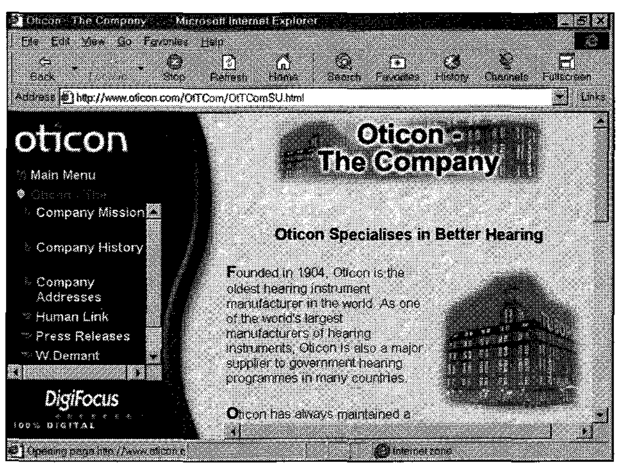
After two years, Kolind realized that cost cutting and a new marketing strategy had accomplished about all they could.

> I sat down on New Year's Day . . . and tried to think the unthinkable; a vision for the company of tomorrow. It would be a company where jobs were shaped to fit the person instead of the other way around. Each person would be given more functions and a job would emerge by the individual accumulating a portfolio of functions.

Kolind wanted to transform Oticon from an industrial organization producing a standardized product to a "high quality service organization with a physical product." He envisioned an organization in which various functional units worked together in an integrated manner to develop innovative products. Kolind realized that he would have to create a new flexible organization.

Kolind wrote a memo describing Oticon as one team of 150 employees at headquarters, all continuously developing and learning new skills. Each employee should be able to do several tasks—those he or she already did well and those where the employee would be challenged to learn new tasks. The idea was not to focus on functional expertise, but for each person to be able to do several jobs. Kolind also felt that paper hindered efficiency because paper hides information instead of sharing it. He imagined computer systems that would eliminate paper and allow all employees to share information.

FIGURE 18-8
The Otícon web site.



Kolind called his new plan a **"spaghetti organization"** since he envisioned people playing multiple, intertwined roles in the firm. To begin, he combined two separate offices into a new building designed for his new organization. Unlike many business process redesign projects, Kolind invited the participation of his employees in designing the new organization. It should be noted that, at first, there was a great deal of resistance to Kolind's proposals. When Kolind backed off a plan to move headquarters to Jutland, a remote part of Denmark, and chose instead to locate in the Tuborg industrial park, resistance faded. It is clear that the changes described below would not have happened without Kolind's strong and forceful leadership.

The first step was to eliminate traditional departments. The head office became one large department and work was organized as projects. Oticon views projects as temporary. Employees with different skills work together on different projects. This team-oriented arrangement works very well when the workload is uneven. In a more rigid structure, the marketing department would have to be staffed to handle its heavy load in the fall for exhibitions and trade shows. In the new structure, the marketing task becomes a project and enough resources are assigned to complete it. Normally, about five people work consistently on marketing tasks. When the busy season arrives, this core group recruits other employees with different backgrounds, like R&D, to help out.

The second major innovation was to organize work in the form of projects. There is a project manager and a number of other employees who work on the project. The project manager is responsible for staffing the team and for carrying out the task. A project manager advertises the project on an electronic bulletin board on the Oticon system, and employees at their workstations sign up for the project.

Employees occupy several positions at Oticon depending on the number and variety of projects for which they volunteer. This approach to organizing takes maximum advantage of diversity. An employee in accounting might sign up for a project involving marketing, bringing a whole new perspective to the marketing project.

To be successful, Oticon had to adopt a new philosophy of control. Management must trust employees to sign up for projects. This volunteerism should result in greater commitment to the firm and to more worker responsibility. Managers spend less time monitoring workers while managers must be innovators and motivators.

To bring about this new structure, Oticon had to rearrange its physical and technology domains. First, Kolind eliminated all private offices, including his own. All employees have identical desks and chairs in a large open space. There is a workstation and a mobile phone charger on the desks. Desks are not assigned. A worker moves his or her small lockable caddie to a desk. The caddie has a drawer for personal items and shelves for storing up to 10 files. Access to information is gained through the workstation.

Kolind also wanted to banish paper, and Oticon's technology eliminates 95 percent of the paper in the office. The company scans all documents as they are received, and workers are prohibited from keeping paper files. Original documents are shredded. All of this information is stored in electronic form, and users can retrieve it from their workstations, assuming they have access rights.

When an employee enters his or her ID into the workstation, the system is configured with that individual's electronic desktop. The system has tools for creating, transmitting, and storing documents containing text, drawings, and graphics. This combination of physical and electronic flexibility makes it possible to create task forces almost immediately to solve a problem.

Oticon has enjoyed a return to profitability; 1992 profits were nine times better than those of 1989 and 1990. Sales are increasing, and the company has reduced its cycle time to market new products. A new hearing aid that adjusts itself to the level of ambient sound was brought to market six months earlier than it could have been without the new organization.

Oticon demonstrates *technological leveling,* using the technology to reduce layers of management and substitute work groups. This approach also changes the role of the manager, making this person much more of a leader than a person who monitors employees. The company also illustrates **technological matrixing** since employees work on many different projects. Information technology helps form the project teams, facilitates communications, and provides tools to team members to help accomplish their task. Oticon has created a highly flexible and virtual organization through process redesign combined with the use of several IT design variables. Oticon is a good example of a firm making progress toward becoming a T-Form organization. It also shows how reengineering can be applied at the level of the firm rather than a business process.

REENGINEERING THE ENTIRE FIRM AT LITHONIA LIGHTING

Our last example of reengineering also involves an entire organization, though we are not sure others would call it reengineering. Lithonia Lighting was founded in 1946 in Lithonia, Georgia. The current senior management team arrived in the early 1960s to a strong, regional company. There were few national firms in the industry, and Lithonia was no exception with sales of $18 million primarily in the southeast (see Figure 18-9).

Management embarked on a strategy of becoming the number one lighting supplier in the U.S. Most of Lithonia's growth was internal, though they did buy a few other companies. By 1990, an industry of over 1300 companies coalesced into nine major manufacturers of lighting fixtures, which accounted for 75 percent of industry sales. In 1990, Lithonia had sales of over $700 million.

The lighting industry has complex distribution channels. Lighting can consume 50 percent of the electricity in a commercial building, and architects work with contractors to manage this kind of energy consumption. Most of Lithonia's products are aimed at the commercial lighting industry, which means the customers are industrial builders, not end users. Architects, contractors, electrical engineers, distributors, and agents are all involved in Lithonia's sales.

The industry has found it must sell through lighting agencies rather than sales people. Lithonia deals with about 85 independent lighting agencies. An agent sells

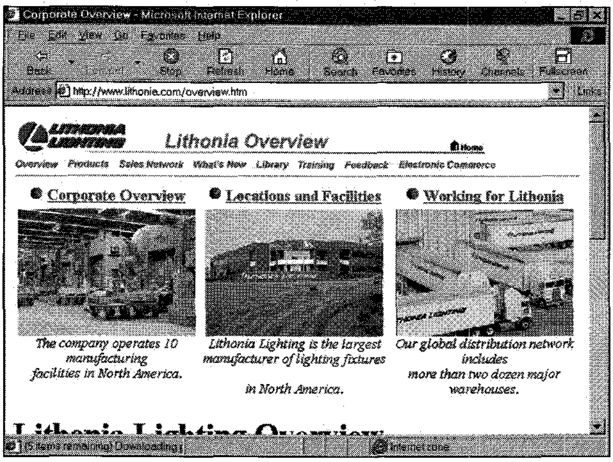


FIGURE 18-9
The Lithonia Lighting web site.

to distributors who in turn sell fixtures off the shelf. However, the majority of agency sales come from efforts to influence the buyers for large construction projects, such as a new office building. The agents do not stock products nor do they carry inventory. The electrical contractor who bids successfully on a project makes the ultimate decisions on what fixtures to buy. Agents tend not to handle competing products.

In 1979, the IS manager at Lithonia was asked to find a way to tie together all of the major players in Lithonia's business including agents, distributors, contractors, warehouses, and so on. The IS manager's team soon found that it had to take Lithonia out of the center of its diagrams. The only picture that made any sense was to put the agent at the center of the diagram.

This exercise convinced Lithonia to change the way it looked at its business: The agent became the key to sales. Lithonia developed a series of innovative computer and communications applications called Light*Link to coordinate sales and distribution. In fact, the high level of cooperation between the CEO and IS manager at Lithonia won an award from the Society for Information Management (SIM).

The general assessment of the Light*Link system is that it generated considerably more sales volume without a concomitant increase in staff. In fact, one agent changed its ratio of sales representatives to administrative staff from 1:1 to 3:1. Lithonia credited the system with dramatic gains in sales. Of course, we should be cautious about such claims because sales are primarily determined by the health of the construction industry.

Lithonia developed its new concept of business before anyone invented reengineering or business process redesign. In retrospect, it seems to be a clear case of a firm redesigning itself and its processes with a fresh view of the environment. The Light*Link system provided a number of *electronic work flows* between the company and its agents and enhances communications within Lithonia. To some extent, the systems also provided *production automation* as computers were able to generate some quotations and specifications for customers.

IMPLICATIONS

In summary, Mutual Benefit Life and Merrill Lynch represent classic cases of business process redesign. Each firm first looked at its own business in detail. Reengineering's major contribution to management is its focus on process and on be asked whether or not a process, itself, is necessary. The questions that should be asked include:

1. What are our key business processes?
2. Do we have to execute this process at all?
3. What totally new ways, taking advantage of information technology, exist to perform this process?
4. What does redesigning a process imply for the structure of the organization?
5. How can we use IT design variables in conjunction with process redesign to change the structure of the organization?

Oticon and Lithonia practiced a different kind of reengineering. They focused on the entire organization instead of isolated business processes. In their reengineering efforts, these firms used technological leveling to reduce the number of layers of management and supervision. They substituted electronic work flows for the physical movement of documents and applied production automation where possible. Technological matrixing helped solve problems and encourage employees to make decisions themselves rather than refer problems up a managerial hierarchy. All of these changes combined produced organizations with virtual components.

MANAGEMENT PROBLEM 18-2

You have spent a significant amount of time involved with the "education industry." In the U.S., a child is likely to start a nursery school program by age 3 or 4 and may continue to college and graduate school until age 25 or older. Roughly one-third of a typical life span for this individual is spent getting a formal education, and most graduates must continue to learn throughout their lives to keep up with the pace of change.

Just as you can think of reengineering a business process, you could conceivably reengineer an educational process. Think about the processes involved in education, from learning to administration, and develop a plan for reengineering some aspect of education. You may want to use some of the IT design variables and concepts of the T-Form organization from Chapter 4 as a basis for your reengineering effort.

Reengineering: Success or Failure?

As mentioned in the introduction to this chapter, some of the popularity of reengineering has waned since it is estimated that only 30 percent of business process redesign efforts have been successful. What are the reasons for this lack of success? Reengineering seeks very large changes, the kind that are the most difficult to implement and the most risky. A process often involves multiple organizational subunits so the change may involve organizational structure as well as operations. Michael Hammer, one of the founders of the field, stated that he and his colleagues "forgot about people" in developing reengineering principles. Adopting reengineering to cut staff is not likely to produce positive results. The real benefit comes from reorganizing work to make people more productive. The examples in this chapter demonstrated strong management interest and leadership; it is also possible that some reengineering efforts have failed because of a lack of a project champion in management. We explore change and implementation in the next chapter. As you read Chapter 19, think about the magnitude of the changes demanded by reengineering. Is it surprising that not all reengineering projects are successful?

CHAPTER SUMMARY

1. Reengineering focuses attention on business processes. These processes are related to tasks and they cut across functional departments in an organization.
2. Reengineering seeks to make radical changes in the organization, for example, a ten-fold improvement in outcome variables.
3. It may be possible to eliminate a process entirely or to turn it over to an external organization so that it becomes a virtual component of your organization.
4. There may be a limit to the number of reengineering efforts an organization can mount at one time. They require capital and human investment, and they can be traumatic for the people involved.
5. Incremental improvement is a reasonable strategy for a number of systems in the organization.
6. It is wise to stay out of the middle ground shown in Figure 18-1, where you end up investing a great deal for only modest improvements.
7. Reengineering applies to the structure of the entire organization as well as to individual business processes.
8. A company like Oticon offers an example of applying the IT organization design variables from Chapter 4 to restructuring a company that was losing market share and money.
9. A manager needs to stay alert to the opportunities for reengineering processes for the entire organization.
10. Reengineering serves to focus attention on business processes and the difference between radical and incremental change.
11. Reengineering has not been completely successful, primarily because of the magnitude of the changes it entails and the difficulty of changing organizations in general.

IMPLICATIONS FOR MANAGEMENT

It is difficult to create the significant improvements in a process demanded by reengineering. You may want to limit your efforts to a reasonable number of reengineering projects because of the problems associated with creating massive changes in an organization that go with each project. Reengineering the entire firm, as attempted by Oticon, is also a major challenge. However, if organizations want to remain competitive in the twenty-first century, they will have to take advantage of IT in structuring themselves. You may not want to call it reengineering, but you will want to make major changes in the processes and organizations you encounter during your career.

KEY WORDS

Character recognition
Electronic work flows
Expert system
Incremental improvement
Obliterating a process
Process
Production automation
Radical change
Reengineering
Spaghetti organization
Technological leveling
Technological matrixing

RECOMMENDED READING

Bjorn-Anderson, N.; and J. Turner. "Creating the 21 Century Organization: The Metamorphosis of Oticon," *IFIP Working Group 8.2 Conference,* August 1994. (A good description of changes at Oticon.)

Davenport, T. *Process Innovation: Reengineering Work Through Information Technology.* Boston: Harvard Business School Press, 1993. (A readable account of reengineering.)

Hammer, M. *Beyond Reengineering: How the Processed-Centered Organization Is Changing Our Work and Our Lives.* New York: Harper Collins, 1997. (This is Hammer's newest book on business reengineering and covers many current issues and problems related to organizations' reengineering initiatives.)

Hammer, M.; and J. Champy. *Reengineering the Corporation.* New York: Harper Collins, 1993. (An expansion of Hammer's first paper with a number of examples of reengineering.)

Huizing, A.; E. Koster; and W. Bouman. "Balance in Business Reengineering: An Empirical Study of Fit and Performance", *JMIS.* 14, no. 1 (Summer 1997). pp. 93–118. (A very good article addressing the importance of organizational fit in business reengineering.)

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Levent, O. "A Model Management Approach to Business Process Reengineering," *JMIS.* 15, no. 1 (Summer 1998). pp. 187–212. (A thorough article dealing with redesigning business processes after the introduction of information technologies.)

Lucas, H. C., Jr.; D. Berndt; and G. Truman. "A Reengineering Framework for Evaluating a Financial Imaging System," *Communications of the ACM.* 39, no. 5 (May 1996), pp. 86–96. (A discussion of the Merrill Lynch system.)

DISCUSSION QUESTIONS

1. What is a business process? How does it relate to a function?
2. What is your definition of radical change?
3. What is incremental change? Where is it appropriate?
4. What is "the middle ground," and how can it lead to problems?
5. What is the difference between an image and a character representation of, say, this page of text?
6. What is a spaghetti organization?
7. What problems do you see in an organization that does not seem to have a formal organization chart?
8. How does Oticon staff projects?
9. What is the role of the expert system for receiving securities in the Merrill Lynch branch office?
10. If the Merrill Lynch control computer has information from the expert system, why is it necessary to recognize three fields on the documents scanned in the SPC?
11. Why did Lithonia Lighting find it necessary to put its agents at the center of its business processes?
12. How did Mutual Benefit Life use technology to change the way its staff processed information? What other kinds of assembly line processing of information might make use of this kind of reengineering?
13. What is the major contribution of reengineering?
14. Why has reengineering been so popular with senior management? What kind of business strategy does it promote?
15. Is reengineering fundamentally driven by technology?
16. Look at a firm or at your university and outline the major business processes. Then examine what functional departments play a role in each process.
17. What role does comparing your operations with those of similar companies play in reengineering?
18. How did reengineering make it possible for Merrill Lynch to outsource some of its securities processing operations?
19. Do you think Oticon's success has been influenced by the fact that it is located in Denmark with a different tradition of worker-management relationship than the U.S.? Do you think Oticon's structure would work in another country?
20. The U.S. healthcare system is often described as a candidate for major change. Do you see a way to reengineer it?

CHAPTER 19

Implementing Change

Outline

Focus on Change

This chapter is about one of the most important characteristics of change: how you bring it about. Implementing change is a very difficult task for a manager, yet change is the reason for deploying innovations in information technology. For IT to transform the organization, you must be successful in implementing change. The manager must take advantage of what the technology offers to restructure the organization. As suggested in earlier chapters, we think that IT will naturally lead toward the T-Form organization structure.

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The application of information technology implies change; individuals and organizations adopt technology to change and improve the status quo. In Chapter 1, we described a hierarchy of change:

Within the organization
Organization structure
Interorganizational relations
The economy
Education
National development.

In this chapter we explore the nature of these changes, emphasizing how one can increase the probability of success in implementing new technologies.

Change happens one application of technology at a time. The changes described earlier in organization structure, relations among organizations, and the economy all occur as the result of the implementation of many individual technology initiatives. We know that developing a system is a complex task; there are many activities and subtasks involved. Table 19-1 lists some of the things that can go wrong in developing a system.

The system may be very unpopular in the organization. Employees may object to a substantial reengineering project because they do not like the changes the effort is likely to make in their jobs and in the organization. The original design of the system may be faulty and not provide the functions the firm needs. Specifications may be incorrect or incomplete so an important action is not included in the system. Systems may not work technically; for example, there may be so many errors that no one trusts the output from the system.

The interface of the system with the users refers to the way in which we come in contact with the system, for example, through printed forms, terminals, or printed reports. In one system, terminal input was so complicated that no one submitted data and the system had to be discontinued. Users may also be unhappy about the way designers went about developing the system: the process of design. For example, designers sometimes make arbitrary design decisions and fail to consult relevant users.

Finally, the operation of a system involves longer-term issues after a system is designed and installed. If the **operations** section of the information services

TABLE 19-1

SOME POTENTIAL SYSTEM PROBLEMS

The original design of the system
- The system will make substantial changes in the organization.
- All needed functions are not included.
- The database is incomplete.
- Procedures for processing information have errors.
- There are design errors, e.g., incorrect specifications.
- There are programming errors.
- The system has communications network problems.

The interface of the system with users
- Input or output is difficult for the user to understand.
- Input screens are complex.
- The user has no incentive to provide input.
- Input devices do not work well, e.g., a defective wand cannot read a bar code.
- The work force has been inadequately trained to provide input.
- The system permits a large number of input errors.

The process of design and implementation
- Users are not consulted on crucial design decisions.
- Users are not motivated to participate in design or use the system.
- The system attacks an uninteresting problem, one that is not crucial.
- Designers make arbitrary decisions that turn out not to work in practice.
- Users do not take time to participate when invited to do so.
- The design and programming process drags on for an inordinate amount of time.
- There are significant conversion problems due to poor planning.

The operation of the system
- The system has bugs.
- Response time is inadequate.
- The system is frequently unavailable for long periods of time.
- The system is not backed up.
- The IS staff is not responsive when there are problems.

department does not provide good service (for example, having excessive response time or downtime), systems will not achieve their potential.

IMPLEMENTATION

What Is Implementation?

Implementation is part of the process of designing a system and is a component of change. We develop a new information system to change existing information processing procedures and often to change the organization itself. Implementation refers to the design team's strategy and actions for seeing that a system is successful and makes a contribution to the organization.

Our definition stresses the long-term nature of implementation. It is part of a process that begins with the very first idea for a system and the changes it will bring. Implementation terminates when the system is successfully integrated with the operations of the organization. We expect most of implementation to be concerned with behavioral phenomena since people are expected to change their information processing activities. Implementation becomes more important and difficult as systems design becomes more radical. If a firm undertakes a major reengineering project, it should make major changes in tasks to reduce costs and improve productivity in the organization.

Success or Failure

How do we know that we have successfully implemented a system? Researchers do not agree on an absolute indicator for successful implementation. One appealing approach is a cost/benefit study. In this evaluation, one totals the costs of developing a system and compares them with the dollar benefits resulting from the system.

In theory, this sounds like a good indicator of success, but in practice it is difficult to provide meaningful estimates. Obtaining the cost side of the ratio is not too much of a problem if adequate records are kept during system development. However, an evaluation of the benefits of an information system has eluded most analysts. Chapter 3 described a number of categories into which we might classify the benefits or value provided by an application of technology. These categories included:

Infrastructure
Required applications
Applications where technology was the only solution
Applications providing a direct return
Applications with indirect returns
Technology initiatives that are a competitive necessity
Strategic applications
Transformational information technology

For only a few of these categories are we likely to be able to demonstrate a direct financial return, which makes it difficult to perform a cost/benefit analysis to determine the "success" of a system.

As an alternative, we can choose among several indicators of successful implementation for an individual application, depending on the type of system involved. In many instances, use of a system is voluntary. A manager or other user receives a report but does not have to use the information on it or even read the report. Systems that provide interactive retrieval of information from a database also can often be classified as voluntary. The use of such a system is frequently at the discretion of the user. A manager with a personal computer in his or her office is not required to use it. For the type of system in which use is voluntary, we shall adopt high levels of use as a sign of successful implementation. We can measure use by interviews with users, through questionnaires, or in some instances, by building a monitor into the system to record actual use.

For systems whose use is mandatory, such as a production control system or a computer that provides stock market quotations for a broker, we shall employ the user's evaluation of the system as a measure of success. For example, one can examine user satisfaction, although it will probably be necessary to measure several facets of satisfaction, such as quality of service, timeliness and accuracy of information, and quality of the schedule for operations. An evaluation might also involve a panel of information processing experts reviewing the design and operation of the system. We should also note that managers might well consider a system to be successful if it accomplishes its objectives. However, to accomplish its objectives, a system must be used. We would also hope that one objective of a system would be extensive use and a high degree of user satisfaction.

Finally, though it is difficult to do, we can try to estimate the impact of a system on individuals and the organization. How has a system affected personal productivity and output quality? Can the organization point to added sales or increased revenues from a competitive application? Can we show that IT has had an impact on performance, either for individuals or the organization?

RESEARCH ON IMPLEMENTATION

Most research on implementation is an attempt to discover factors associated with success. What independent variables are related to successful implementation as defined by the researchers? If there is any basis for believing a causal connection

On the Future of Tall Buildings

We know that information technology can have a dramatic impact on the place and time of work. The invention of the electric elevator and the development of steel and reinforced concrete framing made possible modern high-rise office buildings, the largest of which are classified as "skyscrapers." These large buildings made it possible to house thousands of office workers in close proximity to each other so they could interact easily. The buildings let workers access central repositories of data while supervisors could monitor work closely if they desired.

The tallest buildings project a sense of wealth and power for their owners and include the Empire State Building and World Trade Center in New York, the Sears Tower in Chicago, and the Petronas twin towers in Kuala Lumpur, Malaysia. There is even a committee to define what is to be measured to determine building height (do you count the television towers on top?) and finally to rank the world's tallest buildings.

Is the skyscraper obsolete? Information technology accomplishes much of what these buildings do, though without projecting power and prestige. The Petronas Towers are 452 meters high, while Microsoft's headquarters in Redmond Washington is 20 meters in height! Tall buildings have some undesirable side effects, including blocking sunlight and changing wind patterns (the canyons of lower Manhattan are one example). In addition, they encourage commuting into the center of a city, something that creates significant pollution in most major cities. The rise of telecommuting, the easy accessibility of databanks from anyplace in the world, and electronic communications all significantly reduce the appeal of the modern skyscraper as a place to work.

exists between independent and dependent variables, we can develop an implementation strategy around the independent variables. For example, suppose we found in several studies using different research methodologies that top management's requesting a new system and following through with participation in its design is associated with successful implementation. If there were sufficient evidence to support this finding, we would develop an implementation strategy that emphasized top-management action.

Although individual studies of implementation address a number of independent variables, there is no real consensus in the field on an explanation of successful implementation or on a single implementation strategy. Table 19-2 contains a list of some of the variables employed in past implementation studies. Dependent variables used to measure implementation success generally can be classified as measures of use, intended use, and/or satisfaction with a system. The independent variables fall into several classes, as shown in the table.

A Model of Implementation

There have been a number of different studies of systems implementation, many of which are reviewed in Lucas, Ginzberg, and Schultz (1991). In this study, the

TABLE 19-2

VARIABLES ASSOCIATED WITH IMPLEMENTATION STUDIES

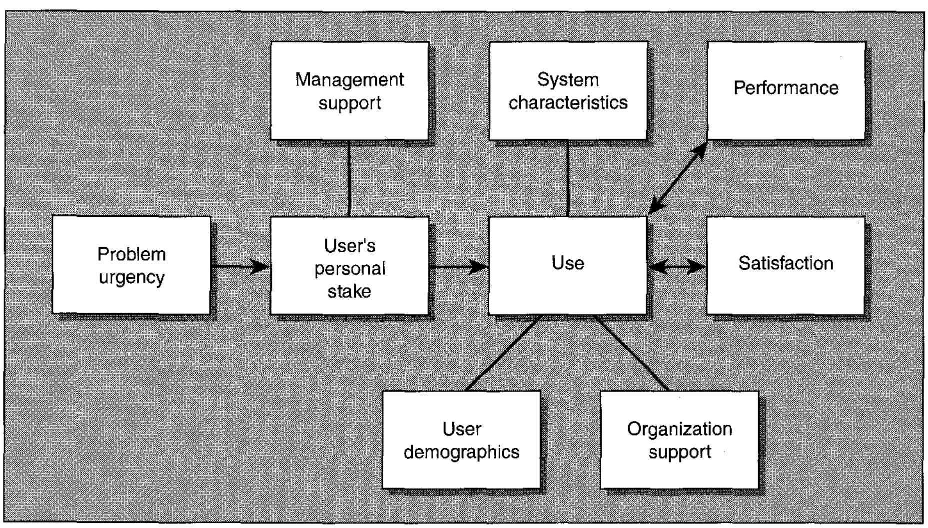
Independent variables	
Information services department	**System characteristics**
Policies	Quality
Systems design practices	Ease of use
Operations policies	
	Decision style
Involvement	Cognitive style
User origination of systems	
Involvement and influence	**Management**
Appreciation	Actions
	Support
User demographics	Managerial style
Personality type	
Business history	**Organization support**
Social history	Ease of access
Past experience	
	User performance
User's personal stake	
Problem urgency	
Dependent variables	
Implementation	
Frequency of inquiries	
Reported use	
Monitored frequency of use	
User satisfaction	

authors propose and test a model of implementation for system users. Figure 19-1 is a model based on the most significant findings from the research in the study discussed above. The model suggests that the user's personal stake in the problems addressed by the system will be an important determinant of use. Personal stake refers to how important the domain of the system is for the individual. A marketing manager is expected to have a high personal stake in a market research system that addresses the brands she manages. Personal stake is hypothesized to be influenced by the level of management support for a system. The most consistent finding across implementation studies is the importance of management support and leadership in successful implementation. Problem urgency is likely to influence personal stake. The more urgent the problem, the higher the personal stake.

We expect personal stake to influence use directly, when use is voluntary. System characteristics will also influence use. A poorly designed system may be virtually unusable. User **demographics** such as age and past computer experience are also likely to affect system use. Organizational support refers to actions that make a system easy to use. For example, we found that use of a system increases with the ease of accessing it. If a user must leave his or her office to find a PC, usage levels are lower than when a PC is located in the office. The model suggests that high levels of use should lead to high levels of satisfaction, and a high level of satisfaction is likely to increase levels of use.

Although the evidence is not strong, it does appear that use of technology is related to either individual or firm performance in certain instances. This relationship is likely to be complex. For example, one study found that high-performing

FIGURE 19-1
An implementation model.



sales representatives used the output of a system to work with buyers in a store to figure out what to order. Low-performing sales representatives also used the output of the system, but they focused on information that might indicate what was wrong in their territories. There are also a number of technology efforts where it appears a firm has reduced costs or increased revenues. However, it is hard to demonstrate causality in such situations because so many variables are changing at one time.

The Implementation Process

The research described above deals with variables or factors associated with successful implementation. There is also a school of thought that stresses the process of implementation as the most significant determinant of implementation success. The implementation process refers to the ongoing relationship among individuals involved in developing a system. A process model might look at various stages during implementation and describe how different parties work together during these stages.

Our process model includes the stages outlined in Table 19-3. This model emphasizes tasks that take place in design. In reading between the lines, however, we can see the need to concentrate on the relationship between designers and users. During the early stages, the individuals involved with the system must develop trust in each other's objectives and competence. The designers should want to help users, and users must be willing to spend time working with designers and on their part of the design. If those involved do not develop a cooperative relationship and become adversarial, the system is doomed.

A major objective during the design process is for users to accept ownership of the system. Professional designers, ironically, almost never use the systems they design! The user is left with a system at the end of a project. If the user does not "own" the system from a psychological point of view, the system is unlikely to be successful. There has been some research to show that the termination stage in the model above is the most important. Here is where we learn if users have developed feelings of ownership and commitment to the system.

TABLE 19-3

A PROCESS IMPLEMENTATION MODEL

Stage	Activity
Initiation	The first contact between the users and designers
Exploration	Getting a feel for the problem
Commitment	Making a decision to proceed with a system
Design	Developing the logical design and specifications for the system
Testing	Verifying that the system works
Installation	Converting to the new system
Termination	Design team finished; users must now own the system
Operations	Routine operation plus enhancements and maintenance

AN IMPLEMENTATION STRATEGY

We need an implementation strategy that takes into account the crucial process issues in designing an information system as well as the factors that appear to influence success. We also view systems design as a planned change in activity in the organization. We stated earlier that the reason for developing a new information system is to create change. Dissatisfaction with a present situation stimulates the development of a new information system. Alternatively, a user sees how the technology can be used in a new way to improve the firm's competitive position.

For many years, articles and books on design stressed user participation in the design process based on research in psychology that maintains that a change approach based on user participation is most likely to succeed. The first part of our strategy, then, is encouraging users to participate in and influence design. Some of the reasons for a participation strategy are:

- Participation builds self-esteem, which results in more favorable attitudes.
- Participation can be challenging and intrinsically satisfying, leading to positive attitudes.
- Participation usually results in more commitment to change. In this case, commitment means that a system will be used more.
- Participating users learn more about the change, and therefore get to control more of the technical qualities of the system and become better trained to use it.

MANAGEMENT PROBLEM 19-1

A major stock brokerage firm developed a broker workstation to support its private client group, the brokers who work with very high net worth individuals. This business is very profitable for the brokerage firm, and its technology had fallen behind the competition, giving rise to the new system. The workstation provided the brokers with a graphical user interface for the first time, along with a large amount of data on the market and various financial instruments. The transactions and records for each client remained on a legacy mainframe system, but the broker could access this system through a window on the new workstation. However, once this window became active, the interface reverted to the old character-based system that ran on the mainframe.

The brokers worked in groups of two to five along with one or more sales assistants. A study found that the major users of the system were the sales assistants! One objective of the workstation project was to reduce the ratio of sales assistants to brokers in order to lower overhead. However, if the sales assistants used the new system more than brokers, how could the brokerage firm achieve its objective? Why do you suppose this pattern of usage evolved? Do you think it should be changed? If so, how would you go about encouraging more use of the workstation by brokers?

- Technical quality will be better because participants know more about the problem domain than the IS staff.
- Users retain much of the control over their activities and should therefore have more favorable attitudes.

How should users participate in the design of a system? Participation requires the efforts of both the IS staff and the users. The IS department has to encourage participation, while users have to be willing to participate and devote considerable effort to design work. In the past, although most information services departments attempted to involve users, the effort frequently produced what would have to be classified as "pseudo-involvement." To bring about the necessary participation, it has been suggested that users actually design their own systems.

The Role of Design Teams

Teams consisting of managers, end users, and systems professionals design most applications today. How do users and professional systems analysts work together on a team?

The first task delineated by the analyst might be a discussion of the functions the system is to perform. Working together, the team might develop high-level data flow diagrams for the system. The analyst, from knowledge of the capabilities of technology, presents alternatives for the user to consider.

Users help conduct interviews to determine the requirements for a new system. They also contribute to and review the design of the system as it unfolds. Users should have the final say in how the system will function. In this way, users become knowledgeable about the system and develop ownership, one of the major objectives of the process model.

An Implementation Framework

A team approach that stresses cooperation and participation addresses the issues raised in the process model of implementation, but what about the factors discussed earlier in the chapter? Our complete implementation strategy comes from merging the most important factors with the steps of the process model (see Table 19-4).

The combined model in Table 19-4 arrays the steps of our process model with the variables from the factor model of Figure 19-1. During **initiation,** one key to success is having a sponsor or champion for the system. Without the active support of a senior-level person in the organization, the chances for success are greatly reduced. Similarly, the factor model suggests that attacking urgent problems is a good strategy. It is hard to develop enthusiasm for boring systems that are unlikely to have an impact on the firm. We should locate users with a stake in the problem and start to think about who the users will be when the system is done. User demographics are not under our control in the short run.

When we are exploring possible solutions, we need management support to provide resources. It is also useful to think in cost/benefit terms. Who pays the costs to use the system and who gains? If users are expected to provide complex

TABLE 19-4

AN IMPLEMENTATION MODEL

Management support	Problem urgency	User's personal stake	System characteristics	Use	User demographics	Organization support	Satisfaction	Performance
Initiation								
Having a sponsor is key	Attack the most important problems	Find users for whom the stakes are high	Determine requirements and architecture	Who will use the system?	Not under the control of designers	Find the champions	One objective is satisfied users	Determine any performance objectives
Exploration								
Sponsor commits resources	Urgent problems help provide motivation	Show how system is important to user	Choose among alternatives	Who pays the costs of use?	In longer term may be able to choose team members	Be sure someone will provide the resources you need	Design for satisfaction	Is there likely to be an impact on performance?
Commitment								
Sponsor provides time for users to work on system	Dealing with key problems helps obtain cooperation	Involve the important stakeholders	Develop prototypes to aid in design	Who gains from use?	Look for users with successful history of working on IS projects	Get a commitment before starting	Consider user surveys	Be honest about what to expect
Design								
Sponsor helps make key policy decisions	Urgent problems demand quality designs	High stakes should lead to a lot of design input	Build the highest-quality system possible!	Design to encourage use, e.g., good interfaces	Provide education where needed—prototypes help	Make the system as easy to use as possible	Design for satisfaction	Try to understand what leads to performance, and design for it

Management support	Problem urgency	User's personal stake	System characteristics	Use	User demographics	Organization support	Satisfaction	Performance
Testing								
Sponsor reviews results	Test carefully	Let the stakeholder verify the results	Test exhaustively	Make sure system is usable	Let the worst critics help test	Get resources for testing	Let users plan tests, too	Test carefully if system affects performance
Installation								
Sponsor provides added resources	Plan installation to minimize disruptions	Users with a high stake should plan installation	Use extensively	Expect and prepare for use problems	Everyone will have to help	Be sure there is enough support	Try to plan a smooth installation	Install carefully if performance is an issue
Termination								
Sponsor rewards team	Is the problem solved?	Stakeholders should own the system	Transfer ownership to users	If successful, expect high use	With luck, there will be new supporters	Support users with help desks, etc.	High satisfaction should lead to user ownership	If successful, user will use system to enhance performance
Operations								
Sponsor continues to provide resources	Continue to work on problem	High-stake users should continue their interest	A high-quality system is easy to use	Continue to refine to encourage use	Even the skeptics will use a good system	Provide ongoing organizational support	Obtain ongoing feedback from users	Monitor performance changes

input but receive no benefits from the system because the data are used only by senior management, there may be resistance to the system. During **exploration** we begin to see the architecture for the system and can determine what kind of organizational support we need in order to encourage use. During the **commitment** stage, the sponsor has to prepare the organization for the design effort, often by providing release time and resources for the design team. One good way to enlist support and to show how the systems design effort will solve problems is to develop a prototype of some or all parts of the system. We might also employ user surveys to gain information for design.

During **design,** we need the sponsor to help make key policy decisions. For example, if we are planning an EDI application, what is the target audience? How do we approach suppliers and customers? Will senior management negotiate with potential EDI partners? Remember that we want to attack urgent and important problems. These problems demand a high-quality design that will encourage use.

Testing is extremely important in preparing for installation. Management and as many users as possible should be involved in designing and verifying tests. **Installation** is difficult because any system is designed to change existing procedures. Because we want to tackle important problems, the risks are very high. A failed installation threatens some key component of the organization. We need careful testing, a good cutover plan, and a lot of help from users to succeed in installation.

Termination marks the departure of the professional analysts and probably the completion of the design team's responsibilities. If the design team has been successful, users will develop a sense of ownership of the system. The installed system will help solve an urgent problem for user stakeholders, and the organization will provide adequate resources to support the system. Users will be satisfied with the resulting system.

When the system is in *operational* status, it is not finished. As users work with the system, they will see ways to improve it. Business conditions are also likely to change, necessitating ongoing maintenance and enhancements. The organization must continue to support the system by expanding it as conditions warrant. The operations staff of the IS department must provide maintenance and should obtain periodic feedback from users.

This combined implementation model is based on implementation research and experience. It can help develop systems that are successful and that will be used. The threats to a successful system are many and varied, as portrayed in Table 19-1. Following a conscious implementation strategy is the best way to maximize the probability of a successful design project.

Some Examples

The procedures for systems design recommended above have been used for the development of several successful information systems. In one instance, a feasibility study and systems design were carried out for a grass-roots labor organization. The design team consisted of union members, and faculty and students from a university. The union members in general had a low level of formal education, and the design team was concerned about the effect of computer technology on the union and its individual members. Because of hectic union organizing activities, the union staff could not devote the time needed to develop a system, although eventually several full-time union staff members began to work on the project.

To begin the analysis, the university design team interviewed members of the union staff and gathered data on existing procedures and requirements. After jointly determining that a system was feasible, the design team developed a rough design. To turn ownership of the system over to the union and to be sure the union staff was in control of the system, a day-long review session was held to present the draft of the system. At this meeting, the union president explained to the members that there were many tasks to be done and that no one would be replaced by a computer. He stated that instead workers probably would have more interesting jobs, and he asked members to think about how the system could help the union.

The design team began its part of the meeting by stressing that the session would be successful only if at least half of the system presented was changed: The team offered ideas, not a finished product. They did not use elaborate flowcharts and visual aids. Instead, a very simple tutorial on computer systems began the presentation. The designers spoke from rough notes and listed report contents, files, and inputs on a blackboard. The highly motivated union staff quickly grasped the relationships among reports, files, and input documents. Substantial changes to the rough system were made in front of the audience during the meeting.

MANAGEMENT PROBLEM 19-2

Raffles Corporation is a large holding company in Singapore. The firm has interests in ship building and repair, property, banking, engineering, communications, and transportation. The chairman of the firm, Tek Ming Neo, would like to reduce overhead and create more dynamic and flexible organizations in the various subsidiaries. He is concerned, however, because each of the subsidiaries has a different organizational structure. "How can the same principles of organization apply to a ship building company as to a bank? Are we faced with the task of developing a new organizational structure for each subsidiary? If we do, does that mean a different implementation and change program for each? We may never finish!"

Are there characteristics of a modern organization that take advantage of information technology that applies to all subsidiaries? Is there a notion of corporate culture? If so, can culture be the same throughout the entire set of companies? How would you recommend that Neo go about developing a new organizational structure for the company, and how do you propose that he implement these new structures? What are the major advantages and risks of your recommendations?

Several weeks later, a follow-up meeting was held with union leaders, who suggested management-oriented reports. The design team helped the union develop specifications for bids and worked on a consulting basis with the union staff, which finally developed a system. The designers intentionally reduced their role as the union became more capable in the systems area. The system was successfully implemented. The level of use was high, and users, from the union president to clerical personnel, appeared pleased with the system.

In another situation, a system was developed to support the decisions of a group of three managers. These managers were responsible for setting production schedules in the commercial laundry products division of a major manufacturing company. The production manager wanted to minimize setups and have long production runs. The marketing manager wanted to have wide product availability at warehouses throughout the country to provide high levels of customer service. The market planning manager had to resolve differences in objectives so the three managers could develop a feasible production plan. Because future production depended on the decision for the next month, a 12-month planning horizon was used.

In the original manual system, managers generated possible solutions analyzed by clerical personnel who performed a large number of manual calculations. On evaluation, it was usually found that a solution had to be modified because some part of it was infeasible. More meetings and more clerical computations were required. Sometimes almost the entire month elapsed before the next month's schedule was ready.

The research group trying to improve this decision process observed the managers at work for some six months. After three months, a rough system featuring an interactive graphics display terminal was developed. The first prototype system was shown to the market planning manager, who learned how to operate it. This manager made many suggestions for changes, which the designers incorporated into the system. Then the market planning manager trained the production and marketing managers in the use of the system. They too had numerous suggestions for modifications, which were incorporated into the system. Over time, the researchers modified the system for the managers in this particular decision situation. The managers were very satisfied with the system and resisted attempts by the information services department to discontinue it after the research project was officially completed.

Emergent Change

The changes described above are all planned; managers determine in advance their objectives for change within the organization. However, individuals adapt technology in a number of diverse and interesting ways, constituting **emergent change** (Orlikowski, 1996). These kinds of changes occur in the absence of explicit intentions and objectives for change. In fact, such changes cannot be anticipated in advance because people adapt to the technology as they use it. Such emergent change can be a very positive, unintended consequence of a new application.

Zeta Corporation, a leading software vendor, installed Lotus Notes to support its customer services department (CSD). The 50 representatives in this department answer phone inquiries from customers and try to solve the customer's problem. Notes is a groupware product that promotes sharing and coordination. Management encouraged CSD representatives to enter all their calls, the nature of the problem, and information about the solution into the Notes database. CSD members can access this database in a number of ways and can search it for past incidents that are similar to the one they currently face. Within a year the database contained 35,000 entries of problems and their resolution.

How did change emerge from this technology investment? First, CSD representatives found a similar problem in the database for 50 percent of their calls; past solutions let them respond quickly with the correct answer to these customers. With this level of access, the representatives quickly became highly dependent on the database and technology. Management noted the change in the way representatives solved problems and reorganized the department into senior and junior representatives based on experience and expertise. The idea was that junior staff members would field all calls and pass the difficult ones on to the senior staff. However, junior representatives were not comfortable assigning problems to senior colleagues, so management created the role of an intermediary who would review problems and decide when they needed a referral to a senior representative.

CSD employees noticed a decline in face-to-face contact and began to find reasons to meet each other. Some of the representatives became proactive, looking for open problems in the database when they were not too busy. The company expanded use of the system to two overseas offices, creating some problems at first when the foreign representatives did not completely understand the process for creating and using the database. As the groups adopted shared norms for the system, however, the problems disappeared.

When others in the company wanted access to the data, the CSD staff was concerned since the database contained so many details. To solve this problem, non-CSD employees were given access to "sanitized" reports. The CSD staff also began to publish technical notes for the company based on the database. Finally, Zeta used Notes to create a "bug" database to facilitate identifying and fixing problems with their products.

This example of emergent change is very positive; CSD staff members found ways to integrate the Notes database with their jobs and to improve the quality of customer service. They expanded their use of technology to have a broader impact on Zeta than originally planned. In this case, information technology facilitated changes that emerged spontaneously from employees using the technology. You cannot plan for emergent change, but you can support and encourage it as changes become evident.

IMPLEMENTING *IT*-BASED TRANSFORMATION OF THE ORGANIZATION

The discussion above focused on the changes caused by an individual system or a reengineering effort within the organization. How do you implement the massive changes required to use information technology to transform the organization and create new structures and relationships within the firm and with external organizations? Earlier we argued that the IT design variables presented in Chapter 4 could be used to create a new kind of structure: the T-Form organization. The advantages of this structure include:

1. A **lean organization** with the minimal number of employees necessary for the business to function
2. A **responsive organization** that reacts quickly to threats from competitors and changes in the environment
3. A minimum overhead organization
4. A structure with low fixed costs due to more virtual components, partnerships, and subcontracting
5. An organization that is responsive to customers and suppliers
6. An organization that is more competitive than firms with traditional structures
7. An organization that allows its employees to develop their capabilities and maximize their contribution to the firm

One of the major advantages of this kind of organization is its lack of a large number of hierarchical levels. The firm is flat with few levels of management. This organization is *responsive* because decisions are made quickly; large numbers of levels of managers do not slow decision making. All these features add up to lower overhead than the traditional bureaucratic organization. The end result should be a firm that is more competitive than a traditional hierarchical organization because of its responsiveness and lower operating costs.

There are costs that go along with these benefits including:

1. The organization has to invest in information technology.
2. The firm has to be able to manage IT.
3. Employees have to learn new technologies and constantly update their knowledge.
4. Managers have a wide span of control.
5. Managers have to supervise remote workers.
6. Firms have to manage close relationships with partners and companies in various alliances.

Another cost of using technology to transform the organization is learning new technology. Products and systems are constantly changing. New releases of PC software, like spreadsheet packages, seem to average more than one per year. If you do not upgrade and learn new systems, eventually it becomes difficult to share with others. And, of course, you forego the improvements in the new version of the packages.

The T-Form organization features a wide span of control for most managers. The idea is to substitute electronic for face-to-face communications. Implicit in a wide span of control is a degree of trust in subordinates. Electronics will not substitute for the close control one can exercise over subordinates when a manager has only five or six direct reports. A recent news story on Japanese management showed a large number of workers arranged in two rows of desks, each row facing the other. At the end of the row sat the workers' supervisor with his desk perpendicular to the workers so he had them under constant view. Evidently a common feature of Japanese organizations, this physical structure is probably the ultimate in close supervision. The T-Form organization is at the opposite end of the spectrum. It requires managers to place more responsibility with subordinates to do their jobs.

Closely related to the need to adopt a management philosophy stressing subordinate responsibility is the problem of managing remote work. Companies are likely to eliminate physical offices for employees who spend a great deal of time traveling or who work from a satellite office or home. Work-at-home experiments have shown that some managers feel uncomfortable trying to supervise subordinates they rarely see. Remote work also requires the manager to trust subordinates, and of course, requires subordinates to act responsibly. Some subordinates have reacted negatively to losing their offices and to using part of their homes as offices. They feel the company is forcing its overhead costs onto them. Virtual offices will undoubtedly call for new managerial skills and relationships between managers and the people reporting to them.

The final management cost of a technology-based organization is handling relationships with external firms. These firms might be suppliers or customers, partners in a strategic alliance, or governmental agencies. These partners are a vital part of your business, but they do not report to you. Managers have to manage a cooperative arrangement without having the usual "tools" given a manager such as reporting relationships and control over subordinates' salaries.

Analyzing the Costs and Benefits of Change

When trying to implement something new, it is helpful to compare the costs and benefits as we have just done. Figure 19-2 contains a vertical line that represents an equilibrium in which costs and benefits balance each other. Moving the line to the right is progress toward the T-Form organization and moving it left is toward traditional hierarchical firms. The benefits of the T-Form organization are on the left pushing toward the right with the costs on the top of the right pushing left. When managers see the benefits exceeding the costs, they will move toward the T-Form.

We would expect that the advantages of the T-Form for new organizations would far outweigh its costs because the T-Form fits start-ups very well. A number of Silicon Valley companies employ virtual components and electronic linking and are well along the way in using IT design variables. A company makes a scanning system and software that is aimed at eliminating paper in the office. Their corporate office in Palo Alto is responsible for design, marketing, and sales. Subcontractors manufacture the product: the circuit board comes from Singapore, and a Boston firm makes the case, tests the product, and ships it to customers. Other partners help write the software. Sales representatives in the field do not have physical offices but are linked by mail, voice mail, and cellular phones.

What are the possibilities of moving more traditional firms toward the T-Form? In addition to the costs and benefits shown in Figure 19-2, there are additional

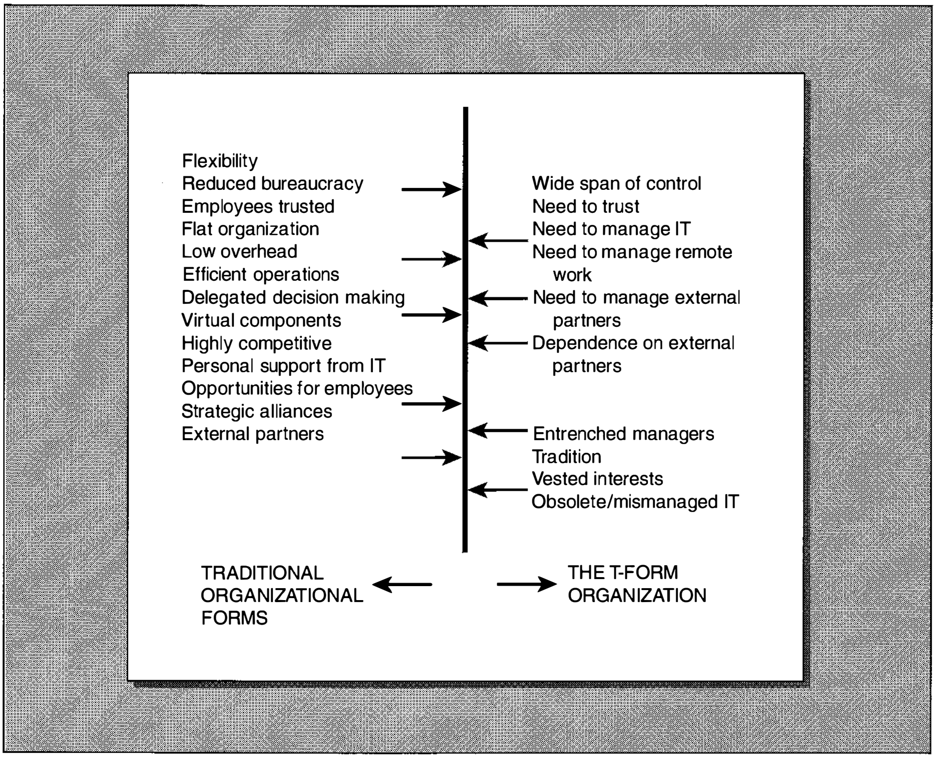


FIGURE 19-2
Forces for changing organization structure.

forces acting against the T-Form in hierarchical firms. These forces are "costs" to the current employees of the firm as the technology-based organization clearly threatens many vested interests. A minor restructuring of a department or workgroup will not let the firm enjoy the benefits of a new structure for the organization. We are suggesting a massive change that includes all employees and units of the firm. You might start in one department or division, but as with other technologies we have seen, you need a critical mass. E-mail does not achieve its potential if only 50 percent of the firm use it. Customers may be happy to use EDI with one division, though they may wonder why the rest of the company does not offer electronic linkages.

Massive changes are difficult to carry out since there are many forces acting against them. Major change programs create a number of threats to those already in the firm. The first of the threats is to the entrenched bureaucracy. Middle managers and others have proven very adept at protecting their jobs. As a result of many IT-stimulated restructurings, it is likely there will be fewer employees.

The new organization structure will require the company to downsize. Clearly, downsizing is a threat to existing employees, and it is natural for them to oppose an organizational form that encourages a smaller firm.

A manager committed to using IT design variables will also ask fundamental questions about all the tasks performed in the organization. Should we continue to operate a transportation system, or should we contract with outside carriers? Should we eliminate all forms of payment except credit cards and do away with the accounts receivable department? Should we contract out our IS operations? The threat of any of these partnerships or alliances is certain to arouse resistance on the part of current employees.

Motivating Organizational Change

Figure 19-2 also shows the addition of these "costs" that help to maintain the status quo, traditional organization. In fact, the cost/benefit assessment in Figure 19-2 is a helpful tool in understanding all kinds of change efforts.

It will be very difficult in many traditional firms to create movement toward the T-Form organization. What might motivate such a firm to change structures?

1. A merger or acquisition
2. A major crisis, e.g. substantial losses
3. Bankruptcy
4. Rebellion by the board of directors
5. Legal or regulatory reversal

Mergers and acquisitions often result in new management teams. New managers might look at the firm and realize that integration of the two companies provides a good opportunity to develop a new overall structure. Unfortunately, sometimes it takes a major crisis to motivate managers. We might include a rebellion by the board of directors here as well. The chairmen of companies with significant problems have been asked to resign in record numbers in the last few years. Powerful chairmen at IBM, DEC, Westinghouse, and GM among others have suffered this fate. Being a new manager in a crisis situation provides a certain amount of leverage for changing the organization.

Bankruptcy is a traumatic event that may well provide the opportunity for a dramatic restructuring of a firm. Unfortunately, the bankrupt firm is at a bit of a disadvantage with efforts to partner and form alliances given the history that put it into bankruptcy in the first place. It may also lack the funds necessary to develop a technological infrastructure. Finally, a legal or regulatory reversal may also provide the motivation for a firm to use IT design variables to come up with a new structure.

It appears that a crisis may be the strongest motivation for reorganization. Possibly the second reason is the competition. If a firm sees the competition performing significantly better after adopting a new structure, it may imitate the competitor.

A Challenging Implementation Problem

The futures exchanges are going electronic, ending the open-outcry system of trading. The Chicago Board of Trade, the world's largest futures exchange, is preparing for electronic trading around the clock. The CBOT will continue to use the open-outcry system on its floor but will be ready if customers demand electronic trading. Efforts are under way to develop software to handle difficult trades like options trading and spread trades. Europeans are moving quickly to electronics. Deutsche Terminboursre, or DTB, gained market share in trading German government 10-year-bond futures away from a rival exchange in London because of DTB's user-friendly automated trading platform. The London International Financial Futures and Options Exchange is now rushing to develop its own electronic trading system. The Paris derivative exchange introduced electronic trading alongside open-outcry operations. Soon floor trading disappeared, and the exchange closed the floor. Electronic markets make it easy to trade in different places. The CBOT, DTB, and the Swiss Options and Financial Futures Exchange will all trade products on each other's systems, expanding the choices for customers.

Imagine the implementation issues with these electronic trading systems. Customers must learn new ways of using technology, but experience indicates that they learn quickly. The more difficult problem is what becomes of the floor trader when there is no more floor? Open outcry brokers do not want to see the end of the physical exchange, and they are likely to resist electronic markets. Competition, however, with exchanges that have adopted electronic training is a powerful impetus for implementing electronic exchanges.

A Change Program

How should a manager go about trying to create a T-Form organization? You are trying to move the organization from one state, say a traditional, hierarchical organization, to another, the T-Form. Change is one of the most difficult things to bring about; our discussion earlier in the chapter has pointed out a number of forces acting against the manager who wishes to change a firm's structure. Figure 19-2 can be thought of as a **force field** as it shows the forces acting for and against change. To bring about change, the manager can either increase the forces for change and/or decrease the forces opposing change.

We suggest some approaches to strengthening the forces for change, but each organization is different and a change program must be custom tailored. Table 19-5 describes the key steps and some recommended actions. It is based on some of the ideas of Nadler and Tushman (1988).

The first step is to motivate the change. We have suggested some crises that may provide enough motivation for action. There may be some less dramatic events that convince everyone change is needed. It is helpful here to have broad support from the board of directors and others with influence in the firm.

Having a plan for the transition to a new organizational form is very important since it provides a roadmap for action and keeps employees aware of what

TABLE 19-5

MOVING TOWARD THE T-FORM ORGANIZATION

Step	Action
Motivate the change	Explain reasons such as competition and falling sales; look for broad support from places like the board; communicate with everyone in the organization
Develop a transition plan	Use a task force to develop the vision for the new organization; describe steps that must be taken to reach a new organizational structure; take full advantage of IT design variables
Accumulate power and resources	Obtain support from key individuals and groups in the organization; be sure you have the influence and resources to bring about change
Manage anxiety	Communicate with employees; consider a groupware rumor mill application; provide outplacement and counseling; involve employees in designing the new organization
Build IT capabilities	Technology must be in place to enable the T-Form; there is often a lead time for implementing IT before you can make changes in the organization

is happening. Task forces for developing the plan are a good way to bring employees into this process and tap their knowledge for building the new organization. The results of the task force should be widely disseminated. Be sure to take maximum advantage of the IT design variables discussed in Chapter 4.

Employees will experience much anxiety with just the suggestion of a change in the status quo that could alter their jobs or eliminate them. Nadler and Tushman suggest that one job for management is to manage anxiety in the change process. Involving workers is one way to reduce, but not eliminate anxiety. Individuals will be aware of the company's plans, but they may also see changes that look very threatening to them.

On balance, it is a good idea to stress open communications rather than keep plans secret. In today's business environment, a responsible firm will also provide counseling and outplacement services for employees who are no longer needed.

Making the transition to a technology-based organization requires that the firm have adequate technology in place. You may develop the capabilities needed in house, or you may turn to outside vendors. At a minimum you need a communications network and e-mail. Depending on your business, you need electronic connections to buyers and suppliers. Some of these links can be "purchased" through value-added carriers and other service companies. Workstations in offices and networks connecting them are important. Increasingly, it appears that groupware like Lotus Notes (discussed in Chapter 21) and the Internet will become important ways of managing within the organization and a mechanism for linking to external partners.

The task here is to design the firm's technology so it will enable, not constrain, its ability to move toward a T-Form organization. Once the technology is in place, the **IT design variables** can be used to develop the structure of the organization. Below are some questions to help you use IT variables in the design. It is important to recognize that each organization will develop its own unique structure.

1. What are the most significant processes in our organization, e.g., order fulfillment, manufacturing, etc.?
   a. To what extent should these processes be redesigned?
   b. What opportunities do new technologies and IT design variables offer for improving these business processes?
2. Who are our major partners, including customers, suppliers, and others (banks, accountants, and law firms, among others)?
   a. What opportunities are there for electronic linking and communications with these organizations?
   b. Where should we try to establish electronic customer/supplier relationships?
   c. What additional services can these partners provide? What opportunities are there to create virtual components?
3. How should we structure our strategic organization—by product, region, or a combination of factors?
4. What is our competitive strategy? How do IT design variables help us implement this strategy?
5. Given the major processes in our business, how do we assign personnel to be sure these processes are accomplished?
   a. Can we use technological leveling to minimize the number of layers in the organization?
   b. Do production automation and electronic work flows have something to contribute to our business processes?
6. What kind of managerial hierarchy is necessary?
   a. Can we use technological leveling to reduce layers and broaden the span of control for managers?
   b. Can we use *technological matrixing* to form temporary task forces and work groups instead of establishing permanent departments and reporting relationships?

The overall objective is to create an organization with a flat structure, flexibility, responsiveness, decentralized decision making, effective communications, links to business partners, and the other characteristics of the T-Form structure.

We think that the major challenge facing managers in the twenty-first century will be to design organizations that take advantage of the **IT design variables** discussed here. Moving toward the T-Form organization requires new ways of thinking for the start-up organizations and massive changes for traditional organizations. Senior managers must decide if the benefits we claim for this kind of organization are sufficiently compelling to confront the perils of changing the organization.

BEYOND STRUCTURAL CHANGE

How do we bring about changes in interorganizational relations, the economy, education and national development with the help of new technologies? We have seen in our discussion of the impact of IT how firms use electronic communications and linking to change interorganizational relationships. Since these changes generally involve individuals who are not part of your organization, how do they occur? The implementation framework shown in Table 19-4 has a column for Management Support; in this column we mention having a sponsor or champion. This individual is at a senior level of management and provides the leadership necessary to create change. For developing new interorganizational relationships, you need such a champion to initiative ideas, meet with managers of the other organizations involved, and obtain support in your own organization for the change.

How does information technology facilitate changes in education or national development? Here again, a sponsor or champion is important for change. Since these kinds of changes take place in a political arena, they are highly uncertain and probably irrational. Changes at the national level involve multiple constituencies, competing political philosophies, and different personal objectives. The force field analysis shown in Figure 19-2 can provide a number of insights to help the sponsor identify various constituencies and the forces leading to their positions.

Changes enabled by technology at the level of the economy reflect all the other changes we have discussed. These changes will be emergent rather than planned. In recent years the U.S. has experienced steady levels of economic growth, low inflation, low interest rates, and high levels of employment. Classic macroeconomics suggests that this combination is unlikely to occur. One explanation, without much data to support it, is that information technology has finally led to increases in productivity, which allow for modest wage gains without inflation. If this observation is true, then overall productivity gains are emerging from the individual change efforts of thousands of firms in the economy.

CHAPTER SUMMARY

1. Implementation is a change process that is designed to alter existing practice. With information technology, we make changes through individual applications and by using IT variables to redesign the organization.
2. The ability to use IT to change procedures and organizations themselves is one of the most exciting parts of technology. *With IT, a manager can make a difference in how an organization functions and in its chances for success.*
3. There has been a great deal of research on the implementation of individual systems, but it is still too often the case that new applications fail completely or fail to achieve their potential.
4. The chapter reviews factors thought to be related to successful implementation and a process model for the stages of systems development and implementation.

5. Table 19-4 combines the factor and process models to provide guidelines for improving the chance of successful implementation for an individual application of the technology.
6. The chapter recommends a high level of user involvement and influence in the design of a system for a number of reasons, including the psychological commitment that involvement helps create and the knowledge that a user brings to the design project.
7. It is important to transfer psychological ownership of a system to the users of the application.
8. Emergent change is unanticipated; it emerges from individuals who adapt the technology and use it to change the way they work.
9. The problems of implementing change are multiplied when the change target is the entire organization.
10. IT organization design variables are some of the most exciting contributions of the technology; however, using these variables to adopt a new design like the T-Form organization is a formidable challenge.
11. A force field analysis of the forces encouraging and inhibiting change can help to plan for a new organization structure.
12. It will in general be easier to use IT design variables when creating a new firm than when trying to change the structure of an existing one.
13. The motivation for a traditional organization to adopt a technology-based structure is likely to come from a crisis or from seeing competitors become T-Form converts.
14. IT also enables changes in interorganizational relations, the economy, education, and national development.
15. Change is one of the most difficult assignments, but it is through change that management assures organizations will survive and flourish in the future.

IMPLICATIONS FOR MANAGEMENT

Implementation of change is clearly a management responsibility. Managers should constantly be looking for improvement projects, ways to operate more efficiently and effectively. The hardest part of this assignment is implementation—seeing that changes occur in the organization. If you look at stories about successful managers, they usually have brought significant change to their organizations. This is particularly true for "turn around" situations in which the manager rescued a sinking company. As a manager, you will find change one of your most challenging and frustrating tasks.

KEY WORDS

Champion
Change
Commitment
Demographics

Design
Emergent change
Exploration
Force field
Implementation
Initiation
Installation
IT design variables
Lean organization
Operations
Responsive organization
Termination
Testing

RECOMMENDED READING

Lucas, H. C., Jr. *The T-Form Organization: Using Technology to Design Organizations for the 21st Century*. San Francisco: Jossey-Bass, 1996. (A book devoted to the design of technology-based organizations.)

Lucas, H. C. Jr.; M. Ginzberg; and R. Schultz. *Implementing Information Systems: Testing a Structural Model.* Norwood, NJ: Ablex, 1991. (Presents a review of implementation literature and a new framework for approaching implementation.)

Nadler, D.; and M. Tushman. *Strategic Organization Design.* New York: HarperCollins, 1988. (An excellent book on traditional approaches to organization design.)

Orlikowski, W. "Improvising Organizational Transformation Over Time: A Situated Change Perspective," *Information Systems Research.* 7, no. 1 (March 1996), pp. 63–92 (A well-written article that provides many insights on emergent change.)

DISCUSSION QUESTIONS

1. Why is implementation more than just the last few weeks of the systems life cycle?
2. What definitions and measures of successful implementation can you suggest other than the ones discussed in this chapter?
3. What are the responsibilities of users in the systems design process?
4. How do the responsibilities of managers differ from those of other users during systems design?
5. What are the crucial differences between an internal information system and an interorganizational one from the standpoint of implementation? What are the key similarities?
6. What is the role of a consultant in helping to design information systems? How does this role change under the systems design policies suggested in this chapter?
7. What approaches are there to evaluating the benefits of information systems?
8. How would you measure the impact of an information system on decision making?
9. What factors mitigate against massive change in the organization?
10. What might motivate a firm to use IT design variables to make a radical change in its structure?
11. What problems does user-oriented design create for users, their management, and the IS department?

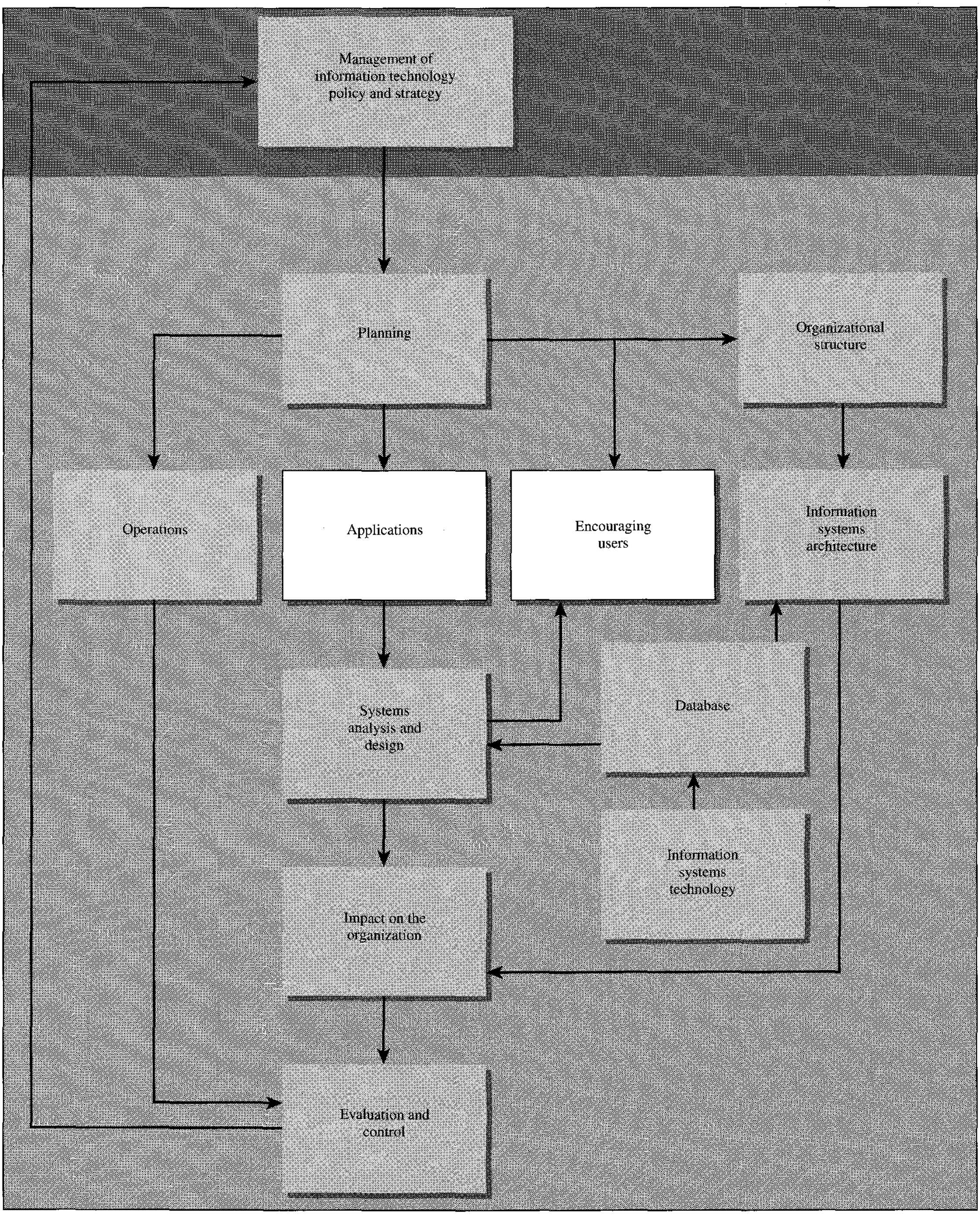
12. Can user-oriented design work for a system encompassing large numbers of people, for example, a reservation system involving hundreds or thousands of agents? What strategy could be adopted in this situation?
13. What are the advantages of an organization with a wide span of control? What are the disadvantages?
14. How does IT enable change in the economy?
15. What implementation strategy does the process model suggest?
16. Why do some authors think the hierarchical organization is doomed in the twenty-first century? What are the advantages of a flat organization structure?
17. How can information technology make major changes in education?
18. As a potential or present user of information systems, how do you respond to the idea of being in charge of the design of such a system?
19. Why should we be interested in the relationships among system use, user satisfaction, and performance?
20. Are the techniques suggested here applicable in other contexts? What situations can you suggest in which user control might be more successful than control by a group of technological experts?
21. How can you transform a huge firm like General Motors with the help of information technology?
22. When does planning for successful implementation begin in designing an information system?
23. What is the role of the technological infrastructure in moving toward the T-Form organization?
24. How does information technology affect national development?

CHAPTER 19 PROJECT

A Systems Survey

In any organization, you will observe large differences in the extent to which individuals use information systems. Find an organization that will allow you to conduct research, for example, a place where you once worked, a university, or some public agency. Develop a series of interview questions about the kind of systems available to members of the organization, ranging from administrative systems to the personal support provided by PCs.

When you have interviewed 10 to 15 members of the organization, see if you can diagnose why there are wide-scale differences in system use. What points do your findings suggest for systems designers? For management? What kind of implementation strategy can you recommend?


Management of
information technology
policy and strategy
Planning
Organizational
structure
Operations
Applications
Encouraging
users
Information
systems
architecture
Database
Systems
analysis and
design
Information
systems
technology
Impact on the
organization
Evaluation and
control

PART FIVE

EXCITING DIRECTIONS IN SYSTEMS

This part of the text explores recent trends in information technology. Of particular interest is supporting users who work with technology. Most professionals today, and practically all in the future, will have a workstation on their desk. They will be connected to a network and will access various computers and databases over the net.

Decision-support systems are an exciting way to use information technology. These applications help managers make decisions. A decision-support system does far more than just process transactions.

Technology is increasingly used to support individuals and work groups in their tasks. Groupware has the potential to dramatically change the way firms are structured and the way co-workers interact.

In this part we also explore multimedia and look at the various purposes for this technology.

Intelligent systems represent an applied area within artificial intelligence. These systems capture the expertise of an individual or group of individuals and make it widely available throughout an organization. Intelligent systems have a great deal of potential for applying the technology in a way that is quite different from traditional data manipulation.

CHAPTER 20

Supporting Knowledge Workers

Outline

Focus on Change

Users with their workstations, especially those connected to Intranets and the Internet, are changing the nature of the organization. Individuals within and external to the firm are connected to each other, making it possible to restructure workgroups and form alliances with outside organizations. Applications built around groupware, discussed in Chapter 21, can create a knowledge base for the organization. How much encouragement should you provide for your colleagues to become involved with and use the technology?

In the 1980s a phenomenon known as end-user computing grew out of frustration. Users found that it took an inordinate amount of time for the information services department to process requests for changes to existing applications, such as the creation of a new report. Why does it take so long for a simple request to be completed?

The IS department has limited resources. Analysts and programmers can work on new applications or they can be assigned to maintenance. It is the maintenance staff that generally handles requests for enhancements like new reports. Since most IS managers feel they are understaffed and because management's focus is often on new applications, maintenance and enhancements sometimes get a low priority.

IBM of Canada conducted an experiment to see if it could satisfy more of its internal users. This company set up something called an information center, a room staffed with terminals and consultants to help users become familiar with technology. The center helped end users work with high-level languages so they could retrieve data from the company's computers and prepare their own reports with that data. This effort was the beginning of attempts to support end-user computing.

Who, then, was the user? This individual is generally considered a nonprofessional in the systems field. He or she has a different function from information systems; for example, a user may be a professional in finance, accounting, or production. A more appropriate term might be "knowledge worker."

Today, with the prevalence desktop computing and client-server architectures, the term "end user" is outdated. It is clear that most of us are users of the technology in some way. The question is, what do we want to encourage users to do with IT and how do we support their efforts?

THE RANGE OF USER ACTIVITIES

Table 20-1 shows the different ways users are involved in computing. For the most part, knowledge workers use personal computers and networks, often accessing data on file servers and/or mainframe computers. The user might begin working with a system like a spreadsheet package. The vast majority of spreadsheets are created by users rather than some intermediary. Users also tend to develop their own graphics for presentations. Knowledge workers may define their own database using a program like Microsoft Access. However, the user may also let a professional set up the application and only perform queries on the database.

Companies with Intranets encourage users to publish material on their internal Web. Firms also have "Extranets," Web pages that external organizations access, for example, to order products and services. The large number of HTML editors and Web page development products encourages all of us to become Web publishers. The components of Microsoft's Office suite can save their output as HTML documents to be posted to pages accessible through an Intra- or Extranet. More advanced development tools like FrontPage encourage you to design all or

TABLE 20-1

USER-COMPUTING ALTERNATIVES

Packaged applications
Spreadsheets
Database management systems
Presentation graphics
Special-purpose languages, e.g., SAS, SPSS
Web/Internet applications
Publishing documents with HTML editors, development tools
Creating Web pages with tools like FrontPage
Building Net applications
Query languages
Database query facilities
Development tools
Visual Basic
PowerBuilder
DBMS development languages
Object-oriented languages

part of a Web site. Web development tools may be the invention that lets knowledge workers develop applications that large numbers of people access through the Internet.

Queries on a PC can be done with the query processor that comes as a part of the database management systems described above. Products like Access let you save a query for reuse. With more effort you can develop an application using macros and Visual Basic, though at some point you will probably want to refer the development to a professional staff member.

The fourth major category in Table 20-1 describes systems-building tools. There are varying levels of sophistication among users. Some want to build complete systems and others do not. As we have seen in earlier chapters, defining and constructing an application of information technology is a time-consuming, labor-intensive task. However, there are probably small applications you will want to develop yourself. There are many tools for building PC-based systems, including languages like Visual Basic. This language facilitates the construction of an application that will run under Windows. However, you are getting heavily into programming if you select this alternative.

Other options for developing custom applications include a PC database management system. These systems make it possible to define input screens and output reports, and to link different relations in the database. Although they are not as difficult to use as a general-purpose programming language, it would still take considerable effort for you to develop a system using one of them. In the future, we hope that object-oriented programming will develop so you simply have to point to various icons on a screen with a cursor, click a mouse key, and assemble the icons into a program. We are not quite there yet, however.

Helping an Unusual Group of Users

In an earlier sidebar, we talked about helping the farmer improve the efficiency of his or her operations. Technology can also do something for the cowboy who carries a laptop. Currently about half of the over 9 million dairy cows in the U.S. are monitored electronically. The next frontier is to monitor beef cattle to improve the quality of meat. In addition to ropes and chaps, a cowboy may carry a scanner to collect data from an electronic ear tag on a steer. The user downloads the data to a laptop to see each cow's family and medical history.

There are an estimated 88 million beef cattle in the U.S. The difference between a steer that yields prime cuts and one that produces mostly ground chuck is about $300. The objective is to learn what feed and other characteristics produce the kind of cuts for which Americans are willing to pay a premium. As we have become more health conscious, meat consumption has declined. Growers want to satisfy customers with prime cuts of leaner, more healthy meat. The cattle industry generates $50 billion a year in sales at the retail level.

Feedlots can use ear tags to trip sensors that record how often and how much a cow eats. They may also use ultrasound to determine the leanness and marbling of meat. If an animal is getting too fat, the grower can reduce its feed, saving money in the process. Information on the kind and quality of beef is also being sent back to the farms where calves are born and raised to improve breeding programs. Veterinarians scan the tags to record the immunizations and medicines the cow receives.

Dairy cows have been monitored for a number of years. Sensors on milking equipment note when a tagged cow enters the milking area and is attached to a machine. During milking the sensors record how much milk the cow produces, its fat content, and the milk's white blood cell count, which indicates the cow's health. A third of dairy farmers transmit their information by modem to the Department of Agriculture in Maryland where it is compiled and analyzed. The results are returned to the farmers to help them improve their operations. Where will this kind of technology turn up next?

Will Knowledge Workers Design the Entire System?

The unanswered question about computing is exactly how much responsibility do users want? Will they want to do more than use a PC package? Will we find that in 10 years, there will be no more systems analysts and programmers, only users who work on computers?

It is unlikely that knowledge workers will want to develop large multiuser systems because of the considerable amount of time required. Also, when one moves from defining reports to database design, communications networks, and so on, the average user does not have the expertise required to develop a major application.

You may, however, want to develop a simple application for colleagues in your department. The tools described above offer some alternative approaches. You will probably need some kind of consulting help to complete such an application. One approach to providing this consulting is to recruit "power users" from within the organization. As development tools improve, you will be able to accomplish a great deal in a "part-time" systems-building effort.

Supporting Knowledge Workers

Computing cannot be the sole responsibility of the user; there must be support. The information services staff should help select the needed tools and systems, and provide adequate training. IS staff members should provide ongoing help about the systems and languages with which users are working. The IS staff should help the user locate data, and they may need to write programs to collect data from different files or process these data in some way before the end user can access them.

The term "user services" has become popular for describing a support group for users. Consultants in the group have a number of duties:

- Solving immediate problems for users on the telephone or through e-mail.
- Teaching courses about available computers and software packages
- Consulting on the use of packages and languages
- Providing assistance in deciding on the acquisition of computers and peripherals
- Helping users by extracting, merging, and reformatting data on company databases, and making the data available in a file for easy access by users

The consultant aids the user, answers questions, and provides help in accessing data. The user determines the data needed and creates the program to process the data.

Information centers are transforming themselves to focus more on departmental needs and solving business problems as opposed to teaching people how to use computers or specific packages. The information center needs to be a consultant for the user who wants to develop applications and solve problems.

The Data Warehouse

One strategy adopted by companies in which many users primarily want to access data on corporate files is to create a user database. The data warehouse contains data of interest to users in a format that is easily accessible to them (see Chapter 10). Users working on their own PCs access these multidimensional file structures to answer their questions. In a client-server environment, the user will access corporate data by making requests of the server for information that will be transmitted to his or her local workstation. The success of the data utility depends on choosing the right information from the main corporate database and making it available on the user's computer. A data warehouse is very appealing for users as they can finally access data they know is available!

POLICY ISSUES FOR MANAGEMENT

Support

One policy question for the information services department is how many resources should be devoted to supporting users. A more difficult problem is controlling the proliferation of hardware and software. Users conducting their own research may come up with a number of different approaches. Each new system, whether hardware or software, requires the IS staff to learn how to support it. Such an effort is costly and time consuming. Thus, information services, with support from senior management, may establish a policy that all software and hardware be purchased through and with the approval of the IS department. Then the IS staff can evaluate the systems recommended and allocate staff members to become familiar with them. The IS department can keep control so that a reasonable number of different systems are acquired.

Making Mistakes

There are many examples of users making costly mistakes doing their own computing. Knowledge workers are not systems professionals, and they may not develop adequate test programs. One construction firm actually sued Lotus (the suit was dismissed) because a user included a new item in a bid but failed to include that new item in the final summation of all costs. As a result, the bid was too low and the contractor lost money.

If management gives users the freedom to develop applications, it needs to provide some guidelines and training on how to do it. Management should also expect

MANAGEMENT PROBLEM 20-1

A major East Coast business school has a computer center staffed by more than 40 individuals. It operates a modern network with 12 servers, 5 Unix time-sharing computers, and more than 1000 PCs. Because faculty and students found the staff unresponsive, the director of the center established a new department called user services, which consists of five people, each of whom is assigned to help one or more academic departments with its problems.

In general, the representatives from user services have been very well received by the faculty. They have limited student contact at this point. The problem is that user services reports directly to the director and has no group reporting to it. As a result, when it finds out that something is wrong, user services personnel have to negotiate with other departments in the computer center to have the problem fixed. For example, if there are problems in the PC labs, the head of user services must ask the head of the PC labs to fix them.

Although the user services representatives would like to help their users, their hands are tied because they can only ask others in the center to solve problems. Needless to say, the members of user services are very frustrated.

What actions can you suggest to solve this problem? How might the organization be restructured to improve the services provided to users?

mistakes and react accordingly. For example, you might want to have crucial numbers checked by another user, or even by a separate system. It never hurts to use a calculator to check a spreadsheet, or to try a new database application to see if you can make it fail!

Standards

As users acquire local computers, the information services department will have to coordinate acquisitions. Various pieces of hardware will probably be linked in some kind of network. Compatibility among the different devices is of concern here. Again, multiple hardware vendors and different types of software place a heavy support burden on the computer staff.

On the other hand, users often develop their own applications to avoid the controls and perceived unresponsiveness of a central IS group. Senior management may well see the need for hardware and software standards, but it should also realize that users need some freedom if they are to do some of their own computing.

Data Access

The user is, by definition, not a systems professional. For most applications, the IS staff allows access to data under its control but will not allow users to change these data. The systems professional must be concerned about error checking, editing, data validation, and protection of the integrity of the database. There is no reason to suspect that the user is necessarily aware of this aspect of systems operation. The consulting staff can raise some of the issues discussed above, particularly when users develop local self-contained applications. For corporate data entrusted to the information services department, however, the staff will have to establish controls on data access and updating.

Is Computing the Right Use of Time?

How much should knowledge workers do in developing technology? One senior manager does not want executives writing programs. He insists that programs be written exclusively by professional programmers; their salaries are much lower than those of senior executives. But what is most productive? What is a program? If a manager constructs a balance sheet using a spreadsheet package on a personal computer, is that programming? Is the use of a DBMS to define a personal application considered programming? Is publishing a report on a Web page programming?

One answer is for you to become very facile in the use of these tools so that you will not spend an excessive amount of time using them. If it is possible to do so, developing your own personal application can be fast and should result in a system that meets user requirements. Earlier we mentioned an Andersen Consulting survey that indicated 81 percent of the senior managers queried were using personal computers. It is unlikely that these managers will discourage others from doing the same thing!

BENEFITS FROM ENCOURAGING KNOWLEDGE WORKERS

Knowledge workers have already discovered the benefits of user computing. They are using personal computers and packages with great enthusiasm. Knowledge workers are demanding tools they can use to solve their own problems. To some extent, the information services department has lost the initiative. To regain it and see that the systems effort is coordinated, and also to avoid duplication and waste, the IS staff need to establish a hardware and software architecture and a support mechanism for users.

Encouraging users to solve some of their own problems is another way to reduce the time required to develop an application. This approach provides immediate feedback. The user becomes the designer of the system. This strategy also adds to the total number of persons working to solve systems problems. By increasing the number of individuals brought to bear on the problem, the backlog of systems work should be reduced. Users can reduce the length of time they have to wait for an application.

CHAPTER SUMMARY

1. You are a likely candidate to solve problems using information technology, probably a personal computer.
2. A key management issue is how much time knowledge workers should take from their normal activities to devote to systems development.
3. Management also has to worry about supporting users. Information centers, data warehouses, and user training are not free.
4. The benefits from encouraging knowledge workers to solve problems can be substantial if management supports them. Knowledge workers can cut the waiting time for information, and they can develop simple systems and reports without involving a systems professional.
5. The user can accomplish a great deal from his or her workstation, given tools and support. The user, rather than the systems professional, is in control of computing.
6. As a manager, you have to decide how much technology you will use and also how to use it yourself, and you must provide guidelines for those working for you.
7. It is clear that users are constantly doing more of their own development.
8. It is also clear that, despite the attractive interfaces of personal computers and windowing software, information technology is becoming increasingly complex. We expect there will continue to be a need for professionals to develop the IT infrastructure and multiuser applications critical to the organization.

IMPLICATIONS FOR MANAGEMENT

Different managers have quite different views on how much time they want their subordinates to spend developing applications for their own use. How do you know when the user has exceeded his or her knowledge? When do you call in the professional? It is safe to say that users have done and over time will be doing more development as the number of computers expands and software becomes more powerful. You will have to make the difficult decision on how the people working for you should spend their time. If you feel they should develop their own applications, then think of ways to support them with educational programs and consulting help when needed.

KEY WORDS

Compatibility
Control
Database management system (DBMS)
Data warehouse
Extranet
Fourth-generation language
Information center
Intranet

RECOMMENDED READING

McNurlin, B.; and R. Sprague. *Information Systems Management in Practice.* 4th ed. Englewood Cliffs, NJ: Prentice-Hall, 1998. (An excellent book with much material on supporting users.)

Mirani, R.; and W. King. "The Development of a Measure for End-User Computing Support," *Decision Sciences.* 25, no. 4 (1995), pp. 481–497. (This paper describes the development of an instrument to measure support for users; the categories into which various items group are very interesting for a manager who wishes to encourage users to work with IT.)

DISCUSSION QUESTIONS

1. Why is everyone computing today?
2. What are the advantages of users solving their own problems? Should management encourage it?
3. What is an information center?
4. What kind of support is needed for knowledge workers?
5. What is a data warehouse?
6. How much programming should users actually do?
7. How do modern tools make it difficult to define what is programming and what is using a package?
8. Why has the use of IT by individuals accelerated in the past few years?
9. Why is a query language alone not sufficient for users to access their data?
10. How does having users solve some of their own problems affect the traditional role of the systems analyst and programmer?
11. Will more user development eventually eliminate the need for professional systems analysts and programmers?
12. What is the impact of client-server architectures on knowledge workers?

13. What guidelines would you give your subordinates about the extent to which they should develop applications for their own use?
14. What is the potential of Intranets and Web publishing in developing applications?
15. How can a manager encourage users to become more involved in systems design?
16. With what kind of project or at what point in time should a user call in a systems professional rather than undertake a project himself or herself?

CHAPTER 20 PROJECT

A Help Desk

Knowledge workers need help! Users are working with more desktop packages and more complex software all the time. Because the knowledge worker is involved in a range of activities, using a workstation constitutes only a part of his or her tasks. This individual may become quite competent at using desktop software and even accessing data on corporate databases over a network. However, this worker at some point will exhaust his or her knowledge of the technology and will need help. If management wants to support knowledge workers, it will provide consultants or a "help desk."

IT staff members working at the help desk answer phone calls and provide advice. We saw the example in Chapter 19 of Zeta Corporation's use of groupware to enhance the performance of a help desk for external customers. For this project, design a database to log help requests from users in the organization. How might you search this database to find answers to frequently asked questions? What use might you make of a corporate Intranet as a way to help users while reducing the workload on the help desk?

Organization Support Systems: DSSs, GDSSs, EISs, Groupware, and Multimedia

Outline

Focus on Change

The technologies described in this chapter can play a major role in transforming the way you do business and manage the firm. Executive information systems, decision-support systems, and groupware offer support to the manager and are ways to coordinate the organization that would not be possible without IT. These technologies have great potential for changing the way people in the organization perform their jobs. Groupware, in particular, offers a platform for several different applications of technology. Groupware can coordinate the activities of individuals with a common task and enable people working together to be in different locations around the world.

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This chapter discusses a wide range of systems intended to support the way people work. These systems by and large *do not* process transactions. Instead, they provide information for decision making, or they support groups of people working together on some task. They may use data collected and processed by a transactions system, but they analyze these data far differently than the system that maintains the database.

DECISION-SUPPORT SYSTEMS

A **decision-support system (DSS)** is a computer-based system that helps the decision maker utilize data and models to solve unstructured problems (Sprague and Carlson, 1982). One of the most frequently used DSSs is a spreadsheet package. The user builds a model and looks at the impact of changing certain variables or assumptions. A user might look at the impact of a change in interest rates on a possible investment in a new manufacturing plant, for example.

Alter (1980) offers a framework for classifying different types of DSSs. His original framework has a number of categories that can be summarized into two main types: data-oriented and model-based DSSs. A data-oriented system provides tools for the manipulation and analysis of data. Various kinds of statistical tests can be run, and data can be combined in different ways for display. A model-based system generally has some kind of mathematical model of the decision being supported. For example, the model might be an operations research optimizing model or a simple model represented by a balance sheet and an income statement for a firm.

Decision-support systems offer tremendous power for managers who can generate and try many different alternatives, asking "what-if" questions and seeing the results. As one manager said, "I'm not being forced to take the first solution that works just because it takes so long to generate an answer; using a model and a spreadsheet program on a PC, I can now try different alternatives and choose the one that looks best."

DSS Design

How does the development of a DSS differ from traditional design?

- The focus is on decisions, not data flows.
- The construction of a DSS tends to follow an iterative or prototyping approach.
- Building one of these systems forces the user to become involved in the design process.
- The system may be designed with the help of a systems analyst or by the user alone. Many decision makers build their own DSSs for PCs.

With a DSS, the user looks to be able to interact with the system and change parameters, doing what-if analyses and trying different scenarios. Even in a DSS that is used primarily to supply data and statistical analysis, it is helpful for the user to be able to generate interactively the statistics from a PC. The systems professional working to develop a DSS faces a problem for which the conventional systems life cycle may not be well suited. The DSS often involves an unstructured decision problem, making it difficult to develop detailed logic specifications. If a group of users is involved, there may be no consensus on the identification of the problem or on the definition of a system.

Under these conditions, an evolutionary, prototyping approach is likely to be the most successful. The developer begins by building a small model of the system. As users are exposed to the model over time, the specifications evolve. An evolutionary approach has the advantage of providing rapid feedback to users, both to obtain feedback on design and to maintain the users' interest in the project.

Today users develop the preponderance of DSSs on their own PCs. The user will not follow a formal design process, but will build and test different versions of the DSS until a satisfactory version is obtained. The ability to develop decision models quickly and easily on a PC has had a major impact on the way decisions are made in the firm. Instead of arriving at a solution that works, you will try many different scenarios and pick the best one. Information technology is clearly doing more than processing transactions. With DDSs, key operational and managerial decisions in the firm are being addressed.

Chrysler Provides Data to Help Suppliers Make Decisions

Before its merger with Mercedes Benz, Chrysler began to open its mainframe production computer systems to some 2000 people in the company. These business analysts and others can use a "point-and-click" interface to access Chrysler information, so just about anyone with a Web browser can obtain data. The effort required to provide this support to a wide range of people making decisions about Chrysler was significant. The company has integrated 21 mainframe transactions processing systems to generate the data. The fact that the Web-based access is directly to the mainframes rather than databases on servers is unusual. However, Chrysler felt that servers might have a problem handling the one million transactions a day with a fast response time to users at assembly plants around the world.

Before the integration effort, users had to sign on and collect data from the 21 different mainframe systems to get a comprehensive view of Chrysler's operations. Frequently these users had to enter data into a spreadsheet to consolidate it for analysis. As an example, if an analyst finds a shortage of brake rotors, it is easy now to see the impact on the company's 21 assembly plants and alter production schedules to avoid a problem. Decision support needs data, and Chrysler has made an extensive effort to make needed information available to its employees through this Intranet.

EXAMPLES OF DSSs

In this section, we look at decision-support systems in some detail to illustrate the contribution they make to the organization.

Yield Management: How to Overbook Gracefully

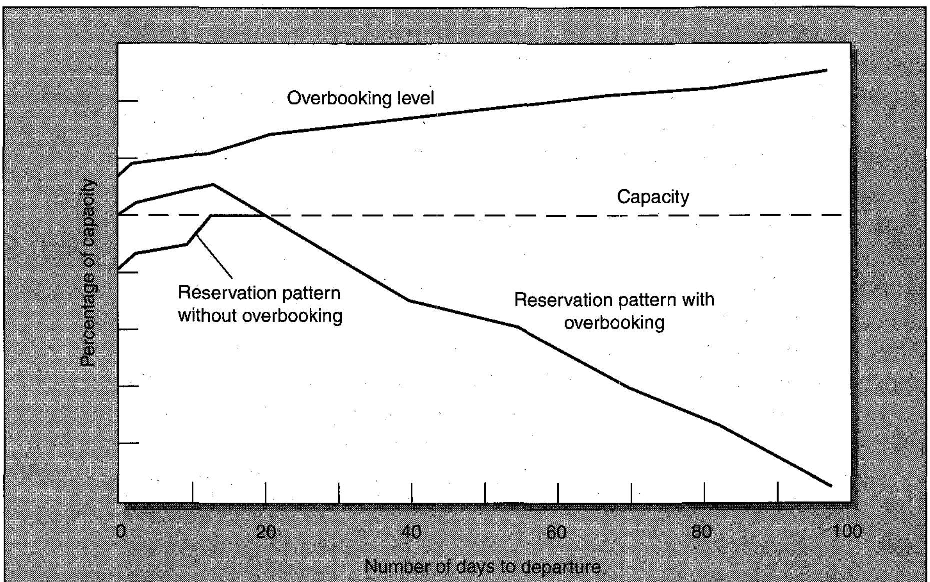
American Airlines faces a problem common to the industry: How can it maximize the revenue or yield from each flight? Yield management for an airline is like inventory control for a food manufacturer. If food items are left in inventory past a certain date, they must be discarded as spoiled. American estimates that without controls to allow for overbooking, 15 percent of its seats would be "spoiled" on sold out flights.

American Airlines estimated that solving the yield management problem using a nonlinear, stochastic, mixed-integer mathematical program would require approximately 250 million decision variables for its entire route system. Instead of developing a single model, American Airlines' operations research group developed a series of models to attack three more manageable subproblems (Smith et al., 1992):

1. The first of the models controls overbooking, the practice of intentionally selling more reservations for a flight than there are seats on the aircraft. An airline overbooks because it expects a certain number of cancellations and no-shows at the gate.
2. The second model helps American Airlines decide how many discount seats to offer on a flight.
3. The third model, traffic management, controls reservations by passenger origin and destination to maximize revenue. Because of the current hub-and-spoke system, the flights are interdependent; a passenger flying into the Dallas/Fort Worth hub may leave on any number of other flights to reach his or her final destination.

Overbooking Figure 21-1 illustrates the overbooking problem. Overbooking allows the airline to accommodate more passengers, but there are penalties associated with denying passengers boarding if they have a confirmed reservation. The airline must compensate "bumped" passengers, and it must provide an alternative flight for them. This cost of overbooking actually increases with the number of passengers denied seats. For example, the airline may have to offer more hotel and meal vouchers and may have to transport the bumped passenger on another airline's flights.

American Airlines developed an **optimization** model shown in Figure 21-2. As the overbooking level increases, net revenue, which is passenger revenue minus overbooking costs, rises to a maximum value and then decreases as the cost of an additional oversale exceeds the value of an additional reservation. The overbooking model draws on data from the SABRE reservation system. The overbooking level has a constraint to prevent degrading passenger service too much. It relies on



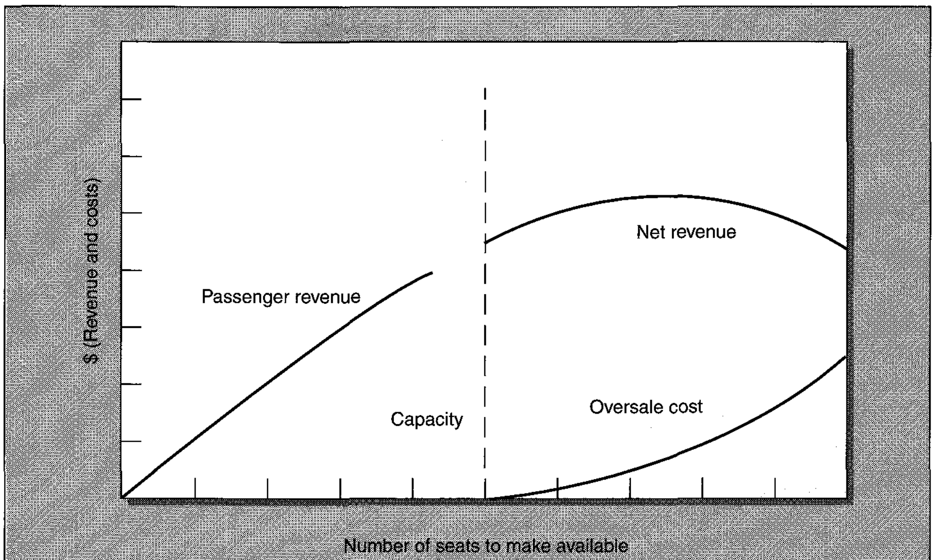
The reservation pattern, defined as the number of reservations divided by capacity, is the same with and without overbooking for flights well in advance of departure. For flights close to departure, there are more reservations accepted with overbooking to compensate for cancellations and no-shows.

FIGURE 21-1
Overbooking allows more reservations to be accepted.

four forecasts: the probability a passenger will cancel, the probability of a no-show, the probability that a bumped passenger will take another American Airline flight, and the oversale cost.

Discount Seats The large number of special fares and discounts greatly complicates the problem of maximizing revenue from a flight. Because there is a fixed number of seats on a plane, selling a seat at a discount that could be sold for a full fare reduces overall revenue. American Airlines cannot control fare classes independently; otherwise it could sell a low-fare seat while turning away a passenger willing to pay full fare. American Airlines uses a marginal revenue approach to determine how many seats to sell in a given fare class. The approach uses a heuristic that finds an acceptable, but not necessarily optimal, solution.

Traffic Management With the introduction of the hub-and-spoke traffic system, American's percentage of passengers flying into a hub to connect with



The optimal overbooking level occurs at the maximum of net revenue curve, where net revenue is the difference between total passenger revenue and oversale cost. When there is little or no overbooking, total revenue equals net revenue. Oversale cost increases with higher overbooking levels, so there is a unique optimal overbooking level.

FIGURE 21-2
An optimization model.

another flight has gone from 10 percent to more than 60 percent. Consider the example in Figure 21-3, which shows a number of alternatives for arriving at and departing from a hub. Flights that used to serve a single market now may serve 30 or more markets. In the example, one might expect that the Portland to Dallas/Fort Worth full fare is less than the Portland to Miami discount fare (connecting through Dallas/Fort Worth), which should be less than the Portland to Miami full fare. American cannot just look at a fare class, it must also consider likely routes. If the airline was controlled by just the proportion of full and discount fares, it might accept a full-fare Portland to Dallas/Fort Worth passenger while turning away a discount seat from Portland to Miami, a decision that would lower total revenue.

Ideally, the airline would exert control on a market and fare class basis. However, the large number of markets and fares makes this computationally infeasible. American developed a method of clustering similar market/fare classes into groupings it calls "buckets" to make the problem more manageable. All the market/fare classes on each flight are clustered into eight buckets. First and business class go into separate buckets while coach market/fare classes are in

Operations Research Helps Taco Bell

Taco Bell, the chain of fast food restaurants, has about 6500 company-owned, licensed and franchised locations in all 50 states and abroad. The company's sales are over $4.5 billion worldwide. Labor costs represent about 30 percent of every sales dollar. Because food must be fresh when it is sold, it is hard to even the demand for labor. The firm cannot use slow periods to make and warehouse food. Over half of daily sales in a typical store take place during a three-hour lunch period. As a result, scheduling labor is a continuing, difficult problem for the chain.

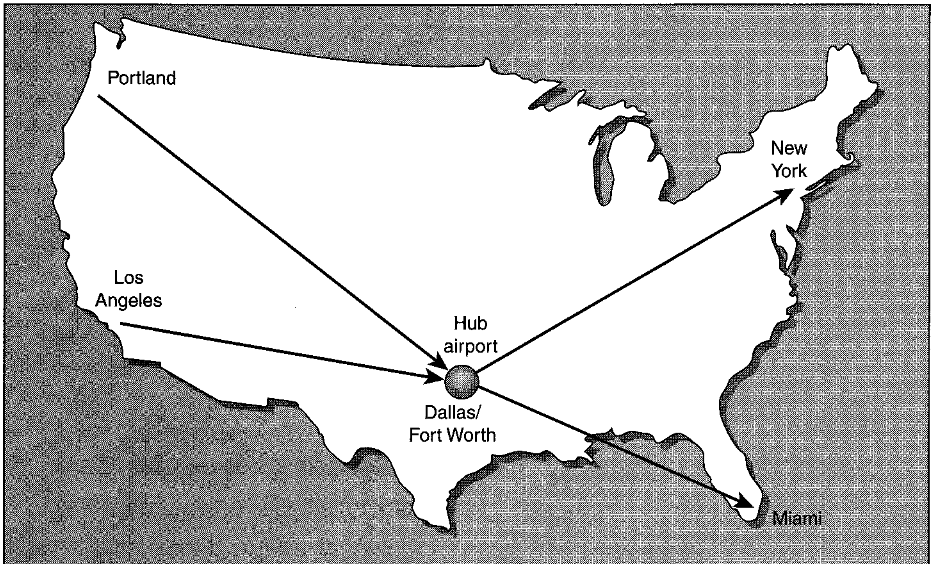
Management decided in the late 1980s to implement "value meals" as a way to expand sales. To manage in a more complex environment, the company installed in each restaurant PCs connected to a mainframe at corporate headquarters and began to develop new systems to support the stores. A project team conceptualized a restaurant as three related subsystems: customer service, delivery of food, and production of food. The important trade-off for the project team is the one between labor and speed of service, a parameter directly related to customer satisfaction.

The project team developed a forecasting model and simulation model providing input for an integer linear programming model that generates a schedule for labor. The store manager reviews this schedule before posting it for his or her restaurant. The objective of the schedule is to produce the fastest service while minimizing payroll costs. Taco Bell estimates that the modeling effort, which cost under $300,000, has saved over $50 million in labor costs. There are many opportunities to combine information technology and modeling to create powerful decision-support systems capable of improving the bottom line.

the remaining buckets (see Figure 21-4). As sales increase, the availability of seats is restricted first to low-value reservations regardless of market/fare class. Although this problem may seem simple, American Airlines currently has 150,000 market/fare classes.

American Airlines uses a dynamic programming algorithm to index the market/fare classes into buckets. The idea is to maximize the variability of market/fare class values between buckets while minimizing the variability within a given bucket. Every time a passenger requests a flight, the SABRE system accesses a condensed table containing bucket information. The system scans the bucket information until it finds the appropriate category for the reservation request, and then makes a decision on whether or not to offer the seat at that fare.

Results American Airlines has developed models to estimate the benefits of the DSS described above. The overbooking DSS has been in use since 1990, and it is estimated to have increased revenue by more than $200 million each year. The discount-seat allocation model is estimated to have obtained from 30 to 49 percent of the revenue opportunity from discount sales, resulting in additional revenue of $200 to $300 million. In three years, the total yield management program



For this sample airline network, passengers travel from two western spoke cities (Portland and Los Angeles) to Dallas/Fort Worth directly or connect at Dallas/Fort Worth to travel to two eastern cities (New York and Miami). For American Airlines at Dallas/Fort Worth, passengers from one flight can connect to any of 30 or more other flights. Yield management must consider the many markets served by any one flight to or from a hub airport.

FIGURE 21-3
The hub-and-spoke traffic system.

produced quantifiable benefits of more than $1.4 billion for American Airlines. For that same three-year period, American Airlines had a net profit of $892 million. This example shows that sophisticated operations research models within decision-support systems can have substantial returns for the organization.

Distributing the Gas at APC

Air Products and Chemicals (APC) produces industrial gases such as oxygen, nitrogen, hydrogen, argon, and carbon monoxide. The company's sales exceed $1.5 billion per year with nearly 19,000 employees in 13 countries. The industrial gas division uses highly automated equipment to manufacture and distribute liquid gases. However, scheduling and delivery of the gases used to be a manual process. Liquid oxygen and nitrogen are produced in APC's automated plants, which also serve as supply depots. The supplier maintains and monitors storage tanks at customer locations. Because the production costs for all manufacturers are about the same, competition is based on service, marketing, pricing, and lower costs from more efficient distribution.

The nature of the relationship with customers provides the gas supplier a great deal of freedom in planning operations. The supplier decides when to send a

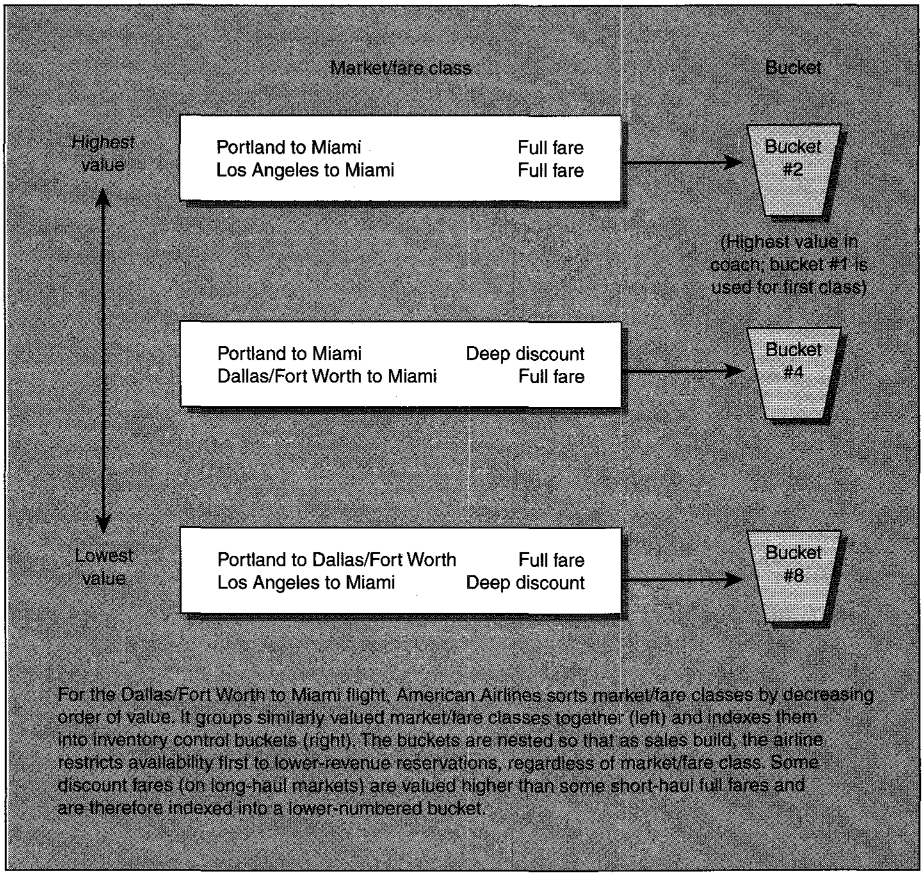


FIGURE 21-4
To control market/fare classes, American Airlines clusters them into "buckets."

shipment based on the inventory in the customer's tank, as well as how much to deliver, how to combine different loads on a truck, and how to route the vehicle. This large amount of freedom makes APC's scheduling much more complex compared with other scheduling problems. Typical APC problems involve several hundred customers and 20 trucks per scheduler.

The Vehicle Scheduling System APC formed a team to improve the operational efficiency of delivery scheduling. The completed system, developed and tested carefully before being widely implemented, makes use of six data files:

1. Customer file, including capacity of tanks, safety stock levels, and historical product usage
2. Resource file, containing a description of each truck in the system, capacity by state, and a list of customers feasibly served by each truck

3. Cost file, including a per-mile rate for vehicle fuel and maintenance and driver pay regulations
4. Mileage file, a network representation of the road system of the United States
5. Time and distance file, containing the distance, travel time, and toll cost between any pair of customers computed from the mileage file
6. Schedule file, containing the schedules developed by the system

The scheduling system produces a list of trips to be taken over the next several days, including start time, scheduled vehicle, quantity of product for each customer, time at which delivery should be completed, and length and cost of the trip. A scheduler can examine this output and make changes necessitated by contingencies not reflected in the system.

The scheduling system solves a very large mixed-integer program to near optimality using a special algorithm developed for this project. The model can contain up to 800,000 variables and 200,000 constants. The authors believe that this is one of the largest integer programs regularly solved to a state of near optimality.

This DSS contains one of the largest operations research models reported in routine use in the literature. It is an example of how the power of the computer can be used not only to compute a solution but also to present it to a user through a decision-support system.

THE PROMISE OF DDSs

The systems described in this section provide information to support decisions. A number of decisions are programmed into the systems. They also evaluate different alternatives and process information that is presented to and acted on by the decision maker. The American Airlines and APC systems showed costs savings, something that is more difficult for other types of DSSs. What is the value of better planning? How do we know that the decision makers using these systems perform better than they did under the previous manual systems? For many DSSs, justification is not done or is based on the faith of the managers involved that the model is helping to solve a problem.

EXECUTIVE INFORMATION SYSTEMS

A number of consulting and software companies suggest that firms need an **executive information system (EIS).** What is an EIS? Companies build an EIS to bring to senior management information that needs its attention. For example, the executive vice president of Phillips Petroleum uses an EIS to check the state of the firm's oil and chemicals business. The system also provides a summary of world news. The vice president feels that the system saves him an hour a day because it pulls together previously less accessible information in one place.

An EIS often involves a mainframe, where much of the data of interest to senior executives reside. However, the data are not easily accessible, and the EIS software must summarize data and make them available for downloading to a personal

MANAGEMENT PROBLEM 21-1

Jim Gilmore is executive vice president of Precious Metals, a firm that buys and processes rare metals such as gold and silver. Recent price fluctuations in the world market have created many problems for Precious Metals, and Jim has tried to find some way to predict price changes.

He knew that some firms were successful in building computer models of various economic markets. With this in mind, he hired Management Models, a consulting firm, to investigate the possibility of building models for each of the commodities purchased by Precious Metals. The company and the industry have very good data on historical prices and other economic indicators.

The modeling effort proceeded very smoothly. The resulting model produced valid results when confronted with the rapid price fluctuations of recent years. Management Models indicated that short-range forecasts should be very good but that the model should not be trusted for extrapolations past one year.

Jim now wonders how to integrate the model into purchasing decisions. For a long time, the brokers at Precious Metals based their decisions on intuition and experience with the market in making purchases. The new model is available on personal computers on the company LAN, and Jim wants the brokers to use it. He feels sure, however, that none of them will take advantage of it if they are merely told that it exists. Jim wonders how to gain acceptance for this new tool. What is your advice?

computer in the executive's office. Since many managers do not like to type and are not comfortable with computers, EIS designers focus on providing an appealing interface and a system that is easy to use.

One characteristic of these systems is a "drill down" feature. The user first sees figures at a high summary level. If these numbers look all right, the user continues. However, if some total looks unusual—for example, sales in the western region are lower than expected—the user puts the cursor on the suspicious figure, clicks the mouse button, and sees a display that contains more detail on just the western region. Depending on how the system is designed, the user might be able to drill down several levels to get to quite detailed data.

Senior managers who use these systems praise them highly. A power company president reports that he can view a series of corporate indicators with one keystroke. He can create a personal menu to look at the indicators he needs to review on a daily basis. This executive feels that the system has improved communications throughout the organization.

Another executive uses the system to look for trouble spots and find out why a division's expenses are higher than anticipated. He gets a quick snapshot of his

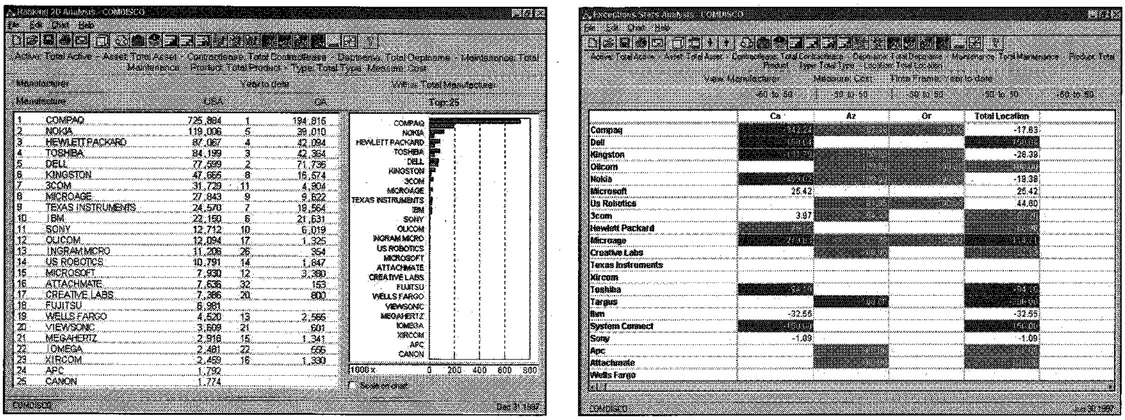


FIGURE 21-5
An example of an EIS GUI.

competitor's financial position through the system as well. Another manager uses the firm's EIS to check for exceptions, such as shipments to customers that are taking too long. Setting up the system forced his company to think about its business and which indicators it wanted to monitor.

There are a number of ways to develop an EIS. Several vendors offer software designed to access mainframe databases and provide a graphical user interface (GUI) for executives. At least two of these products are Microsoft Windows applications. Others are built for use on the Web. See Figure 21-5 for an example of one of these products. It is also possible to develop one's own EIS within the company.

Is an EIS any different from a DSS? An EIS is a type of DSS, but in general it tends to be data oriented rather than model oriented. The systems created to date allow executives to view data and summarize them in different ways. Of course designers have to be very careful and resourceful when designing an application to be used personally by the highest levels of management in the organization!

GROUP DECISION-SUPPORT SYSTEMS

There is much interest in using information technology to support workgroups. A workgroup consists of individuals who have some need to work together. Theoretically, any number could be involved, but typically we find 2 to 20 people who must work on a problem forming a group. How can IT support such a workgroup?

One way is with a **group decision-support system (GDSS).** A GDSS consists of special software and physical facilities, such as a conference room containing PCs for each person in the room. The software helps identify issues and evaluate alternative decisions and actions. A GDSS might also contain a model whose solution provides participants in the group with insights into their problem.

Workgroup decision making may also be supported using technology when the workgroup is dispersed. Electronic mail allows members of a group to exchange messages at any time of the day or night and is insensitive to time zones. An extension of e-mail is the electronic conference. Individuals can all be on-line to a computer at the same time for a conference, or they can join the conference whenever they like, reading and responding to the comments of others at their leisure.

Existing computer packages can be used in a group setting. A network of personal computers might be used to share data on a problem or to share a spreadsheet. A database management package on the network server could provide common data for each participant in a group at his or her own personal computer connected to the LAN.

Technology-Assisted Meetings

A number of companies use specially equipped meeting rooms with GDSS software to conduct meetings. IBM installed a number of electronic meeting rooms based on a room developed at the University of Arizona. A typical meeting room has participants seated at a horseshoe-shaped table, each with a personal computer connected to a network and file server. A projection screen is placed at the open end of the horseshoe to show what is on the discussion leader's (facilitator's) PC.

The role of the leader is very important in setting the pace of the meeting and in helping to form a consensus. A typical meeting might begin by stating the problem to be addressed. Participants brainstorm at their PCs for some period of time, say, 15 minutes to an hour. Each comment appears on all workstations, but without attribution; that is, no one knows who typed a particular entry. This anonymity is one of the features that makes an electronic meeting very different from a conventional one. It is felt that participants will be less reticent, particularly around superiors, if their comments are anonymous.

Next, another piece of software can be used to group alternatives into categories generated in the first stages of the meeting. Each participant could then numerically rank suggested alternatives. The meeting room software would average the ranks and sort the suggestions according to their average. Different software packages offer a variety of features designed to facilitate achieving a consensus about some issue or problem.

Do the electronic meeting rooms work? Participants in meetings generally seem enthusiastic about their experiences. Some claim that the use of these facilities and software reduce the frequency of meetings by a factor of 10. It has also been argued that solutions are better because no one will be intimidated by a superior, as contributions are anonymous.

We should view these claims carefully. Could similar results be achieved without a special room and elaborate software system? Certainly what the computer system does could be done manually by a facilitator and an assistant. The computer helps to automate this process, but you could also simply write ideas on a blackboard for all to see. The use of the computer and a high-tech meeting room may make participants feel better about the results of the meeting. Certainly, the act of using such a room says that the topic being discussed is important.

What are the drawbacks of electronic meeting rooms? In one case, participants generated about 1000 alternatives in half an hour. It is not clear how a group can deal with this number of suggestions! It seems likely that the appropriateness of this type of meeting depends on the subject matter. If we are looking for a number of creative suggestions to a problem or are trying to generate a lot of alternatives, the room could be very useful.

GROUPWARE AND ORGANIZATIONAL KNOWLEDGE

One of the most difficult questions to answer is, "What do managers do?" For the first three or four decades of information technology, IT did little to help managers in their day-to-day tasks, often because IT staff did not understand managers. There were few management information systems, though many companies claimed to have them. The last five years have witnessed the development of groupware, designed to support both the daily tasks of management and coordination, and to provide a repository of organizational intelligence.

Over 25 years ago, Henry Mintzberg (1973) conducted a classic study of managers. He observed their behavior by living with them for a week. Based on his observations, Mintzberg identified a number of roles that senior managers play in an organization. One role of management that seems to be universally agreed upon is leadership: the manager is, and should be, a leader for the organization. In this role, managers set direction, act as a public spokesperson, and try to see that the resources of the organization are employed to achieve the objectives they have set forth.

Management researchers have emphasized the decision-making nature of management since the 1950s. Certainly, we expect managers to make decisions in many different domains. Important decisions include funding R&D and product development, and the decision to introduce a new product. Many managerial decisions revolve around issues of resource allocation. Almost every organization is confronted with limited resources and competing demands for them.

A role that managers often face is as a disturbance handler. Disputes and problems in the organization find their way to managers who are in a position to resolve them. These disturbances may come from inside the firm or they may be prompted by problems with suppliers or customers.

Managers also deal with information in their jobs and function as the spokesperson for the firm. Good managers scan the environment for competitive actions, threats, and new opportunities. Today companies are very dependent on government regulations and actions. Trade treaties can make a major difference to a firm's strategy and operations.

The discussion so far has been about managerial roles, but what actually do managers do during the day? Mintzberg divided his observations into 5 categories. The first of these was scheduled meetings, which consumed over half of the day for the CEOs he studied. Next came unspecified desk work. Unscheduled meetings took 10 percent of the day while phone calls consumed 6 percent of the managers' time. Finally, managers spent a small amount of time on "tours," or "management by walking around."

This analysis of the distribution of time for various activities begins to get at the tasks managers perform. Two activities cut across all of the roles and tasks: communications and information processing. As a leader, spokesperson, decision maker, disturbance handler, and in most other roles, managers are communicating with others. They disseminate the strategy and goals of the firm. Managers receive communications from subordinates, customers, suppliers, the financial community, and many others. Meetings, both scheduled and unscheduled, involve communications as do phone calls and tours. Much of desk work involves letters and memos, which are also a form of communications.

Many communications and much purposeful managerial work revolve around information processing. We frequently communicate to obtain new information. When making a decision, managers must process information to determine the appropriate course of action to take. Suppliers and customers want information. The securities industry seeks information about company plans and performance.

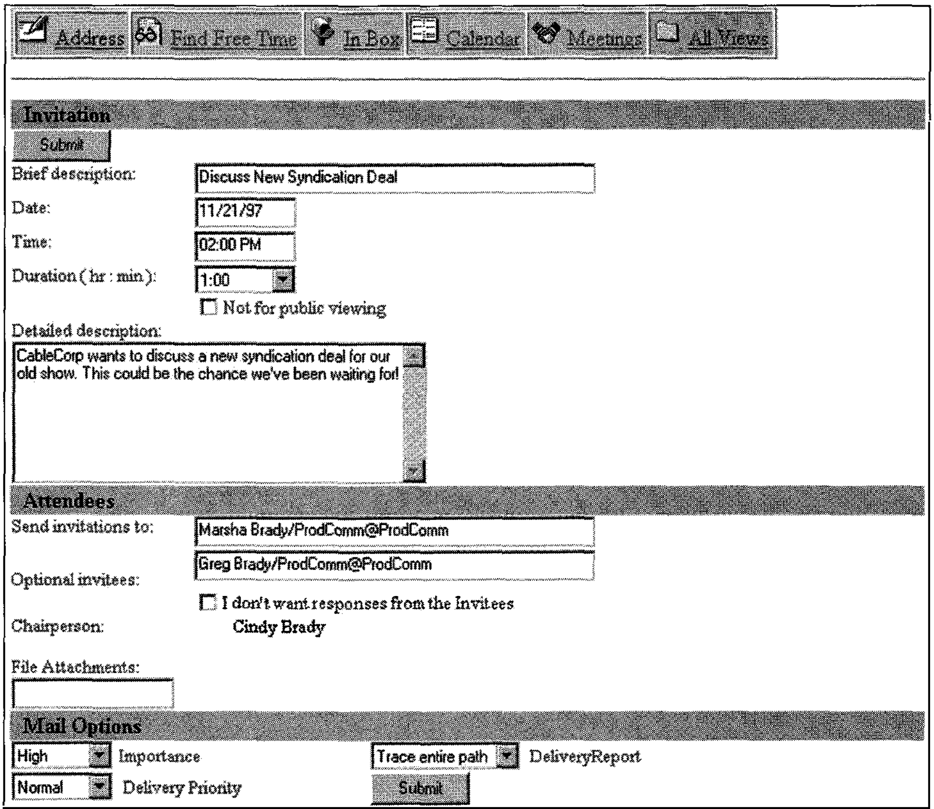
The technology described below is designed to support people in the organization in the tasks they are expected to perform. This technology lets managers and other workers redesign their tasks. It provides a great deal of flexibility and a number of alternatives for the flow of work, communications, and coordination.

Most information systems prior to the development of **groupware** were oriented toward solving problems in the organization, such as how much of a good to produce, how to process orders, and so on. Groupware is aimed at what a manager does—*it supports members of the organization who have a common task and who operate in a shared environment.*

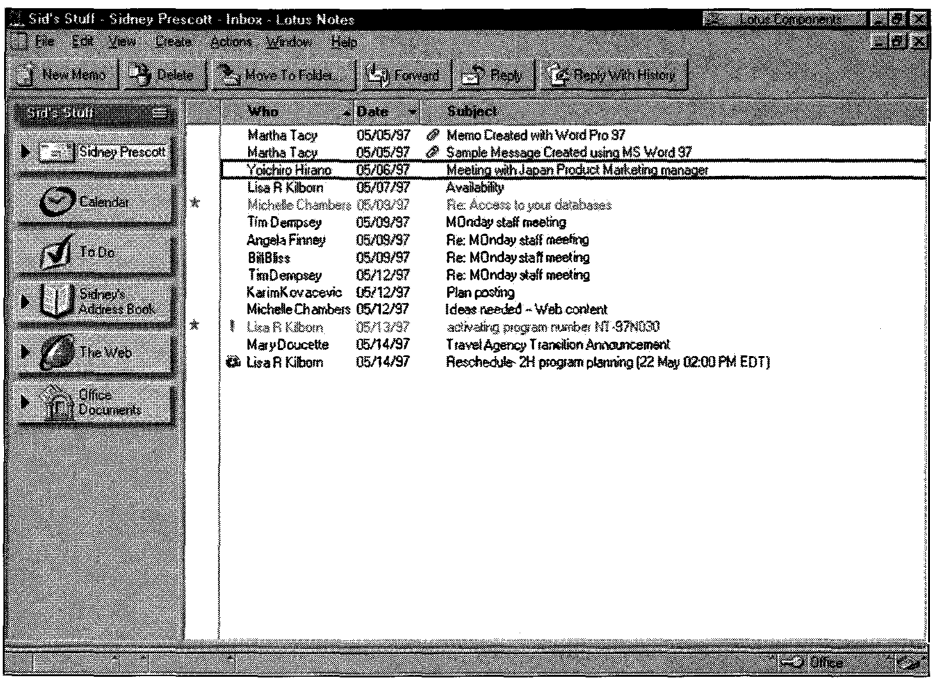
Groupware is sometimes called "coordination software" because it helps managers coordinate the work of others in the firm to ensure that the resources of the firm are applied to achieving its objectives. Coordination means managing dependencies, that is, seeing that individuals or groups that depend on each other or on common resources function effectively.

When discussing groupware, it is difficult not to focus on Lotus **Notes,** a product with about a three-year head start on its competition (see Figure 21-6). What is Lotus Notes? Groupware and Notes are hard to define; even the vendors have difficulty describing the nature of the products. First, Notes is based on client-server computing; the product assumes that users or clients are connected on a local area network with a server. Databases to be shared are kept on the server, though you may have a local database on your own PC. One of Notes' major features is its ability to replicate databases across departments and organizations. You can tell Notes how often to synchronize databases, and it will make sure that all information is consistent.

For example, suppose that you worked for an advertising agency, and the New York and Rome offices are preparing a campaign for a global client. If teams in New York and Rome use Notes, the system could be set up to automatically update databases at, say, 9:00 P.M. U.S. time. Lotus Notes will update both databases to add new information without losing existing data. Thus, team members in New

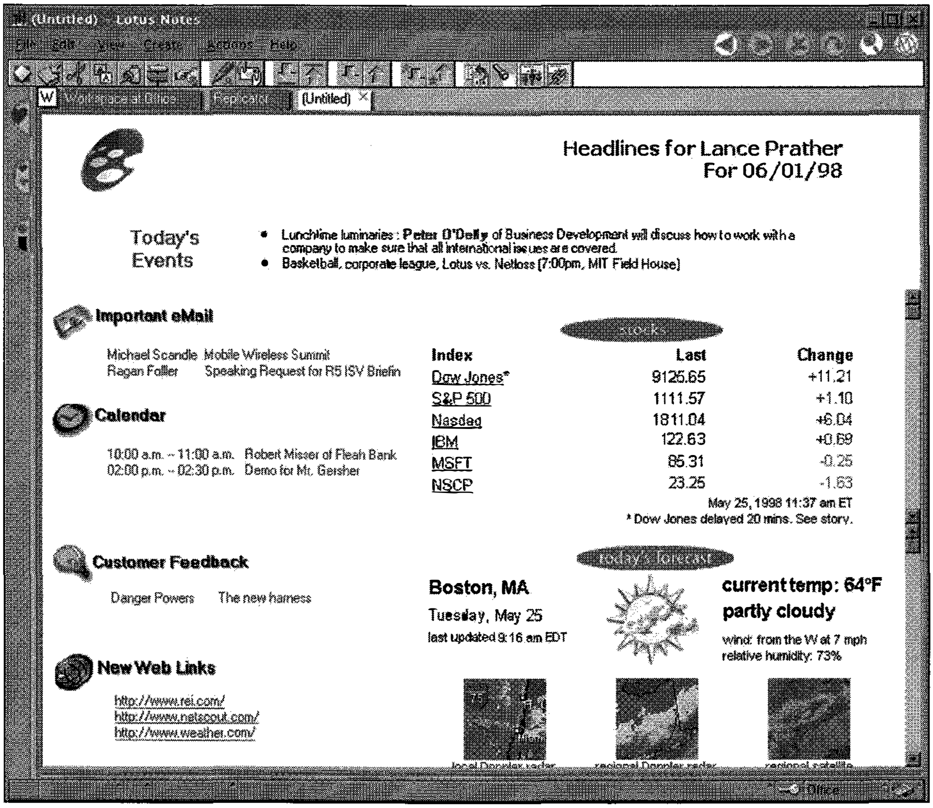


(a)

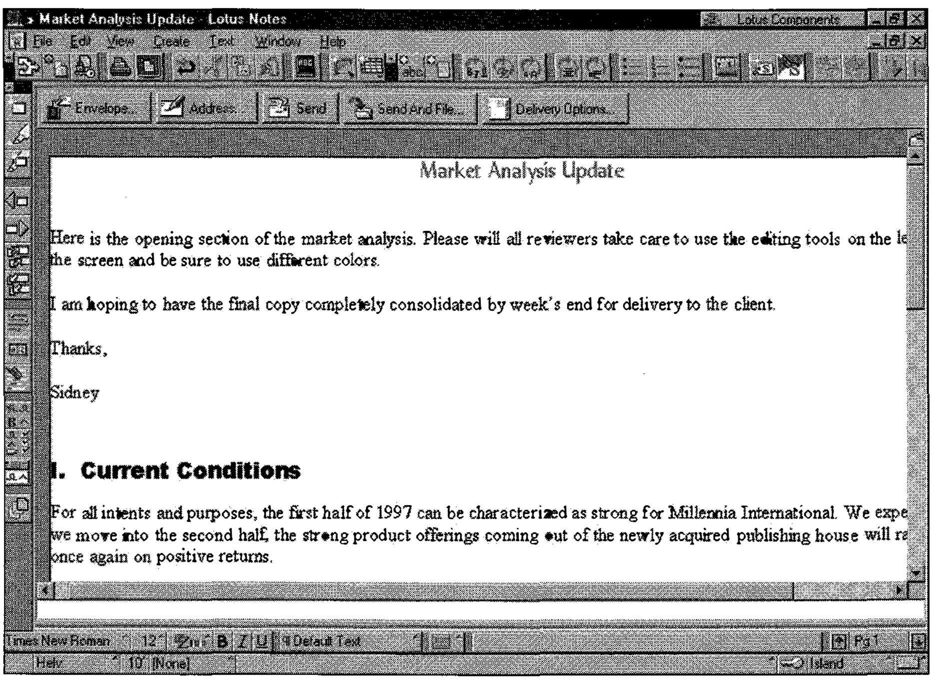


(b)

FIGURE 21-6
(a) Notes completed invitation. (b) Notes mail and desktop.

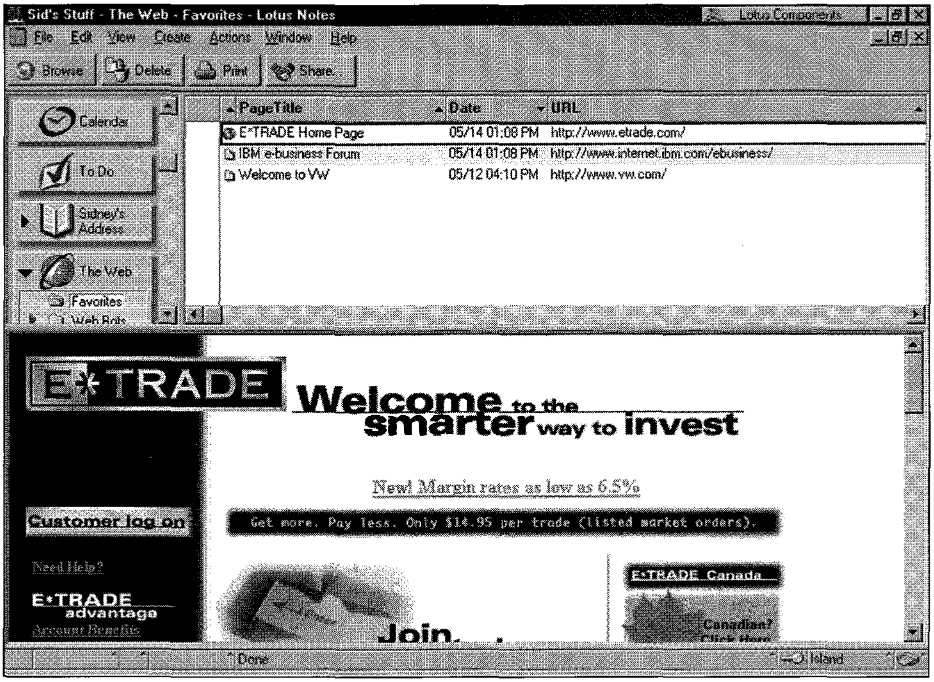


(c)



(d)

FIGURE 21-6 *(continued)*
(c) Personal page. (d) Market analysis document.



(e)

FIGURE 21-6—CONTINUED
(e) Notes and the Internet.

York and Rome can make changes during the day with impunity. The software replicates those changes on both copies of the database. (If two individuals change the same information, Notes flags the changes and leaves it to the people involved to resolve the conflict.)

This database replication feature is one of Notes' coordination features. The software coordinates diverse workgroups and allows them to share information without worrying about updating anomalies. Just having the same database easily available to multiple individuals working on a project, regardless of replication, promotes coordination as well. Lotus Notes also has its own e-mail system, so Notes users can communicate with each other.

The second feature of Notes that makes it suitable for supporting individuals with a common task is its applications development tools. It is fairly easy to design quite powerful applications and share them on the system. For example, it took about 15 minutes to design a shared database of the common materials (videotapes, computer demonstrations, etc.) available for each class session of one of our MBA courses in information systems.

Notes has aggressively integrated its products with the Internet and World Wide Web. Lotus has modified its original Notes software so that a Notes "Domino"

NOTES ON THE NET

The president of Lotus commented at a press conference announcing Notes' strategy for the Internet: "It's our view that essentially all infrastructure components, . . . servers, database servers, transaction servers, all the servers you can imagine, are going to become Web servers. Virtually all client applications [will be] Web-enabled so that applications go out to the Web directly.

"The Web today is a distributed file system . . . access to that file system will be implemented in all sorts of applications. The Web is unbelievably ubiquitous . . . All sorts of servers plug into the Web . . . At Lotus, we have over 8000 (Web) pages and 83 different Notes databases that roll up into our Web site . . . Suddenly I need tools for searching the site and viewing indexes of data. I need to be able to get forms out. I need to be able to accept that data back. I need to be able to search back in databases [and to] . . . interface to transaction processing systems. I may want to implement workflow. I may want to have data . . . coming back, bringing it together with database data and then moving this among a number of people . . .

"The Notes document database can contain either HTML pages or Notes documents in Notes formats . . . We do dynamic translation between HTML and Notes structures . . . If I author a document in Notes and store it in a Notes database and someone accesses it from a Web browser, we on the fly translate it to HTML. Likewise if a document is authored in HTML, stored in a Notes database using . . . Word . . . and someone accesses it from a Notes client, we translate it to Notes format . . .

"We bring to the Web server market a database approach as opposed to a file system approach. We have in Notes . . . a richly structured document database we think gives us a great advantage in Web sites as they get larger . . . Lotus's Web site has 8500 pages . . . a year from now it will have 20,000 pages. IBM's Web site today has 40,000 pages.

"All the development facilities that exist in Notes are now available to build Web applications. . . . Most of the applications built by our 11,000 partners that run on Notes servers can now be accessed from Web browsers. A Notes application consists of defining databases, defining forms, defining scripts that the client and server use to manipulate the data, and in many applications providing the linkage to relational database systems to transactions systems, etc.

"We will deliver . . . four specific application frameworks, one for publishing which includes full subscription management, one for electronic commerce, . . . one for customer service and one for marketing . . . All of these are built on top of the Notes server. . . . The most compelling part of . . . Notes . . . on the Web is [this] . . . piece. It's the ability to rapidly build the kinds of applications we think people are going to demand on the Web. . . . People can use Notes clients to build these applications, deploy them on Notes servers and have them fully accessible on the Web . . . Notes is optimized for symmetric multiprocessing systems to support upwards of a thousand simultaneous sessions per server."

server is also a Web server. The software automatically translates information on the server into HTML (see Chapter 12) format if a Web browser requests it or into Notes format for a Notes client. Lotus believes that Notes is a natural authoring environment for Web information. More than that, Notes is positioned for easy applications development on the Web. Lotus Notes lets companies conduct transactions over the Web, thus allowing them to do more than just retrieve static information. Lotus Notes lets you interact with the person using the client. For example, a magazine publisher would want to have a button on its Web site that a person visiting the site clicks to get a form for subscribing to the magazine. The publisher also would want to accept that person's credit card, search its database to see if this is a new subscriber, and send a message welcoming a new reader or welcoming back an old subscriber. For more information on Lotus's Internet strategy, see "Notes on the Net."

How are firms using Lotus Notes? Significant adopters of the system include General Motors Europe, major consulting firms, and several Big Six accounting firms, including Peat Marwick and Coopers & Lybrand. We studied how one consulting firm used the technology. Interestingly enough, Notes was not used extensively to manage customer engagements. Rather, the firm was using Notes internally to improve administration.

Just as with any other company, a consulting firm has to administer itself. One consultant firm, with revenues in excess of two billion dollars a year, has to administer personnel, manage billings and collections, administer contracts, and perform a wide variety of administrative tasks. The practice manager for the northeast described how Notes improved his operations. The firm had developed a number of administrative applications. His group of direct reports from around the region was able to dramatically reduce the number of meetings through the use of groupware.

Compaq Computer found that its sales staff uses Notes to communicate with customers and rarely comes into the office, preferring to work at home. Boston Market, a rapidly growing restaurant chain, uses Notes to keep track of expansion plans, market research, advertising, cooking procedures, and recipes. Essentially, Notes (and groupware) is becoming the leading dispenser of knowledge in the corporation.

Chase Manhattan Bank has a major Notes site with thousands of users across a highly distributed network. One of Chase's major applications is a service that follows investment reports from providers like Dow Jones. The system is designed to help the analyst spot differences between the bank's evaluation of a company and the evaluation from these other services. Explanations about the differences are posted to a database where they are widely available.

The CIO at Chase Manhattan Bank feels that Notes is unique because it lets you develop applications not previously undertaken; that is, since applications are easy enough to construct, ideas for systems that were infeasible using older technologies suddenly become easy to justify. Chase Manhattan Bank is using Notes in its systems development division on several different kinds of projects. It is particularly useful in coordinating employees who work in London, Brooklyn, and Lexington, Massachusetts.

Applegate and Stoddard (1993) reported on the use of Notes at Chemical Bank prior to its merger with Chase. At Chemical Bank, it was the Corporate Systems Division (CSD) that first became interested in groupware. The senior vice president of corporate systems was launching a productivity program to generate more output from the design and programming staff at the bank. He felt that the division's work was communications intensive and that it was breaking down using conventional forms of communicating. His estimate was that Notes would allow a 15 percent productivity improvement for a staff whose salaries totaled $15 million a year. The vice president also viewed a test in CSD as a good preview for rolling out Notes in the rest of the bank.

The bank brought in a groupware consultant and offered training in the use of Lotus Notes in anticipation of its implementation. The vice president hired a full-time Notes specialist and formed a Notes support group to assist users. Roll out began with 20 senior managers and their secretaries. In a period of less than two years, 300 CSD employees were using Notes and the bank had developed more than 90 applications with Notes.

In the middle of this effort, Chemical Bank decided to first centralize IT resources, then initiate a 40 percent reduction in IT staff. Shortly thereafter, Chemical Bank announced its merger with Manufacturer's Hanover Bank. During this period, turmoil ruled the systems division, and one major application the vice president initiated was the "rumor mill." Concerned employees could post rumors to the rumor mill database, and senior managers would respond. The vice president felt that this simple technique helped create a feeling of trust and openness in the group.

One manager remarked that Lotus Notes let developers create applications quickly to respond to a business need. It also helps create geographic independence. In one application a group in New York worked with developers at a Texas bank owned by Chemical Bank. Lotus Notes also helps make work independent of time since it reduces the need for face-to-face communications.

A *Wall Street Journal* staff writer found that groupware tended to erode the hierarchical nature of organizations. In some cases, however, groupware created problems for management. The vice president at Chemical Bank discussed above resigned after the Manufacturer's Hanover merger, and his successor eliminated the rumor mill. It seemed that the forum had become "unruly" and had begun to receive a number of cutting criticisms of management.

The thrust of the report, however, was more positive. The reporter talked to various managers who felt that groupware helped dissolve corporate hierarchy by making it easy to share information. The rank and file can join discussions with senior management if given access to groupware.

One major contribution of groupware is providing organizational knowledge where it is needed. For example, a worldwide consulting firm like Andersen Consulting, with thousands of employees, has a great deal of expertise. A consultant in Japan may need a way to find out if the company solved a problem similar to the one she is facing in some other country; Andersen uses groupware to provide this knowledge base. In Chapter 19 we discussed the Customer Services Division at Zeta, where employees provide consulting help to customers. These consultants built a large Notes database of problems and solutions, and then began to use this knowledge base to answer new queries from customers. An important role of groupware is to capture organizational knowledge and make it available anyplace in the firm.

Notes versus the Web

Companies are using the World Wide Web to set up internal web sites or Intranets. These sites may be isolated from the Internet and only available within the firm, or outsiders may be given access, an Extranet. Much of the information on an internal web server could also be put on Notes. Which platform is best suited for each different type of information?

Companies are taking a mixed approach. Andersen Consulting is one of the largest Notes customers with over 23,000 users world-wide. The company is using Web servers for a training program in its object-oriented development methodology. The Web's hypertext environment made it easy for students to use the system. The developers praised the Web as a teaching environment.

Notes has a real advantage in terms of document control, security and workflow features. Notes is also appropriate for coordinating groups who must work on the same documents. Notes makes it easy to route documents electronically and it has automatic database replication across different servers. Notes has developed its own links to the Internet in order to satisfy customer interest in the Web.

With its Domino server, Notes also is one approach to developing Web content and publishing it for others to use. Will companies move exclusively to Intranets, or will your organization have to maintain a Web site and a groupware system?

A side benefit of groupware is the way shared information can be used to enhance decision making. This technology may make it easier to create decision-support systems and expert systems since data and expertise are now widely available in an organization.

A number of companies are using Lotus Notes to connect with clients and suppliers. Officials at Notes present this system as the "defining element of the Information Superhighway," feeling that electronic commerce is far more important than video on demand or games.

Of course, a few cautions are needed. Like the phone or any other network, the system works only if everyone who needs access has it. Networks only become useful to service providers and consumers when they reach a critical mass. Another major threat to Lotus Notes is the World Wide Web (see "Notes versus the Web," above). A number of companies are posting information to the WWW. Morgan Stanley is using an Intranet to present information like telephone directories, equity analysis reports, and SEC filings. These applications could also be implemented with Notes. It will be interesting to see if Lotus and IBM are able to co-opt the threat of the Internet with their Domino Internet Notes server.

WHAT ARE THE OPTIONS?

There are a number of ways in which groups of people can work together electronically. Figure 21-7 is a useful framework for thinking about the options. When people are working at the same time in the same place, then a group decision-support system and an electronic meeting room can provide support for their shared tasks.

FIGURE 21-7
Framework for electronic coordination.

Place	Time: Same	Time: Different
Same	Group decision support systems, electronic meeting rooms	Groupware E-mail
Different	Videoconferencing Chat rooms	Groupware E-mail

Moving the Money

Every business day, over $1.23 trillion of currency trades take place in the global economy. London, New York, and Tokyo are the centers for foreign currency exchange, though banks all over the world trade for customers and their own accounts. About half these trades utilize the Reuters Dealing System, which connects some 4000 banks worldwide. (Approximately half of exchange transactions are electronic, and Reuters has a 96 percent market share of electronic trades.)

Currency trading demands a real-time network and real-time decision making. Banks hold their trading positions for only a few minutes in many cases. Traders must make lightning-fast trading decisions, and they place heavy demands on an electronic exchange network. The currency market is a single global marketplace with price trends available to all participants. Specific transactions between the banks, however, are private. Traders contact each other continuously asking for quotes as they try to discern how markets are moving. Up to 80 percent of requests for a bid-ask quote do not result in a trade. Traders type messages on their screens, which appear instantaneously on the screen of the intended recipient. A typical conversation requests a bid-offer quote from the called bank. This bank responds, and the original calling bank accepts or declines the quote. This entire conversation may take place in less than a minute.

Foreign exchange trading requires high-speed decision making; the Reuters Dealing System provides information to make this marketplace operate globally. During the currency crises at the end of the 1990s, the ability of this network to rapidly move large amounts of currency around the world became evident.

If you want to work from different locations at the same time, then there is increasing interest in videoconferencing, especially using the Internet. Chat rooms are another possibility, though they do not seem all that popular in business. If those with a shared task are only able to communicate at different times, then location is not too important. Groupware and e-mail are two technologies that facilitate asynchronous communications.

MULTIMEDIA FOR BUSINESS, EDUCATION, AND ENTERTAINMENT

Multimedia is generally defined as a combination of different presentation media which are coordinated through a personal computer workstation. Media that might be included are:

- Artwork or still pictures
- Full or partial motion video
- Sound
- Text
- Graphics
- Animation

Multimedia is used with a windowing user interface. A few examples will help to illustrate the concept. (Unfortunately, a printed book cannot present all of the media above!)

We have created a multimedia presentation of the Merrill Lynch system reengineering project discussed in Chapter 18. The student begins reading one of two narratives about the system. By using the mouse to select a highlighted part of the new system description, the student can choose to see a data flow diagram (DFD) of that part of the system in a window on-screen. (The DFDs were created with a CASE package for the PC.) The child can move around the DFD and use the mouse to go from a higher-level to a lower-level diagram. He or she can click on a process in the DFD, and a window appears with a video scene showing that processing. Using the systems design narrative, the user clicks on highlighted phrases and an individual appears in a window discussing that part of the design process.

There is a series of CD-ROMS that read to children. In "Arthur's Birthday Party," the computer reads a story to a child while highlighting the text being read. The program reads and displays text in English or Spanish. The student using the program can move the cursor to objects on the screen and click on them after the program finishes reading that page. Each object does something; for example, a baby in a highchair cries and throws food, a teapot does a dance and whistles a tune, etc. The program fascinates children and motivates them to improve their reading skills.

At Dartmouth, students studying Italian use a Macintosh to play vignettes from Italian television. The student can select synchronized text and ask the computer to define difficult words, provide a translation in English, or provide a commentary on the culture. At Yale New Haven Hospital, medical residents are learning to identify heart problems using a multimedia computer system. The system displays an animated heart on one monitor and video clips of real diseased hearts taken by an ultrasound machine on another monitor. By clicking on a stethoscope icon, the student hears a recording of how the diseased heart sounds. This system saves time for the teaching physicians as the residents learn from the multimedia system how to interpret ultrasound images of hearts with different types of problems.

The World Wide Web is becoming a significant source of multimedia for education, entertainment, and product promotion. We mentioned the Java programming language in Chapter 9. This language makes it possible for an Internet browsing program to download and execute programs from servers on the network. The downloaded programs are interactive and can feature graphics, video, and audio segments. Macromedia, a San Francisco company that sells multimedia software, distributes a program that plays movies on a browser. This program, called Shockwave, displays interactive content on the Web, similar to Macromedia's CD-ROM development programs. The program makes it possible to have automation, sound, and features such as rotating billboards for advertisers. The Web is a natural distribution channel for multimedia, especially as bandwidths become larger, for example, through ISDN or cable TV access to the Internet.

How is multimedia used? From the discussion above, multimedia can potentially play a large role in education since it allows the instructor to bring together a diverse set of teaching materials and guide access to them. The user can often choose the path through the system, selecting the parts of a presentation to view. The coordination provided by the computer plus this element of choice makes multimedia much more powerful than the use of any single medium alone. There are a number of CD-ROM products for education, some from traditional print publishers and others from companies dedicated to educational software. Corporate training departments create their own CD-ROMs when they need to train a large number of workers and want to avoid the expense of courses. Sun Microsystems offers a server designed for presenting video information to various clients. This system is aimed at corporate training centers that want to use multimedia presentations.

There are applications besides education and training. Vendors of goods and services would like to extend their sales outlets without dramatically increasing overhead. One possibility is to use more automated sales outlets in where many individuals are present such as airports, train stations, and shopping centers. These automated outlets can make use of multimedia to lead customers through a transaction. Firms have provided their sales forces with notebook computers having CD-ROM drives in order to make multimedia presentations to clients. A second use for multimedia, then, is in business for applications that interactively present information to customers.

The third area for multimedia, and probably the application with the greatest investment, is entertainment. Many promoters and companies feel that interactive multimedia will be at the center of the next generation of electronic entertainment. Entertainment and technology companies are forming alliances at a rapid pace. U.S. West, a regional phone company, has invested in Time-Warner, a cable and entertainment firm that is merged with Turner Broadcasting. Microsoft would like to have Windows adopted for managing home entertainment. The converter box that sits on top of your TV is expected to be a PC with at least the power of a modern Intel chip.

A National Multimedia Effort

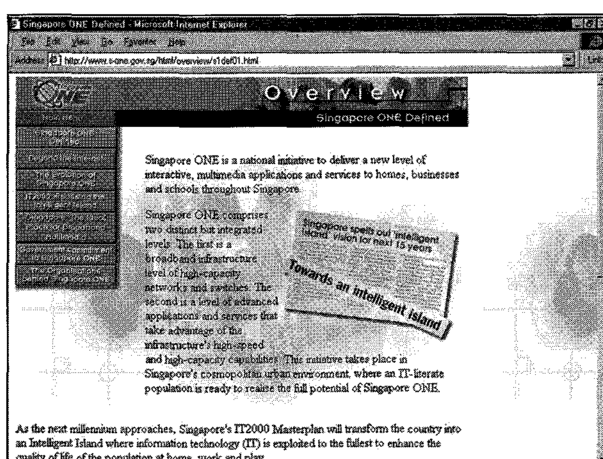
Singapore is a city-state of less than 3 million people, occupying a 625 square kilometer island at the southern end of the Malaysian Peninsula. A small fishing village at the end of World War II, Singapore has become a developed nation. The country has a literacy rate of almost 90 percent and a life expectancy comparable to other postindustrial countries. Singapore has little in the way of natural resources except for a large protected harbor and an excellent location along major shipping routes.

The National Computer Board in Singapore developed a vision of an "intelligent island." Residents will be able to tap into vast reservoirs of electronic information and services to improve their business, make their working lives easier, and enhance their personal, social, recreational, and leisure options. Text, sound, pictures, video, documents, designs, and other forms of information will be transferred and shared through the high-capacity and high-speed nationwide communications infrastructure made up of fiber optic cables reaching all homes and offices, and a pervasive wireless network operating in tandem.

This information infrastructure will also permeate the physical infrastructure, making mobile telecomputing possible, and homes, workplaces, airport, seaport, and surface transportation systems "smarter." All kinds of new infrastructure services, linking government, business, and the people, will be created to take advantage of new communications and wireless network technology.

In this vision, some 15 years from now, Singapore will be among the first countries in the world with an advanced nationwide information infrastructure. It will interconnect computers in virtually every home, office, school, and factory. The computer will evolve into an information appliance, combining the

The Singapore ONE home page.



A National Multimedia Effort—Continued

functions of the telephone, computer, TV, and more. It will provide many ways to communicate and access services. The vision, called IT2000, is based on the far-reaching use of technology (National Computer Board Web Site).

The vehicle for accomplishing this vision of an intelligent island is a fiber optics communications network. Singapore ONE is a national high-capacity network platform that will deliver a potentially unlimited range of multimedia services to the workplace, the home, and the school. It comprises two distinct but interrelated levels—an infrastructure level of networks and switches, and a level of applications and multimedia services. The infrastructure level will consist of a core broadband network connecting several local access networks. The core or backbone of Singapore ONE will be built, owned, and operated by an industry consortium. Singapore ONE will bring public services closer to the people and make it more convenient for them to carry out government transactions. Examples of services include multifunction kiosks for government transactions and one-stop government centers with videoconferencing facilities. High-speed communications will open up a whole new channel for people at home. Potential home applications include: high-speed Internet access, entertainment on demand, electronic shopping, home banking, and electronic information services.

BETTING ON MULTIMEDIA FOR NATIONAL DEVELOPMENT

Malaysia is planning a "multimedia city" to help bolster the country's technology sector. A Web site describes the effort:

> The Multimedia Super Corridor (MSC) is an area 15 km by 50 km running south of the Kuala Lumpur City Centre (KLCC) to the Kuala Lumpur International Airport (KLIA) which will have excellent telecommunications and multimedia infrastructure to induce information technology (IT) and multimedia companies to locate in Malaysia. The MSC will be developed with Putrajaya, the new administrative capital of the country and Cyberjaya, an IT city, as the hub and nucleus of development within the MSC.
>
> Cyberjaya, covering an area of approximately 7,000 hectares with a future population of 240,000, will offer the latest IT infrastructure, top-quality business facilities, state-of-the-art multimedia infrastructure and a superb living environment to meet the business, residential, and recreational needs of the highly skilled and technologically oriented workforce of the multimedia companies located within the MSC.
>
> The Flagship Zone, located in the eastern half of Cyberjaya and covering an area of approximately 2,800 hectares, is the prime phase of Cyberjaya's development and has been specially designed to initiate and catalyse the development of the IT city. The self-contained Flagship Zone offers a superb business and living environment and will consist of four specialized functional precincts, namely, enterprise, commercial, residential, and recreational and public areas.

What Is Digital Convergence?

What is digital convergence and who are the players? **Digital convergence** suggests that all data, voice, and entertainment coming into your home will be digital. There will be one or more "digital" pipes bringing strings of binary digits to you. The converging digits entering your computer (or television) will, at a minimum, include phone calls (voice and video), television, movies on demand, and information from mass market services and the Internet. Interactive television, including the ability to interact with programs, order products on the screen, and treat the TV as you might a PC capable of retrieving and presenting all types of media, is a possible result. Will the computer dominate the television set? By 1998, it was estimated that 40 percent of American homes had PCs; the most frequent reason for buying a home computer today is access to the Internet. Microsoft is urging PC manufacturers to include a TV tuner in the monitors they sell to encourage convergence.

The players in digital convergence include:

- Content providers, that is, television and movie studios that create entertainment programs and home shopping networks
- Broadcast television and cable television: companies that will distribute entertainment to the home
- Long distance and local common carriers that want to supply the pipeline that carries information to the home
- Hardware and software manufacturers that want to make set-top boxes and the software to control them
- Microsoft which wants cable companies to use Windows CE as the operating system in the set-top boxes that interface the TV set or computer to the cable

All these firms have been buying companies in allied businesses. For example, in 1995 Walt Disney Studios bought ABC television, and Time-Warner merged with Turner Broadcasting. None of these players wants to be left out or lack content and the ability to deliver it. The local phone companies have a problem because their twisted pair wires into the house have very low bandwidth. While engineers figured out how to send a movie to the home through **compression** algorithms, their scheme is not yet practical over long distances. The cost of bringing fiber optic cable to the home (curbside) is very high. Local phone companies want to purchase cable systems and use their cable as a pipeline for digital information entering the home.

Cable reaches more than 95 percent of all TV-equipped households and 90 percent of all suburban business campuses in the U.S. Some local cable companies compete with phone companies by offering high-speed data communications lines over their cable networks. Many cable operators offer companies bypass facilities to avoid using a local phone company. Some plan to connect to the Internet and provide high-speed switching services like ATM and frame relay.

Are there less expensive alternatives? A satellite TV service called DirecTV had reached the level of a million customers within a few years of announcing service and continues to experience rapid growth. The company offers up to 150 program

A National Multimedia Effort—Continued

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The home multimedia computer that you can buy for less than $1000, along with a high-speed Internet connection of, say, 100 million bps, should make multimedia very attractive. With this kind of equipment, it will be feasible for you to download a movie from the Net and show it on your high-resolution monitor! If you do not want to spend $1000 on a computer, possibly you will be able to buy one of the "netsurfing" $500 computers to get your multimedia and TV from the Internet. Finally, you can buy **WebTV,** an attachment to your television set that lets you surf the Internet. Microsoft owns WebTV, a purchase that signals its intention to expand its entertainment offerings and combine them with the Web.

The debate continues about digital convergence. The local Bell phone companies have slowed their trials and are trying to figure out what services customers really want. Two "Baby Bells" dropped applications to the FCC to erect interactive networks after the agency had been considering them for two years. Estimates are that it will cost from $1000 to $2000 to wire a home for interactive multimedia. (Running fiber optic cable to each home in the U.S. could cost $120 billion.) Meanwhile, AT&T is offering dial-up service for customers to connect with the Internet, and at least one cable TV company is planning to offer telephone service. Other cable systems offer high-speed Internet connections over special cable modems. Some experts argue that the home PC and the Internet are the only technology capable of providing multimedia services (except interactive TV) in the next few years. It will be several years until the digital convergence scene becomes clear.

Hypertext: The Engine for Multimedia?

Most texts that we read, including this book, are sequential and flat. You might be able to use the index to look for a particular term that is not clear, but in general you are constrained by the sequential nature of the medium. **Hypertext** is nonsequential. If you are reading about a soccer game and come to a passage where it mentions an off-sides penalty, and that term is highlighted, you could click the mouse on it and open up a window that would explain the off-side rules. You might be able to click on a word in the rules to call up a diagram of a soccer field showing typical off-sides violations.

In hypertext, sections of text have links to other pieces of text. The **links** are **pointers,** just as we saw with direct-access files. Now, instead of pointing to a particular record in a file, the pointer must reference a piece of text that is also stored in the system. To see what hypertext markup language (HTML) looks like, access a page on your browser and then click "view" and "source." You should be able to decipher some of the HTML code that tells the browser how to format what you see in normal mode on your screen.

In Chapter 12 we discussed the Internet and the protocol of the World Wide Web, hypertext transfer protocol (http). Each web page has a URL or universal resource locator; the URL is a pointer to a page. Figure 21-8 shows how your PC can point to my home page. My home page links to a series of other pages describing publications, books in progress, research projects, and courses. It does not

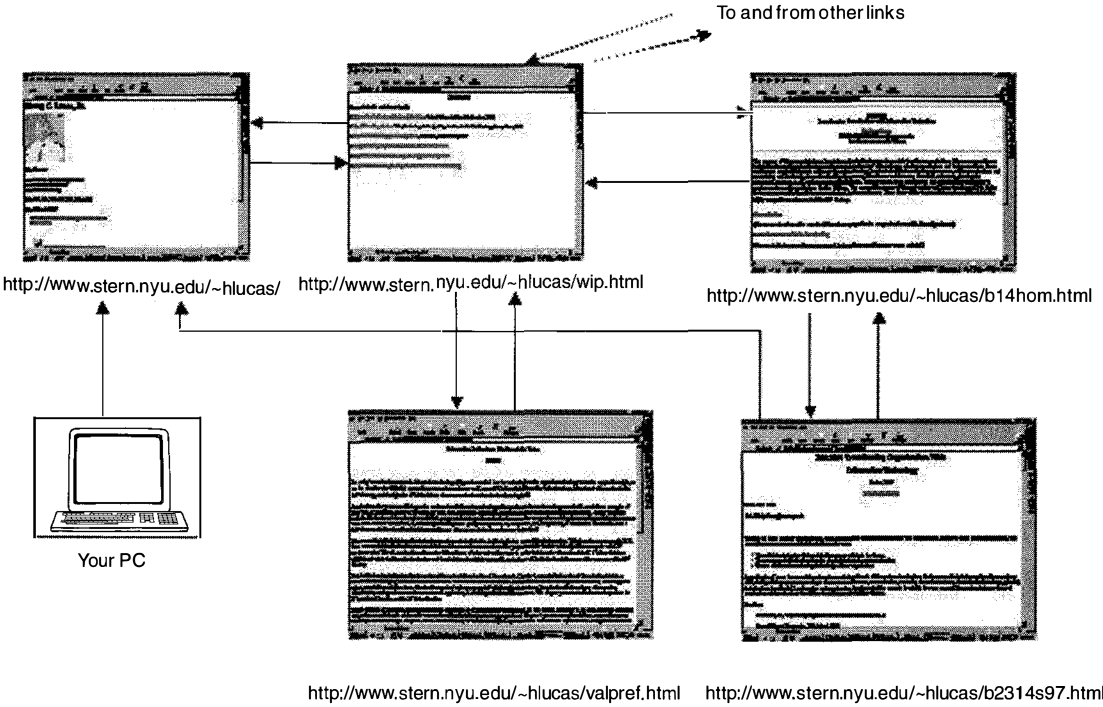


FIGURE 21-8
An example of URL links.

matter on which computer each of these pages is located; they appear on your computer as requested. A computer called a domain name server looks up the URL and translates it to a number that identifies the computer on which the requested page resides. The beauty of this protocol is that the user does not have to know the location of a computer or even very many URLs. By convention, one's home page begins with a tilda (~) in front of the user's name. So my home page is http://www.stern.nyu.edu/~hlucas. Convention also has it that the browser first looks in a directory called public_html for a hypertext file labeled "index.html." If my home page is called index.html and stored in my user directory public_html, then anyone on the Web can access it easily.

Hypertext is used for documentation, user manuals, advertisements, and customer guides. The Soft-Ad Group produced a number of hypertext ads for automobile manufacturers such as Ford, Buick, and BMW. These ads use hypertext so the viewer can move around and select different parts of the presentation. For example, you might first be asked to choose which model car you want to explore and then be given a choice of statistics, engine and drive train, performance, and so on. Each choice brings up a display and the option to choose another display that provides more information on part of what is currently viewed. The price list of various options is followed by a spreadsheet in which you choose the options you want and come up with a total price for the car. The London Design Museum has a hypertext information system for its visitors. The user can access information about various design movements, or they can see information organized by country or manufacturer. You can also access information about individual designers or products.

Hypertext provides the user with the ability to navigate through a variety of material. If this navigation includes different media, hypertext offers a natural vehicle for constructing multimedia applications. Hypertext, then, is one possible model for the overall control of multimedia applications.

CHAPTER SUMMARY

1. The systems in this chapter offer a stark contrast to transactions processing applications as they directly support the efforts of the knowledge worker.
2. Decision-support systems are the oldest systems in this group. They help a decision maker solve problems.
3. A DSS may supply its users with statistics and analysis, or it may be based on some kind of operations research model as we saw in the examples from American Airlines and Air Products and Chemicals.
4. An EIS is designed for a top-level manager. Its objective is to provide the information this executive finds personally relevant.
5. A good EIS has a graphical user interface and allows the user to drill down to lower levels of detail to understand the results displayed.
6. A group DSS provides support for a group of decision makers working together on a problem. The GDSS may be used remotely or at a specially constructed meeting room featuring a facilitator and technology to support the meeting.
7. Groupware is a product that epitomizes the transformation of the computer from a purely calculating device to a communications medium. Groupware assists individuals faced with a common task in a shared environment.
8. Communications are important for coordination and for assuring that individuals are working for the objectives of the organization and for resolving dependencies. Groupware fulfills an important coordinating role in the organization.
9. Lotus Notes, the most successful groupware product, also features an applications development facility. Many users are developing quite sophisticated applications with it.
10. Groupware is also a repository of organizational intelligence, as we saw with a consulting firm that uses it to keep track of its past engagements and the skills of its staff.
11. Multimedia refers to the combination of various media like audio and video. It is used for education and entertainment as well as by corporations to help present their products.
12. Multimedia has generated tremendous interest, but it is not easy to develop multimedia presentations.

13. Digital convergence refers to the pipeline carrying information into the home. Various content providers and communications companies are all trying to figure out how to control the pipeline and what comes through it.
14. The consumer demand for digital convergence, especially in the form of interactive TV or the ability to choose among 500 channels, is not clear at this point.
15. As a manager, you may find multimedia most valuable for training employees, video conferencing and meeting support, providing information to employees and customers, and similar tasks.

IMPLICATIONS FOR MANAGEMENT

Groupware is one of those exciting applications that seems to happen about once every ten years. It has the potential to fundamentally change the way we do business. There are two aspects of this class of software that really stand out. The first is the most obvious, allowing people to work on a shared task while located in different places. The second, and potentially the more important, is the use of groupware to collect and disseminate organizational knowledge. You might think of the Notes database developed by a worldwide consulting firm as an intelligent system, making the experience of the firm available to others. What other kinds of organizations could benefit from this kind of knowledge base?

KEY WORDS

Compression
Decision-support system (DSS)
Digital convergence
Executive information system (EIS)
Group decision-support system (GDSS)
Groupware
Hypermedia
Hypertext
Links
Multimedia
Notes
Optimization
Pointers
WebTV

RECOMMENDED READING

Ciborra, C. *GroupWare & Teamwork*. New York: John Wiley & Sons, 1997. (A casebook featuring actual examples of groupware in different business sectors.)

Nielsen, J. *Hypertext and Hypermedia*. New York: Academic Press, 1990. (An excellent introduction to hypertext by one of the leaders in the field.)

O'Keefe, R.; and T. McEachern. "Web-Based Customer Decision Support Systems," *Communications of the ACM*. 41, no. 3 (March 1998), pp. 71–78. (A practical article connecting DSS to the Web technology.)

Smith, B. C.; J. Leimkuhler; and R. Darrow. "Yield Management at American Airlines," *Interfaces*. 22, no. 1 (January-February 1992), pp. 8–31. (A detailed description of the DSS discussed in this chapter.)

Smith, C. *Computer-Supported Decision Making: Meeting the Decision Demands of Modern Organizations*. Norwood, NJ: Ablex Publishing, 1998. (This outstanding textbook emphasizes the need for computer-driven decision making in modern organizations.)

Sprague, R.; and H. Watson, *Decision Support for Management,* Upper Saddle River, NJ: Prentice-Hall, 1996. (A book devoted to many of the topics covered in this chapter.)

Stohr, E.; and B. Konsynski (eds.). *Information Systems and Decision Processes*. Los Alamitos, CA: IEEE Computer Society Press, 1992. (An excellent collection of articles on organizational support systems by some of the leaders in the field.)

Szuprowicz, B. *Multimedia Tools for Managers*. New York: AMACOM Publishing, 1996. (This book provides a useful guideline for managers on how to take advantage of multimedia to gain competitive advantages.)

DISCUSSION QUESTIONS

1. What is a decision-support system?
2. How does a DSS differ from a traditional system?
3. How does a DSS involve users in its design?
4. For what types of systems might the user need assistance in building a DSS? (Hint: Consider Alter's framework.)
5. How are electronic spreadsheet packages used on a PC for building a DSS?
6. What kind of DSS is a manager most likely to build, a model-based or data-based system? Why?
7. Why is an EIS likely to be data based as opposed to model based?
8. What are the objectives of group decision-support systems? How do they differ from an individual DSS?
9. What do graphics capabilities contribute to a DSS?
10. Should users actually write programs? Is building a DSS programming?
11. How does prototyping contribute to a DSS?
12. What are the pros and cons of electronic meeting rooms as a DSS?
13. What is the role of a model in a model-based DSS?
14. Why do managers want to be able to change values and run a DSS again?
15. What features distinguish an executive information system from a DSS?
16. What is a drill down facility and why is it important for an EIS?
17. How has technology changed the cost/benefit ratio for these decision-support systems since the early ones developed in the late 1960s?
18. Why have information services departments generally not developed decision-support systems? Why do they seem to concern themselves with transactions processing applications?
19. What are the major applications for multimedia presentations?
20. What is digital convergence?
21. Who are the major players in digital convergence?
22. What is the promise (and the mythology) of digital convergence?
23. How can a company use multimedia today?

24. What is hypertext and what is it used for?
25. What is groupware? What kinds of problems does it address?
26. What is Lotus Notes? What features does it provide?
27. How does groupware contribute to coordination within the organization?
28. How does groupware provide a base for organizational knowledge?
29. How would you align the incentive (pay) system for an organization to encourage the use of groupware?
30. Compare and contrast groupware, the Internet, and WWW.

CHAPTER 21 PROJECT

A Decision-Support System

Mary Simon is looking for help in a recurring decision she faces. When helping a client evaluate a business for purchase or merger, she analyzes a great deal of information from the balance sheet of the firm. In addition, she does a competitive analysis by looking at other firms in the industry to see how the potential acquisition is performing. Sometimes she is looking for a leader. In other cases, she wants a firm that is not doing well but has a lot of potential.

Describe the overall design of a system for Mary. How do you think it should be developed? What kind of computer and what language or package would you recommend? How much will Mary have to know to use the DSS? What role will she have in building it? Can you use any of the PC tools you have learned to build a rough prototype for Mary?

Intelligent Systems

Outline

Focus on Change

The systems described in this chapter have the potential to change the organization by capturing and applying human expert knowledge and making it available to others in the firm. When first developed, some observers thought expert systems would dramatically change the world of computing. To date, these systems have not lived up to their potential. What are the reasons for this shortfall? How can intelligent systems lead to competitive advantage and organizational transformation?

ARTIFICIAL INTELLIGENCE

Expert systems, case-based reasoning, neural networks, and genetic algorithms represent an applied branch of the computer science field of **artificial intelligence (AI).** Workers in AI try to develop machines and programs whose behavior might be considered intelligent if viewed by humans. At what activities are humans very good? Men and women are able to learn from experience, they can make sense out of contradictions, and they can reason to come to a conclusion. People are also able to reason inductively—to look at evidence and generate a hypothesis about the process that generated the evidence.

Can a machine do any of these things? Certainly, there is no one machine that can do them all. In looking at AI systems, we must consider their domain—the area in which the system functions. A program to diagnose tumors may work very well with tumor information, but it would be hopelessly lost if asked about viral infections.

How can we agree that a program or device exhibits intelligent behavior? Alan Turing, a British mathematician, proposed a test that is named after him. Turing's test is to place a computer and a human in two separate rooms. An interviewer in a third room, who cannot see the human or the computer user, asks questions that are passed to the computer and to the human. If the interviewer cannot tell the difference between the answers from the computer and the human, the machine is said to exhibit intelligent behavior.

AI versus Traditional Programs

Just as the goals of AI programming differ from those of a conventional information processing system, so do the characteristics of these programs. First and most important, in AI one is manipulating symbols rather than numbers. A program to diagnose diseases does not need to compute arithmetic expressions. Instead it has to manipulate logical symbols, just as someone solving a geometry problem would manipulate symbols rather than numbers.

It is also claimed that AI programs are nonalgorithmic. An algorithm is defined as an effective procedure for solving a problem. If the algorithm is followed, one is usually guaranteed of finding a solution to the problem. As opposed to algorithmic programming, AI programs often employ **heuristics** or "rules of thumb" for finding problem solutions.

Many AI programs are concerned with pattern recognition. In fact, some of the early work in AI is responsible for successful optical-scanning devices since these devices must read input symbols and match them with patterns already in the scanning device to identify the input. Pattern matching is an important human capability. We are able to make sense out of many varied patterns.

EXPERT SYSTEMS: APPLIED AI

Currently, there are few applications in business that a computer scientist would call AI. Instead, organizations take advantage of an applied branch of artificial intelligence called **expert systems (ESs)**—advisory programs that attempt to imitate the reasoning process of human experts (Turban, 1995).

Why build such systems? One purpose is to make the expertise of an individual available to others in the field. One company built an expert system to help diagnose and solve the problem of oil exploration rig drills getting stuck. The knowledge of the firm's best drilling expert became available on all rigs through the expert system.

Another motivation for creating an expert system is to capture knowledge from an expert who is likely to be unavailable in the future, perhaps because of an impending retirement. An expert system also provides for some consistency in decision making. Imagine a brokerage house in which the compliance department must see that brokers follow the firm's and the SEC's rules. If the firm uses an expert system to help advise its analysts, each case of suspected rule violations will be evaluated consistently.

How is this kind of knowledge discovery different from the knowledge bases one can build with a groupware application such as Lotus Notes? Both kinds of applications have the same goals. The groupware solution does simple searches on word matches. Expert systems feature more sophisticated approaches to search; they can discover new patterns and relationships in the data, something that a search on keywords is unable to do.

Are the Markets Efficient?

Most business school finance and economics faculty members have an abiding faith in the efficient capital markets hypothesis. This hypothesis states that the market reflects all information and that securities prices are therefore random. Having past prices and new information does not let you predict future stock prices. Markets are considered to be very efficient processors of information so that people in the market react instantaneously to information; the market has discounted information and reflected it in the price of a security before you can move.

One economist argues that it might be possible to get an edge because the efficient capital markets hypotheses was developed during the days when there was ample time for information about a stock to be absorbed by traders and reflected in the price. Today networks deluge traders with huge amounts of information, more than a person can digest. It is hard to believe that all this information is reflected in the price at every instant.

Two physicists who have done research on complex systems have started a company called Prediction that is trying to find hidden patterns to predict stock prices. The company uses AI software to analyze market and financial data; it sends trading signals to its partner, the Swiss Bank Corporation, which places bets on the movements of foreign exchange rates, interest rates, and stock and commodity prices. Some of the company's programs use neural nets while others use genetic algorithms.

If the company is doing well, according to the efficient markets hypotheses, it could be a matter of luck; if the markets are random, you will guess right some of the time. How much success would Prediction need to convince you that an expert system is better at predicting the market than other techniques, or that the market is not a random walk?

Components of Expert Systems

An expert system consists of the following components:

- The user interface
- The knowledge base
- The inference engine

In our research, we found the **user interface** to be an extremely important component of an expert system. Possibly because users are not accustomed to systems that provide advice, they are more demanding. Also, if the advisory system is used frequently, it becomes an important part of the user's daily activities. A good interface makes the system much more pleasant to use and helps promote its acceptance.

What is a **knowledge base**? How does it differ from a database? One important way to represent an expert's knowledge is through the use of rules. An example of a rule might be as follows:

IF the broker sold stock in an account on one day

AND bought the same stock for the same account the next day,

THEN investigate the transaction p = 10

This hypothetical rule indicates that the probability of an investigation is to be increased if the broker sold stock one day and bought it back the next. The broker might be trying to generate commissions when there was no valid investment reason for the transactions.

A database stores numbers and symbols. It might show a simple relationship among the data because they are stored together or defined as connected in some way. A rule in a knowledge base, however, contains some of the logic of an application. The rule above implies something about when an investigation should be undertaken. An ordinary database makes it very difficult to figure out the logic of the application. A knowledge base contains more information about logic than a conventional database.

Knowledge Representation

The production rule above is an example of one type of knowledge representation. It is one of the most popular for building expert systems in business. Another representation technique is known as a **frame.** The frame provides a way to gather a lot of information about an object into one place. For an expert system to advise us on what personal computer to buy, a frame might contain the characteristics of each PC, including its memory size, the type of chip, the speed of the chip, the type of video board, the monitor, and so on.

Finally, an expert system can use a **semantic network.** In a network, information is connected through a series of nodes. The program traverses the nodes along the paths of the network when it is seeking information for its computations.

The Inference Engine

The **inference engine** is the reasoning part of the expert system. It is one of the major components of an expert system's **shell,** a program that is designed to facilitate the development of an expert system. Many of these shells are designed for personal computers, and typically they work through production rules. The inference engine examines the rules and tries to find rules with true IF conditions. A true rule then "fires" and performs the action indicated in the THEN clause. The inference engine may employ forward or backward chaining.

An example will help illustrate how the inference engine might work (Luconi, Malone, and Morton, 1986). Figure 22-1 contains several production rules for personal financial planning. Suppose the client's tax bracket is 33 percent and her liquidity is more than $100,000 and our client has a high tolerance for risk. **Forward chaining** involves going through the rules one at a time to infer that exploratory oil and gas investments are the best recommendation.

If we are interested only in whether exploratory oil and gas investments are the best recommendations and we are not interested in other possible investments, backward chaining is more efficient. In **backward chaining,** the system begins with a goal. In this case, the goal is to show that the client needs exploratory oil and gas investments. At each stage, the inference engine establishes subgoals that, if achieved, would indicate the client needs exploratory oil and gas investments.

Looking at Figure 22-1, assume we know that the THEN condition of the third rule is our goal. To conclude that the exploratory shelter is recommended, we need to know that risk tolerance is high (which is already known) and we need a rule to show that a shelter is recommended. By checking other rules, the inference engine finds if rule 1 is true, it can achieve its subgoal of having a shelter recommended. The IF conditions of rule 1 are true, so the subgoal is attained and rule 3 is true.

Systems Development

The development of an ES follows much the same process as recommended for a DSS in the previous chapter. Expert-system development lends itself naturally to prototyping and learning through test cases. Sometimes the individual designing the system is called a "knowledge engineer" to distinguish him or her from a traditional systems analyst. The development process is different because advice is far more tentative than the numeric solution of a problem or the processing of transactions.

We should point out, however, how difficult it can be to conduct knowledge engineering. In the AESOP example presented below, many hours were spent in meetings with the expert, and many meetings were canceled because of his schedule. It was not until the meetings moved to the floor of the American Stock Exchange just after the close of trading that we managed to make progress on the system. The expert is extremely knowledgeable, and it was difficult for him to explain his logic because he was not conscious of his decision-making steps.

In some instances, experts are reluctant to reveal their expertise to systems developers. In many cases, systems are developed as an experiment and are never fully implemented. The kind of systems described in this chapter may be some of the most difficult to implement successfully.

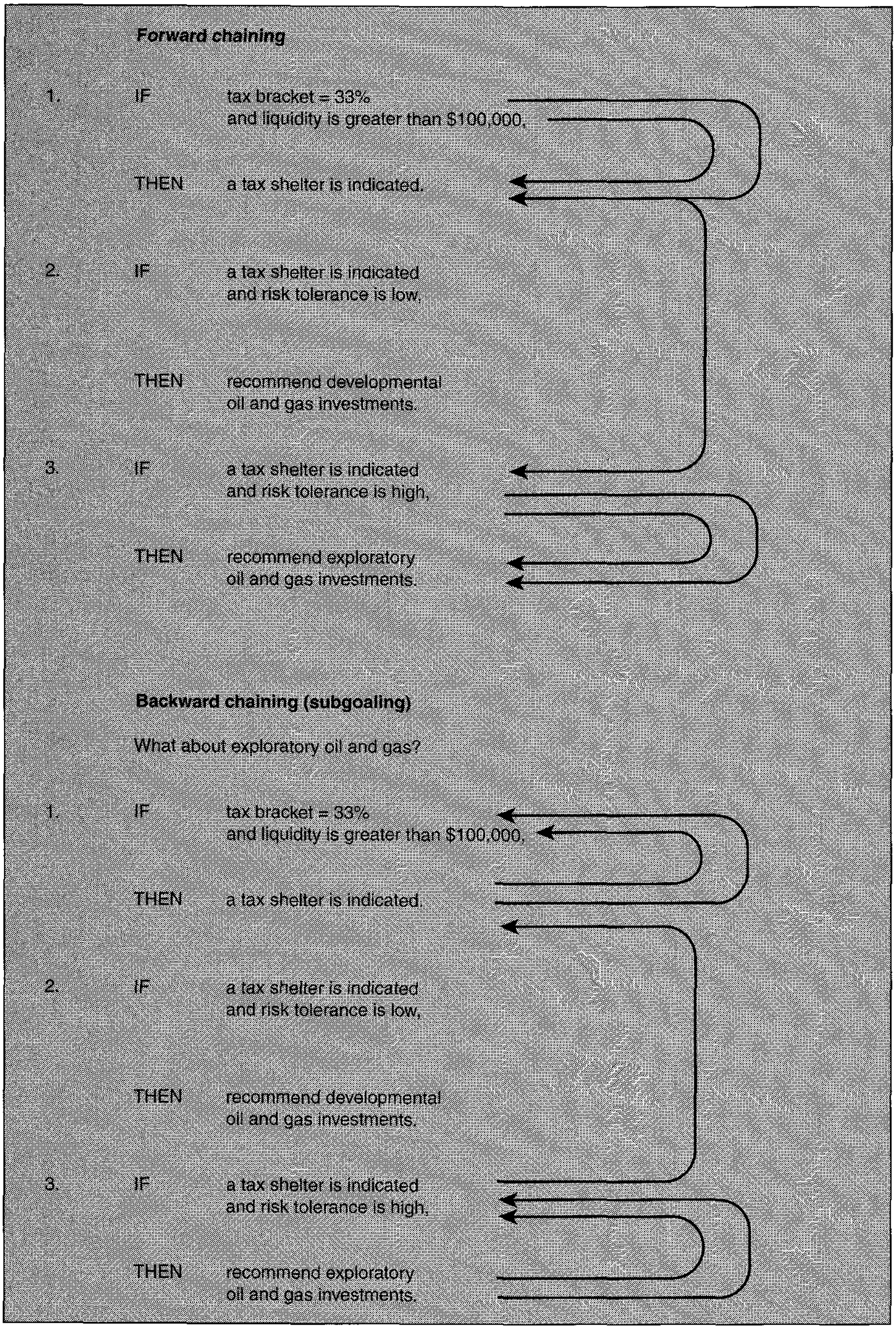


FIGURE 22-1
Expert system example.

Four Examples

Internist-1 One of the earliest and best-known expert systems was developed to provide physicians with a consultant on internal medicine. See Figure 22-2 for a dialog with this system, which is called Internist-1. Professor Harry Pople and Dr. Jack Meyers at the University of Pittsburgh developed the program and built the knowledge base. The system covers about 80 percent of internal medicine and has knowledge of some 500 diseases and 3500 manifestations of the diseases.

The Authorizer's Assistant American Express developed an expert system called the Authorizer's Assistant. Between 200 and 300 authorizers work for American Express at four U.S. centers. They have the responsibility of authorizing transactions charged to American Express cards while the customer is in the store waiting for the sales transaction to be completed.

The cost of making a wrong decision is high. A refusal might alienate a customer or cause him or her to use a different card. American Express would also lose the discount it charges the merchant for processing the transaction. If credit is approved and American Express cannot collect the funds from its cardholder, it has lost the money. Losses from unpaid bills are estimated to be in the hundreds of millions of dollars per year at American Express.

Some 95 percent of the authorizations are approved automatically by a computerized system following set statistical algorithms. Remaining requests are routed to authorizers. Before the Authorizer's Assistant was developed, the human authorizer would receive a screen of data and then access more than a dozen separate database records to synthesize the information needed for a decision.

The Authorizer's Assistant expert system contains about 800 rules, some for combining data and others for making recommendations. The authorizers see a single screen with an accept/reject recommendation and the data on which the recommendation is based. The human still makes the final decision.

The company claims a 20 percent increase in the productivity of its authorizers as a result of the system and expects the system to pay for itself in less than two years. We should note that the user interface provided by the expert system greatly simplified the presentation of information to the human authorizer, demonstrating the importance of the interface in ES design.

AESOP: A System for Stock Options Pricing

Background A **stock option** is a security giving the holder the right to buy or sell an asset at a specified time. A stock option *call* is the right to buy a share of stock at a certain price at a future date; a *put* is the right to sell a share of stock. The price at which one may purchase or sell the stock is called the strike price. On the American Stock Exchange (AMEX), options have an expiration date, at which time they may be exercised. A position in an option may be closed out by purchasing an offsetting contract. All options expire on the third Friday of the month of exercise.

Manifestations are expressed by means of precise sequences of terms in a controlled vocabulary; there are presently approximately 3500 vocabulary items that can be used to describe positive and negative findings.

DISREGARDING: EXPOSURE TO RABBITS OR OTHER SMALL MAMMALS. LEG<S> WEAKNESS BILATERAL. LEG<S> WEAKNESS PROXIMAL ONLY. PRESSURE ARTERIAL ORTHOSTATIC HYPOTENSION. CREATININE BLOOD INCREASED. UREA NITROGEN BLOOD 60 TO 100

CONSIDERING: AGE 26 TO 55. SEX MALE. ANOREXIA. MYALGIA. VOMITING RECENT. FECES LIGHT COLORED. FEVER. JAUNDICE. LIVER ENLARGED SLIGHT. SKIN PALMAR ERYTHEMA. SKIN SPIDER ANGIOMATA. WBC 14000 TO 30000. PLATELETS LESS THAN 50000

RULEOUT. HEPATITIS CHRONIC ACTIVE. ALCOHOLIC HEPATITIS. HEPATIC MILIARY TUBERCULOSIS. MICRONODAL CIRRHOSIS <LAENNECS>. HEPATITIS ACUTE VIRAL

At this point, Internist-1 reports concerning the initial differential diagnosis that will be the focus of problem-solving attention. Three lists are displayed, labeled, respectively, DISREGARDING, CONSIDERING and RULEOUT. The CONSIDERING list identifies those positive findings whose differential diagnostic tasks were combined in coming to the differential diagnostic focus, which is described by the RULEOUT list. The DISREGARDING list tells what positive findings are not consistent with the differential diagnosis as formulated and are therefore being disregarded for the moment; they will, however, be attended to in due course. The key word RULEOUT indicates what strategy Internist-1 is going to pursue relative to this task definition; in this case, as in any case when the differential list contains five or more alternatives, the program will try to find questions to ask that, if the response is negative, will serve to downgrade the score of one or more diagnoses on the list. While pursuing a RULEOUT strategy, the program limits the questions to be asked to items of information obtainable via history or physical exam.

Please Enter Findings of JAUNDICE HX
*GO

There are two formats used for asking questions. In the preceding line, the user is asked to provide any data that might be available within the specified category of findings. Actually, the respondent is free to enter whatever positive or negative data are desired and is not constrained to the category mentioned in the query. In this case, the user chose to respond GO; this passes the initiative back to the program, which then typically follows up on the general question by asking about the specific finding of that category for which it particularly wants a YES or NO answer.

JAUNDICE INTERMITTENT HX?
NO

FIGURE 22-2 *(continued)*
An example of a session with Internist-1.

If the respondent did not have any information concerning this direct question, he could have answered N/A—meaning not available.

Please Enter Findings of APPETITE/WEIGHT
*GO

WEIGHT LOSS GTR THAN 10 PERCENT?
NO

The program asks a series of questions that have been selected in accordance with its problem-solving strategy, then repeats the scoring and partitioning of the task definition procedure.

DISREGARDING: EXPOSURE TO RABBITS OR OTHER SMALL MAMMALS. LEG<S> WEAKNESS BILATERAL. LEG<S> WEAKNESS PROXIMAL ONLY. PRESSURE ARTERIAL ORTHOSTATIC HYPOTENSION. CREATININE BLOOD INCREASED. UREA NITROGEN BLOOD 60 TO 100.

CONSIDERING: AGE 26 TO 55. SEX MALE. ANOREXIA. MYALGIA. VOMITING RECENT. FECES LGIHT COLORED. FEVER. JAUNDICE. LIVER ENLARGED SLIGHT. SKIN PALMAR ERYTHEMA. SKIN SPIDER ANGIOMATA. WBC 14000 TO 30000. PLATELETS LESS THAN 50000

RULEOUT: HEPATITIS CHRONIC ACTIVE. ALCOHOLIC HEPATITIS. HEPATIC MILIARY TUBERCULOSIS. HEPATITIS ACUTE VIRAL. INFECTIOUS MONONUCLEOSIS

Except for the substitution of an acute process (infectious mononucleosis) for a chronic one (micronodal cirrhosis), this differential diagnosis is not significantly changed from the initial formulation. Note that the possibility of cirrhosis has not actually been ruled out; it has merely dropped out of sight because its score has fallen below the threshold used by the task definition procedure.

Please Enter Findings of PAIN ABDOMEN
*GO

ABDOMEN PAIN GENERALIZED?
NO

ABDOMEN PAIN EPIGASTRIUM?
NO

ABDOMEN PAIN NON COLICKY?
NO

ABDOMEN PAIN RIGHT UPPER QUADRANT?
NO

FIGURE 22-2—CONTINUED

DISREGARDING: JAUNDICE. SKIN SPIDER ANGIOMATA. CREATININE BLOOD INCREASED. UREA NITROGEN BLOOD 60 TO 100

CONSIDERING: AGE 26 TO 55. EXPOSURE TO RABBITS OR OTHER SMALL MAMMALS. SEX MALE. ANOREXIA. DIARRHEA ACUTE. MYALGIA. VOMITING RECENT. FEVER. LEG<S> WEAKNESS BILATERAL. LEG<S> WEAKNESS PROXIMAL ONLY. PRESSURE ARTERIAL ORTHOSTATIC HYPOTENSION. PRESSURE ARTERIAL SYSTOLIC 90 TO 110. TACHYCARDIA. WBC 14000 TO 30000. PLATELETS LESS THAN 50000

DISCRIMINATE: LEPTOSPIROSIS SYSTEMIC. SARCOIDOSIS CHRONIC SYSTEMIC

The effect of the negative responses concerning abdominal pain has been to lower the scores of all of the hepatic disorders considered in the previous differential diagnosis. This time, when the partitioning algorithm is invoked, the highest-ranking alternative is systemic leptospirosis; the only other diagnosis on the list capable of explaining substantially the same set of findings is systemic sarcoidosis. The key word DISCRIMINATE indicates that the list of alternatives contains between two and four elements, the leading two of which are selected for comparative analysis. When engaged in a DISCRIMINATE mode of analysis, the program will attempt to ask questions serving to support one diagnosis at the expense of the other; more costly procedures may be called for in order to achieve this objective.

Please Enter Findings of VOMITING/REGURGITATION
*GO

HEMATEMESIS?
NO

HEMOPTYSIS GROSS?
NO

Please Enter Findings of TEMPERATURE
*GO

RIGOR<S>?
YES

Please Enter Findings of NEUROLOGIC EXAM CRANIAL NERVE<S>
*GO

NERVE PARALYSIS SEVENTH CRANIAL BILATERAL?
NO

SPLENECTOMY HX?
NO

FIGURE 22-2 *(continued)*

The program is not actually interested in the answer to this question; what it wants to know is whether the spleen is enlarged. Because of the possibility of being misled by a negative answer, appropriate blocks have been created to prevent the program from asking about an increased spleen size in a patient whose spleen had been removed.

Please Enter Findings of PALPATION ABDOMEN
*GO

SPLENOMEGALY MODERATE?
NO

Please Enter Findings of XRAY LUNG FIELD<S>

CHEST XRAY HILAR ADENOPATHY BILATERAL?
NO

DISREGARDING: JAUNDICE. SKIN SPIDER ANGIOMATA. CREATININE BLOOD INCREASED. UREA NITROGEN BLOOD 60 TO 100

CONSIDERING: AGE 26 TO 55. EXPOSURE TO RABBITS OR OTHER SMALL MAMMALS. SEX MALE. ANOREXIA. DIARRHEA ACUTE. MYALGIA. VOMITING RECENT. FEVER. LEG<S> WEAKNESS BILATERAL. LEG<S> WEAKNESS PROXIMAL ONLY. PRESSURE ARTERIAL ORTHOSTATIC HYPOTENSION. PRESSURE ARTERIAL SYSTOLIC 90 TO 110. RIGOR<S>TACHYCARDIA. WBC 14000 TO 30000. PLATELETS LESS THAN 50000

PURSUING: LEPTOSPIROSIS SYSTEMIC

The questions about rigors (shaking chills) is enough to separate the scores of these items so that now there is only one alternative left in the differential diagnosis. Before concluding that this diagnosis is actually correct, however, the program will now attempt to achieve a degree of separation between this diagnosis and its nearest competitor (now below the threshold and not printed out) that is twice the threshold value. The program invokes a PURSUING strategy, which calls for the identification and acquisition of clinching data; at this stage, the level of questioning is unconstrained so the program can ask about biopsies, if useful, or other specialized procedures capable of providing pathognomonic data.

LEPTOSPIRA AGGLUTINATION POSITIVE?
YES

This finding is enough to clinch the diagnosis. However, the program proceeds to ask additional questions that are automatically included in each consultation.

FIGURE 22-2—CONTINUED

TABLE 22-1

AN EXAMPLE OF A CALL OPTION

XYZ Calls
Stock Price $42

	40		45		50	
	Bid	Ask	Bid	Ask	Bid	Ask
May	3 5/8	3 7/8	0 5/16	0 4/8	0 0/8	0 1/8
June	4 1/8	4 3/8	0 13/16	1 0/8	0 0/8	0 1/8

Table 22-1 is an example of a call option for XYZ stock. The price of a May option to buy a share of XYZ at $40 (the "ask" price) is $3⅞. (Options below $3 are priced in one-sixteenths, and above $3 are priced in one-eighths.) The "bid" price for the May 40 is $3⅝. The quote for the May 50 call option is "no bid," one-eighth asked. The price is given for an option to buy or sell one share of the stock; however, contracts on the AMEX are for 100 shares. An option for a stock at a certain strike price is called an options series.

Assume that the current price of a share of XYZ is $42. A May 40 call is said to be "in the money" because, if the stock price holds until expiration, an option owner has the right to buy a share for $40 and can sell it immediately for $42. The May 45 and 50 calls are "out of the money." For puts, the opposite logic holds. A May 40 put is out of the money because, if the $42 stock price holds until the option expires, there is no gain from having the right to sell a share of stock at $40 when the market price is $42. The May 45 and May 50 puts are in the money.

The Specialist The options specialist is a market maker in an option. He or she is responsible for posting the bid and asking quotes for the stock option at the options post on the floor of the exchange. There is only one specialist on the exchange for each stock option. The specialist maintains an inventory of options and can trade from his or her own account. Specialists also maintain a position in the underlying stock as a hedge on their inventory of options. The role of the specialist is to ensure a fair and orderly market. The specialist buys and sells from his own account to prevent price changes from being unduly erratic.

If the specialist posts an incorrect price, he or she does not obtain the maximum return on invested capital and runs the risk of incurring a large loss. Investors, noting a discrepancy between the price of the option and the underlying stock, will arbitrage against the specialist. Errors in pricing provide the investor with an opportunity for nearly risk-free profits. (The specialist's exposure is limited because a public quote is good for only a limited number of contracts.)

An important role of the specialist is to represent *limit orders.* The limit order is a bid to buy or sell an option at a particular price. The specialist is responsible for executing a trade for the limit order when the option price reaches the price on the limit order, assuming that the specialist has a customer who will take the other side of the trade or that he or she will handle the trade from inventory.

For example, assume the specialist has a customer who puts in a limit order to buy at $4\frac{2}{8}$ and the current bid price for the option is $4\frac{3}{8}$. The specialist can lower his quotation so that the public bid price is $4\frac{2}{8}$. However, he cannot lower it to $4\frac{1}{8}$ because he holds a limit order from a buyer willing to pay $4\frac{2}{8}$.

The specialist involved in this project used the Black-Scholes options-pricing model for a number of years and was reluctant to change models. The specialist provides the parameters for the model. His most frequent change is in the underlying stock price. The stock for his options is traded on the New York Stock Exchange, and the monitor at his post displays the bid and ask prices as well as the last sale price of the underlying stock at the NYSE. The specialist also changes the interest rate for the model and inputs new volatilities for the stock.

The output of the Black-Scholes model is of invaluable assistance to the specialist. Because of the assumptions of the model and the unique situation of the specialist, however, the specialist must modify the theoretical prices. The problem domain of the specialist requires that he or she take the following constraints into consideration when pricing:

1. The model outputs point estimates, and the specialist must put a bid/ask spread around the theoretical price. (The specialist has a desired spread, which is one of his decision variables. The stock exchange also has guidelines for spreads that are a constraint on the decision process.)
2. The specialist cannot price through limit orders. He must constantly check his book of limit orders.
3. There are a number of exchange rules that apply to pricing. For example, on the maximum spread allowed between bid and ask prices, the requirement to price is one-sixteenth below $\$3\frac{1}{8}$ above.
4. The specialist's own inventory position in a series must be considered.
5. The possibility that certain quotations when combined provide an opportunity for someone to arbitrage against the specialist. (The theoretical price prevents arbitrage, but some of the constraints cited in this section force the specialist to post prices that differ from the theoretical price and therefore create opportunities for arbitrage.)
6. The level of current trading activity in the option is also considered.

The Expert System AESOP integrates the Black-Scholes mathematical model with an expert system and attempts to provide recommended quotations for the specialist that are closer to what he or she can post than the theoretical prices produced by the mathematical model alone. The AMEX sponsored the development of the system with a research grant. Its objective was to assess the use of expert-systems technology at the exchange. A major goal of this project was to show that such a model could succeed in the challenging environment of a stock exchange floor.

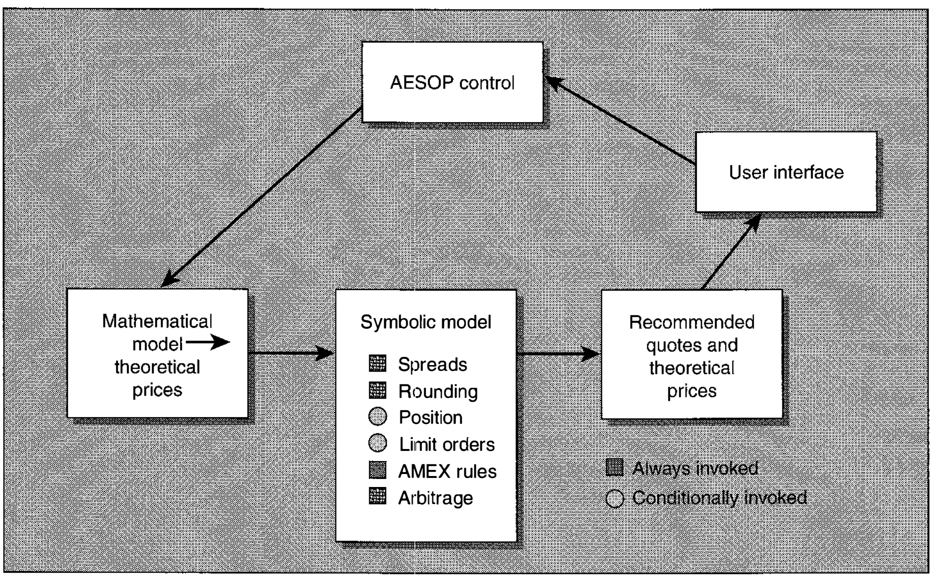
Many expert systems are advisory and operate with loose time constraints. The options-pricing specialist must function in close to real-time as the market changes. AESOP would have to function on the floor of the exchange and provide recommendations whenever the specialist changed input parameters. The recommended prices would have to appear quickly enough to be posted to the public quote board before a trader could take advantage of an "old" price.

The expert system was developed over a two-year period with a senior options specialist at the AMEX as the human expert. The ES uses rules to represent the knowledge of the specialist. This particular approach to knowledge representation seemed natural given the environment. The American Stock Exchange has a series of rules that apply to options prices. The heuristics used by the expert specialist also seemed to follow an if-then structure: "If I am long on contracts, then reduce the asking price by one increment."

Figure 22-3 presents an overview of the AESOP system. The specialist interacts with the system through the user interface managed by AESOP's control module. When the user changes any parameter, the control module invokes the Black-Scholes mathematical model to generate theoretical prices for each series. If the specialist has four different strike prices for each month for four months for both puts and calls, there are 32 theoretical values to be computed (four strikes × four months for puts and calls). The expert always considers the specialist's desired spreads (the difference between bid and ask prices) and always applies the specialist's rounding rules (public quotations must be stated in sixteenths and eighths of a dollar).

If the specialist's position in any series exceeds a threshold level, the expert model adjusts the price of that option to encourage (specialist is long) or discourage

FIGURE 22-3
The AESOP model.



(specialist is short) trading. The symbolic model also looks for limit orders and adjusts the bid/ask prices based on the presence of these orders. Limit order adjustments are the most complicated and potentially the most valuable feature of the symbolic model.

The expert system always checks the AMEX rules to be sure exchange regulations are not violated. The model also scans for arbitrage possibilities. In almost all cases, arbitrage arises because bid/ask prices are adjusted away from the theoretical price for some reason, most often because of the presence of a limit order.

The user interface presents the recommended quotations of the symbolic model along with the theoretical prices generated by the mathematical model. The user is free to override any recommendations, ask for an explanation or trace of the symbolic model, and/or change parameters and rerun the entire system.

Figure 22-4 is a print of the main AESOP screen, which has color coding and pop-up windows as a part of the interface. The user activates the menu by using the function keys shown at the bottom of Figure 22-4. The user interface provides the following functions:

- Entering and processing limit orders
- Invoking a system for updating contracts, positions, etc.

FIGURE 22-4
The main AESOP screen.

AESOP - AN EXPERT SYSTEM FOR OPTIONS PRICING ACCT: RIC OPTION: TANCALLS
2:05 PM

MONTH	STRIKE	TH.VA	LIMIT. BOOK		RECCO.QUOTE		CURR.BOARD		
			BID	ASK	BID	ASK	BID	ASK	STOCK
MAY	40.00	3.72			3^5	3^7	3^6	4^0	43.500
	45 00	0 35			0^05	0^4	0^3	0^09	XDIV
	50.00	0.00		0^1	0^0	0^1	0^0	0^1	06/25/09
JUNE	40.00	4.15			4^1	4^3	4^2	4^4	INT.RATE
	45.00	0.89			0^13	1^0	0^7	1^1	10.25
	50.00	0.06		0^2	0^0	0^1	0^01	0^03	V1
JUL	35.00	9.15			9^0	9^3	9^1	9^5	22
	40.00	4.52			4^3	4^6	4^4	4^7	V2
	45.00	1.34	0^09		1^1	1^3	1^2	1^4	21
	50.00	0.21	0^2	0^5	0^2	0^05	0^2	0^3	V3
OCT	40.00	5.65	2^1		5^4	5^7	5^4	6^0	20
	45.00	2.54		4^0	2^05	2^09	2^3	2^5	V4
	50.00	0.88		1^3	0^13	1^0	0^7	1^01	20

FN.KEYS
AF1 DEL.LO
AF3 CHG.PR
AF5 DL.OVR

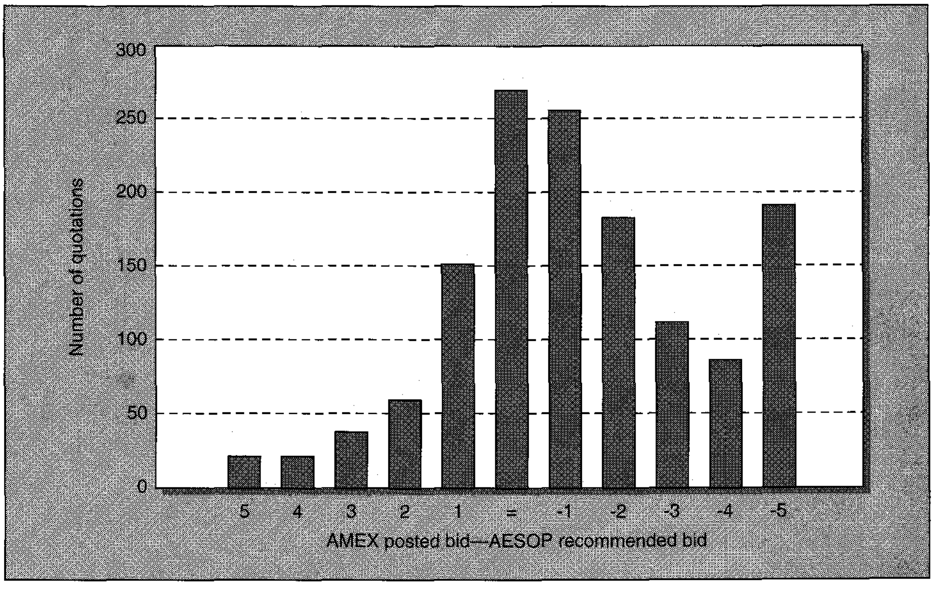
F1-Lim0 F2-OVS F3-Parms F4-Expln F5-Ovrd F6-Send F7-Posn F8-Log F9-Calc F10-End

- Changing parameters in the Black-Scholes model or bid/ask spreads
- Explaining the reasoning behind each recommended quotation and alerting the user to arbitrage possibilities
- Manually overriding any recommended price
- Posting recommended quotations to the "Current Board" columns on the screen
- Displaying the position or changing the threshold position for position rules to apply
- Turning a log on or off
- Running the Black-Scholes model

A specialist used AESOP on an experimental basis for two months. Figure 22-5 compares AESOP's recommendations with the actual quotes posted by the specialist for calls with an ask price in eighths. The graph presents the number of times the specialist posted what AESOP recommended (the "=" column in Figure 22-5) and a distribution for the number of increments by which the specialist's and AESOP's quotes differed. As an example, Figure 22-5 shows that 269 times the specialist posted the ask price in eighths recommended by AESOP; 151 times the specialist raised the recommended bid by one-eighth, and 256 times he lowered it by one-eighth.

Further analysis of puts and calls showed that AESOP performs best on calls. There is more trading activity in calls than in puts. AESOP also performs better on eighths than sixteenths, which seems reasonable as it is more difficult to select the "right price" out of sixteen increments than out of eight. It appears AESOP

FIGURE 22-5
Calls ask price in eighths.



is successful, demonstrating that an expert system can improve the ease of use of a mathematical model and that it can do so in a demanding, semi–real-time environment.

The Port of Singapore Authority Singapore has long had government policies promoting economic growth and employment. Since trade is vital to Singapore's economy, applying technology to processing trade-related information was a natural choice. In addition, Singapore knew that its main rival as a port, Hong Kong, was developing an EDI system for trade. Trade involves many entities in Singapore, so the effort to reengineer trade information processing included representatives of the Economic Development Board (EDB), the National Computer Board (NCB), the Trade Development Board (TDB), and various statutory boards involved with trade such as customs, the Port of Singapore Authority (PSA), and the Civil Aviation Authority.

It was clear that automating present procedures and documents would produce few gains: It was necessary to reduce the 20 plus forms involved in trade to a few forms, or even one. The design effort for TradeNet resulted in a single, long, formatted computer screen to serve nearly all trade documentation for Singapore. The development effort led to the creation of Singapore Network Services (SNI), which established its EDI system. SNI purchased a mainframe EDI "engine" from IBM to serve as the core of the trade system; a local Singapore firm wrote, for example, the custom interfaces and monitoring and billing subsystems. Other subcontractors developed the user interface software for the trading companies that would use TradeNet (King and Konsynski, 1994).

The TradeNet EDI system links the TDB, customs, shipping agents, the ports, freight forwarders, traders, and others. When implemented in January of 1989, the $10 million plus system was a tremendous success. Customer response was much greater than anticipated, and by 1991 the use of TradeNet had become mandatory. Several freight forwarders reported savings of 25 percent or more when handling trade documentation. An evaluation of TradeNet showed that the TDB staff handling trade documentation and procedures fell from 144 before the system to 38 afterward. After the system, turnaround time for documents that took two days under manual processing dropped to 15 minutes while documents that used to require four days now normally take four hours (Teo, Tan, and Wei, 1994).

At the Port TradeNet has greatly facilitated document processing at the port, and it has reduced time delays for most of the parties that use it. Port operations, on the other hand, impose severe, real-time requirements on information processing. The objective of outstanding customer service, which is measured by minimum ship turnaround time and error-free container handling, imposes significant constraints on information processing and port operations. PSA, in combination with various partners, developed an integrated set of traditional and expert systems to provide exceptional customer service to shipping lines. It is estimated that there are more than 300 applications used in all facets of the

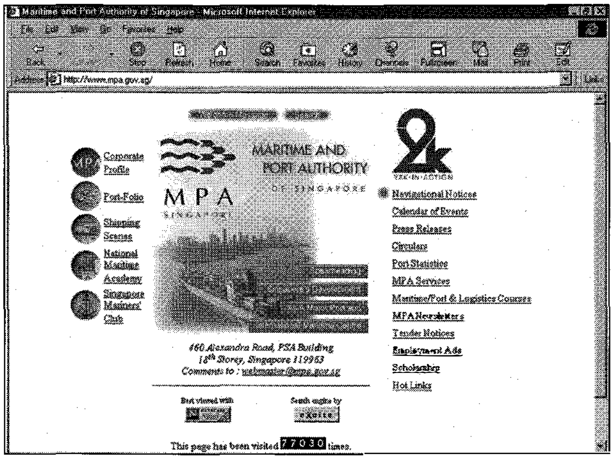


FIGURE 22-6
Technology from the Port of Singapore Authority.

Port's operations (Tung and Turban, 1996). There are two major systems and many subsystems that allow the port to provide superb service despite the shortage of land area for storing and moving containers. See Figure 22-6 and the PSA web site for more details.

PortNet and MAINS Two major systems provide information to port customers and PSA staff. The first system is PortNet, which is a nationwide system connecting PSA to users; it is linked to TradeNet. Prior to the arrival of a ship, shippers use PortNet, an online system with about 1500 subscribers to notify the Port Authority of the containers to be loaded. In response, PSA provides a window of time when the shipper's trucks should appear at an entry gate to the Port. The objective is to have trucks go to the right stack of containers and to have a yard crane available to offload the container from the truck. Such scheduling minimizes the need to handle containers.

The second system is Maritime Information System (MAIN), which collects data from shipping agents, shippers, truckers and others about, for example, a vessel's contents, schedule, and cargo, and provides a central database of information that other systems can access (Tung and Turban, 1996).

CITOS The Computer Integrated Terminal Operations System (CITOS) supports planning and management for all operations of the port. The subsystems in CITOS process information for allocating berths to ships, planning the stowage of containers, allocating resources in general, reading container numbers, and operating trucking gates. The first prototype of CITOS appeared in 1988; it was converted to a production system in 1989, and won an Artificial Intelligence

Innovation Award shortly thereafter. There are five subsystems: berth allocation, stowage planning, yard planning, resource allocation, and a neural network application for gate automation.

1. *Berth planning.* The assignment of ships to berths is complex, given the large number of ships handled daily (40 or more), priorities, weather constraints, changes in schedules, and the need to allocate resources like quay cranes. The expert system relaxes some of the problem's constraints by using different heuristics. The system provides about 80 percent of the solution, and planners use it as a starting point, using a graphical user interface to drag and drop vessel icons in different berths. The system reduces the planning time by up to 90 percent and has improved the utilization of berths (Tung and Turban, 1996). (PSA has not put this system into operation.)
2. *Stowage planning.* The planner assigns containers to cranes and to bays on a ship and determines the containers to be removed and loaded. Each ship is different and has a unique template showing its holds and the locations of containers. Planners must balance the load on the quay cranes according to safety and ship balance constraints. (There are 20 to 30 berths and 10 quay cranes.) The design team first built a prototype using TI (Texas Instruments) Explorer; after proof of concept, they developed the system for a Sun system using Objective C and LISP.

   This problem is complex because ships typically carry cargo for several destinations, and it is important to minimize handling by loading containers in the right sequence. As an example, one of the new large container ships, the 6600 TEU (twenty-foot equivalent containers) *Sally Maersk,* recently made her maiden voyage to Singapore. PSA achieved a rate of 203 container moves per hour for this vessel, exceeding its 1997 average of 88 moves per hour (the fastest in the world). The Port handled 1700 boxes and turned the ship around in less than 8.5 hours. The ship loaded containers from 44 other vessels and discharged containers to another 38 during her visit.
3. *Yard planning.* Singapore is a small island with limited space. PSA stacks containers up to nine high, which is much higher than other ports with more land. Retrieving a container on the bottom of a stack requires a lot of handling and time. Consequently, the yard planner must determine the placement of containers to support rapid turnaround of ships. The objectives are to use space efficiently and keep yard activities orderly.
4. *Resource allocation.* This system helps deploy operations staff and container handling equipment with the exception of quay cranes. Users work with a graphical tool to produce a resource deployment plan. Employees insert their staff passes, which are smart cards, in a machine that provides them with instructions.
5. *Gate automation.* As trucks carrying containers arrive at the entry gate to the port, the Container Number Recognition System reads and interprets the container's number. The system uses a video camera for each letter and number of

the 11-character container ID that is painted on each container. A neural net recognizes each character, and the system checks it against its record of the container that was expected. The gate automation subsystem also records the weight of the vehicle and directs the driver to the container's desired location within 45 seconds. This system reduced the number of individuals manually checking IDs from 16, one per lane, to 3.

CIMOS The Computer-Integrated Marine Operations System (CIMOS) helps to manage shipping traffic and the activities of the port. It includes a Vessel Traffic Information Subsystem, which watches the Singapore Straits and its approaches. This information is available in a database that shippers access via PortNet to learn the status of vessels in the port.

Planning Systems There are five expert systems used for planning, including applications to assign ships to anchorages, schedule the movement of vessels through channels to terminals, deploy pilots to tugs and launches, route launches, and deploy tugboats.

1. *Vessel traffic I.* This expert system provides surveillance of the port approaches including the Singapore Straits. It uses a computer-aided radar tracking system with five radar dishes in place. The system relays vessel movement information to a control center where it is displayed on high-resolution, color graphics terminals.
2. *Vessel traffic II.* The second vessel traffic system has four radar dishes to monitor port waters. The information from this system is used to deploy pilots, tugs, and launches, and to assign anchorage space.
3. *Port traffic management.* This system provides a central database integrating all information from other subsystems. It is also linked to PortNet so that customers and others can obtain status information.
4. *Marine radio system.* This system is installed on PSA vessels and transmits operational data using wireless technology. The system is installed on tugs and launches; all pilots carry radios.
5. *Resource allocation planning systems.* There are five expert systems that help plan resource allocations for the port:
   a. Anchorage utilization assigns anchorage slots to vessels according to the ship's characteristics.
   b. Channel utilization plans and schedules movements of container vessels calling at terminals (over 45,000 a year).
   c. Pilotage deployment assigns pilots to tugs and launches.
   d. Launch deployment produces routes for the launches that serve vessels and employees.
   e. Tug deployment allocates tugs to meet service demands.

This example from PSA shows the power of integrating expert systems technology with more traditional applications. The Port has achieved impressive results that contribute to Singapore's overall strategy for trade and commerce.

MANAGEMENT PROBLEM 22-1

The head of information services at Chemway has just finished reading an article about a competitor in the chemical industry who claims to have implemented more than 200 expert systems. The competitor provided expert-system shells on PCs to various scientists and engineers and encouraged them to build systems. Most of the systems involved 100 to 250 rules and were run on a routine basis.

The Chemway official worries that his firm might be losing out to the competition. "I never realized there were so many possible applications of expert systems in this industry," he remarks. His question is how to get started.

"I could offer courses, provide consultants, or even start my own expert-systems development group. I wonder what would be the most effective way to take advantage of this technology."

What do you recommend?

KNOWLEDGE DISCOVERY

Knowledge discovery is an area of active research and application; it combines AI techniques with large databases. In Chapter 10 we discussed data warehouses, which contain data stored according to multiple dimensions. If you combine the resources of a very large database with AI-based knowledge discovery programs, you may be able to learn valuable facts from the data. For example, suppose that you had a database of the credit card charges for thousands or even millions of card users. A knowledge discovery program would look for patterns in the data and report the results to the user. One pattern might include young professionals with an income over $50,000 who eat out at least once a week. You might target this group for a special restaurant promotion.

Today transactions systems routinely generate billions of characters of data. Credit card charges are one example, but they are small compared with the data generated by grocery and retail store scanners each day. Someday a marketing analyst may be able to work with knowledge discovery programs and a large database to generate hypotheses about products and markets as he or she develops a marketing plan. The combination of AI and database technologies has a great deal of potential for extracting useful information from massive amounts of transactions data.

NEURAL NETWORKS

The field of **neural networks** has recently received a great deal of attention. This approach to AI was first suggested many years ago but has only recently become fashionable. The first neural networks were loosely based on how the brain functions. The brain consists of **neurons,** which can be thought of as small processing units. Outside stimuli or other neurons provide input for a given neuron. The neurons are connected in a large complex network.

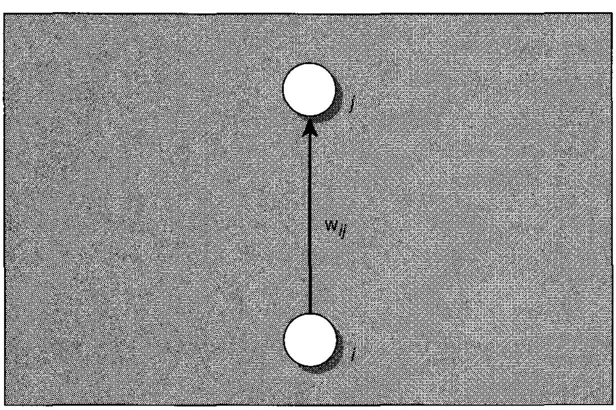
The network has **dendrites,** which transmit messages across various paths. The dendrites are like highways connecting the network. A **synapse** exists where the network connects with a particular neuron. There can be many dendrites (thousands) leading to a single neuron. In the brain the neurons function through a chemical or electrical impulse. These impulses can either excite the neuron, which then "fires," sending a message across the network, or the impulses can inhibit a neuron so it cannot fire. This output goes across a single axon that transmits the neuron's signal to the network. It is estimated that there are trillions of neurons in the human brain (Zahedi, 1993).

How does the analogy of the human brain help create an AI program? The most popular type of neural network is used to classify input into different categories. Figure 22-7 shows the basic building blocks for a neural network: neuron i connected to neuron j. The weight w_{ij} represents the strength of the connection between the two neurons. In a neural network, there are at least two layers of neurons. The input layer receives input from the external environment. The output layer consists of neurons that communicate the output of the system to the user. Figure 22-8 shows a neural network consisting of three layers.

The input to a neuron consists of a weighted sum of all the neurons connected to it that fired. For example, in Figure 22-8 the input to neuron x consists of the output from neurons a, b, and c (assuming that they fired) multiplied by their respective weights. If the sum of this output exceeds some threshold value, neuron x will fire and send its output to the next layer according to the weights connecting it to layer k. The network has to be trained to establish the weights for the connections.

In the simplest network, neurons in one layer are connected only to neurons in the next layer. More complex networks feature neurons that are connected within a layer. Probably the most common business uses of neural nets feature **feed-forward networks;** the neurons in one layer receive inputs from the layer

FIGURE 22-7
Neural nodes.



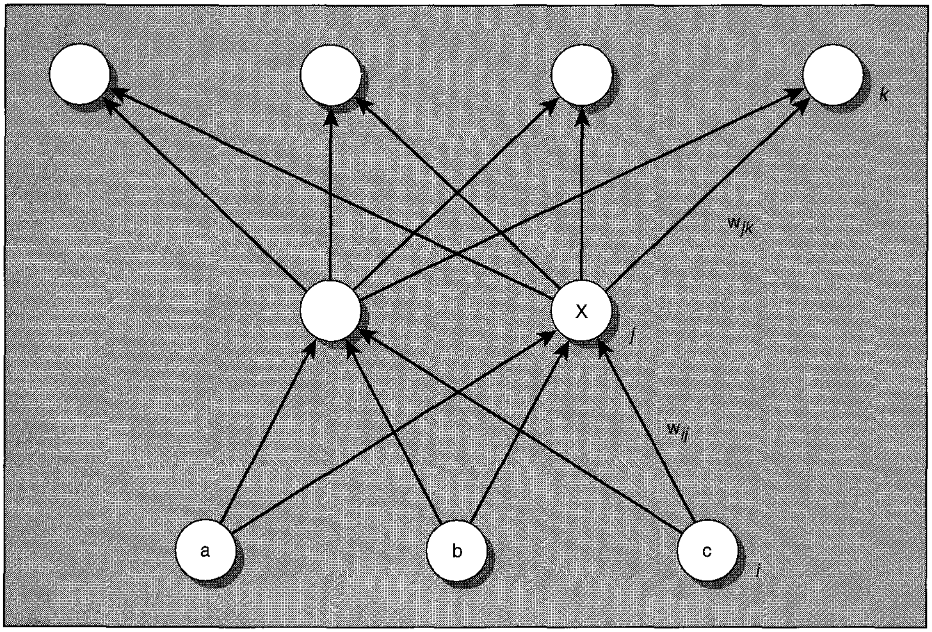


FIGURE 22-8
A three-layer neural network.

below and send outputs to the layer above. In a feed-forward network, the flow of inputs is in one direction, from the input layer, through intermediate layers, and finally to the output layer.

Neural networks have proven to be quite robust in classification problems. For example, suppose that your firm wants to classify new customers into four types: (1) those who are likely to pay their bills on time, (2) those who may take between two and three months to pay, (3) those taking three to six months, and (4) those who are not likely to pay at all. You might design a neural network to try to classify potential customers. The input to the network would be information about the customer, and the output would be a classification into one of four groups corresponding to the likely payment categories.

First you must design the network and then train it. Typically, you would choose a feed-forward network with at least three layers. There is an input layer and an output layer plus one or more hidden layers in between. The layers have connections from the input to the hidden to the output layers. There are also backward connections, which are only used for training the network.

To train the network, you present it with past cases, data on customer attributes, and how these former customers paid their bills. Learning is through **back propagation,** because the learning program looks at the output and then works backward to adjust the **weights** for the connections between neurons. There are various

Case-Based Reasoning for an Online Catalog

Analog Devices manufacturers and distributes electronic devices in the U.S. and abroad; the company has 17 sales offices overseas. Analog Devices sells to many small electronics firms and has a group of engineers to provide customer support. There is also an online catalog with standard search capabilities; however, many customers cannot locate the device they want in this catalog and end up calling customer support for help.

The company funded a project to use case-based reasoning to reduce the number of calls to the support group. The developers focused on a family of components known as operational amplifiers, which offers about 130 products. Each amplifier is described by a product sheet with about 40 parameters. The system computes a similarity index by processing the parameters to develop a recommendation for amplifiers that are closely related to each other.

In a typical interaction, a customer enters parameters into a query form. The system then retrieves the 10 best matches for these parameters. If the results fail to satisfy the customer, he or she is asked to prioritize the most important parameters. Again the system retrieves the 10 best matches. A dissatisfied customer can enter more parameters and keep asking the system for its recommendations. Essentially, the system has some knowledge of the domain for the amplifier family, unlike a standard search engine that might just look for keywords. This knowledge lets the system provide more useful advice to users of the online catalog.

learning rules that are used to adjust the weights during training. For example, the delta training rule attempts to minimize the sum of squared errors between the actual output of the system and the correct output. If, during the training, your network misclassified a former customer, the delta rule would adjust the weights to try to minimize the error. After training with a large number of cases, the weights should stabilize and the network is ready for use. At this point, you begin to use the network to classify new customers based on the same kind of input information you used to train the network.

There are PC shell programs available to help develop neural net applications. This AI approach is used to predict bankruptcies and to help identify thoroughbred horses based on blood samples. A neural network is one way to think about some classification and prediction problems. There are also other ways to classify and predict based on classical statistical procedures such as discriminant analysis, linear regression, and exponential smoothing, to name a few. One challenge is to find the most appropriate technique to use for a given problem.

Case-Based Reasoning

Case-based reasoning (CBR) captures lessons from past experience and uses them to find solutions to a new problem. CBR is both a problem-solving approach and a model of how some experts think individuals learn, remember, and think about problems. A case-based model is particularly appropriate when rules cannot express the richness of the knowledge domain. CBR is described as most useful when there is rich experience but little knowledge.

A case-based system needs cases, a similarity index, a case retrieval mechanism, and an explanation module. A case is similar to the cases you study in school: it has a set of features, attributes and relations, and an associated outcome. A case is specific to a given situation, unlike a general rule in a rule-based expert system. The PERSUADER is a case-based system for mediating management and labor disputes. For this CBR program, a case is a past labor dispute similar to the one it now faces. A repository of past cases is crucial. The more cases and the greater the variety of experiences they represent, the better the recommendations from the system.

A set of indices is the mechanism through which cases similar to the one under consideration are located. The indexing process stores cases and generates similarity indices to be used in retrieving cases similar to the one at hand. The task of developing robust indices is one of the biggest challenges facing developers of case-based systems. Another component, the retrieval mechanism, must retrieve cases with the closest match between attributes of past cases and the current case on which advice is sought. The explanation module allows the system to explain its analysis of the current problem and a proposed solution. It should describe why and how the present problem is similar to past cases.

A user presents the system with a problem and the system indexes its attributes, features, and relations based on standards built into the system. The system uses these indices to retrieve a set of similar past cases and their solutions based on the indices created when the cases were originally added to the knowledge base. The system examines the cases retrieved from "memory" to find the best fit with the current problem. It also examines the solution to past cases until it can generate a proposed solution to the problem at hand. If the system's proposed solution is accepted, it incorporates the current case into its knowledge base to be used again in the future.

Genetic Algorithms

The traditional approach to solving problems in artificial intelligence involves looking at a single candidate for a solution and interactively manipulating it using various heuristics, or rules of thumb. **Genetic algorithms** work on a population of candidates at the same time. This population of candidate solutions may be as few as ten to several thousands. Figure 22-9 describes these **evolutionary computations.** In general the approach involves generating a population of possible problem solutions (the unrated population in the figure) and rating them based on some **fitness function.** The next step is to apply a selection function to the unrated population to select "parents" for the next generation of solutions. A reproduction function generates copies of the parents. These copies go

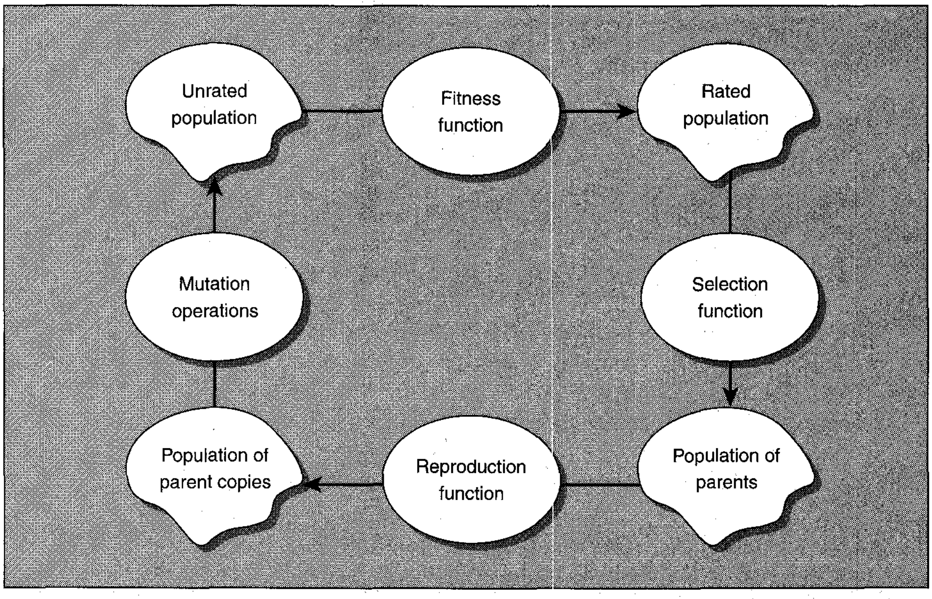


FIGURE 22-9
General procedure for all evolutionary computations. A complete cycle from unrated population to unrated population represents one generation of the search.

through **mutation** operations to create the next generation of solutions for evaluation, closing the loop in the figure at the "unrated population" in the upper left-hand corner.

To start, a genetic algorithm rates how good each solution is for the problem under consideration using a fitness function. This function is similar to a cost function used in other search techniques. The function returns a number denoting the worth of the solution just evaluated. The objective of the genetic algorithm is to minimize (or maximize, depending on the problem) the value returned by the fitness function.

Once the fitness function evaluates all candidates, the genetic algorithm selects a subset of the population to form "parents" for a new population. The algorithm chooses parents based on the relative worth of the candidates in the population as determined by the fitness function. Genetic algorithms feature a variety of selection methods to designate the parents. As an example, a simple strategy would be to take the best half of the current population to be the parents for the next generation. Most of the time, the selection of the better part of the population is augmented with lesser fitness scores to promote diversity.

To create a new generation of possible solutions, the genetic algorithm applies operators known as mutations to copies of the parents it has selected.

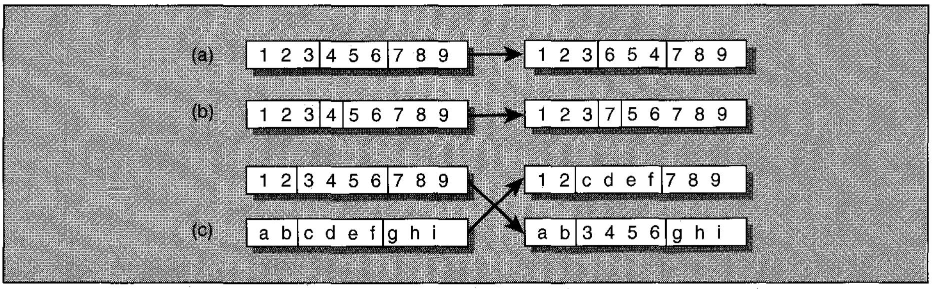


FIGURE 22-10
(a) Inversion, (b) point mutations, and (c) crossover operations used in genetic algorithms.

These mutations alter the content of the parents. As shown in Figure 22-10 genetic algorithms represent problem solutions as fixed-length vectors containing features of the solution. Genetic algorithms mimic the manipulation of DNA and gene sequences. The mutations include **inversion,** point mutation, and **crossover** as shown in the figure. The inversion operation reverses the order of randomly selected, contiguous portions of the vector. A point mutation alters a single feature, replacing it with a randomly chosen value. The crossover operator randomly selects a sequence of features and swaps them between two parents. This latter mutation is the most popular and most frequently used. The creation of populations stops after a set number of generations or after the fitness function reaches a predetermined value.

A rule-based expert system will show the rules that "fired" and allow the user to trace the path used to reach the solution. Like neural networks, genetic algorithms do not provide the user with an understanding of how they reached a solution. Both of these techniques provide good solutions to a variety of problems despite the drawback that their solution mechanism is not obvious.

Intelligent Agents

If you combine AI with networks, the resulting innovation is an intelligent agent. An agent is a piece of software that performs a task for its owner. Some developers call agents "softbots," a play on the mechanical robot. An intelligent agent must exhibit some kind of behavior that observers would consider to be "intelligent." Suppose you could send an agent over the Web armed with a request to obtain the four lowest prices it could find for a certain kind of appliance, say, a VCR, and have it return with the information. Would you consider this to be intelligent behavior? The first applications for intelligent agents have been for consumer tasks like shopping. A pioneer in developing these applications created a Web site to provide recommendations on music. A user indicates the types of music she or he likes, and an agent matches the profile with those of others in the database. It recommends music to the user that matches the

An Intelligent Advisor

One application of the CBR (case-based reasoning) technique has been used for collaborative filtering engines. For instance, CDnow (www.cdnow.com), a leading online music store, leverages this CBR-enabled filtering technique to divine a user's preferences, behaviors, or both based on what other previous customers with similar characteristics liked or did not like. Album Advisor (the music recommendation system at CDnow) asks a customer to enter the names of three artists on the Web screen, and then it returns suggestions based on a historical database of what other people who bought the chosen three artists purchased. By clicking a "play it" button, customers are allowed to listen to the recommended tracks recorded as RealAudio clips. CDnow also sends those customers weekly e-mail newsletters of suggested albums providing the latest information on prices and availability of the particular titles.

Michael Krupit, vice president of technology and creative services, says, "Customers are getting better judgment from artificial intelligence than they would from the human intelligence of most clerks at a retail store." In fact, this collaborative filtering engine technique developed by Net Perceptions (www.netperceptions.com) is also being used by Amazon.com and Billboard Talent Net. According to John Riedl, chief technology officer at Net Perceptions and a former professor of computer science at the University of Minnesota, customers' average order volume has grown between 2 to 5 percent due to the installation of the CBR-enabled recommendation system. In a foreseeable future the impact will be even more significant as its existence is now being much publicized to the users. It seems evident that the CBR technology has helped many Web-based businesses and will continue to convert a lot of casual browsers to buyers in those domains.

profile. We are just beginning to understand the potential that intelligent agents have for serving their owners.

CHAPTER SUMMARY

1. Intelligent systems exhibit behavior that would be called intelligent if viewed by a person.
2. Intelligent systems process symbols as well as numbers.
3. The first widespread application of artificial intelligence to business was through expert systems.
4. An expert system has a knowledge base and inference engine.
5. An expert system (ES) may represent knowledge through the use of rules or frames.
6. An ES is developed through prototyping, and it is important to test it carefully.
7. Expert systems perform well in the domain for which they were designed, but have no knowledge of other domains, while most humans are capable of reasonably intelligent behavior over a variety of domains.

8. Knowledge discovery combines database technology and AI techniques to help a user discover interesting patterns in large databases.
9. Neural networks are an intelligent system loosely based on how the brain functions.
10. The user trains a neural network with a number of cases so the network can solve future problems with similar characteristics.
11. Case-based reasoning uses past experience as a guide to offering a solution to a current problem.
12. Genetic algorithms are based on evolution. They evaluate a large population of potential solutions to a problem, select parents for the next generation of solutions, and apply mutation operators to produce the next generation of solutions for evaluation.
13. Intelligent systems may provide the firm with a number of advantages. For example, they can make expertise widely available in the organization.
14. These systems can also perform more mundane tasks, such as the expert system for accepting securities in the brokerage office in the Merrill Lynch example in Chapter 18.
15. The technology discussed in this and the previous chapter extends the power of the computer to the direct support of decision making and management action. The manager does not have to scan a report and interpret data. He or she interacts with a system designed to support decisions.

IMPLICATIONS FOR MANAGEMENT

When expert systems first became popular, some forecasters suggested that they would forever alter the nature of information processing. Initial enthusiasm waned as the difficulties of developing intelligent systems became more apparent. There is certainly a role for this technology as the examples show. However, you should regard the development of an ES as an R&D project. It is certainly more risky than a conventional application.

KEY WORDS

Artificial intelligence (AI)
Back propagation
Backward chaining
Case-based reasoning (CBR)
Crossover
Dendrite
Evolutionary computations
Expert system
Feed-forward network
Fitness function
Forward chaining

Frame
Genetic algorithm
Heuristic
Inference engine
Inversion
Knowledge base
Knowledge discovery
Mutation
Neural network
Neuron
Semantic network
Shell
Stock option
Synapse
User interface
Weight

RECOMMENDED READING

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DISCUSSION QUESTIONS

1. What are the reasons for developing an expert system?
2. What are the differences between an expert system and a conventional system?
3. In what ways does an expert system resemble a decision-support system?
4. What is backward chaining? Forward chaining?
5. Why are production rule systems popular for advisory systems in business?
6. What is the attraction of using an ES shell on a PC for developing a system?
7. What is the difference between knowledge engineering and systems analysis?
8. How could a system like Internist-1 be used?
9. Why is a mistake in authorizing credit card purchases costly for American Express?
10. Why is prototyping a good approach for the development of an ES?
11. What is the purpose of the inference engine in an expert system?
12. How is symbolic processing different from numeric processing? (*Hint:* Review the example of forward and backward chaining in the chapter.)
13. Why is the user interface an important component of an expert system?
14. What are the differences in managing an expert-systems development project and designing a transactions processing system?
15. How does one go about identifying the expert to be used in developing an expert system?
16. What techniques can you suggest to help the designer extract and document the expert's knowledge?
17. What benefits can knowledge discovery systems provide to the organization?
18. What kinds of problems are best suited to the use of a neural network?
19. What steps are involved in creating a neural net?
20. Explain the way a genetic algorithm functions. What is the underlying model for this approach to intelligent systems?
21. How do expert systems contribute to the port operation in Singapore? How does the technology help Singapore implement its economic strategy?

CHAPTER 22 PROJECT

Expert Systems

The admissions department in your school has asked for your help in developing an expert system for rating candidates. The system should take three input conditions into account:

- Graduate Management Aptitude Test (GMAT) score
- Grade point average (GPA)
- Experience (good, average, poor)

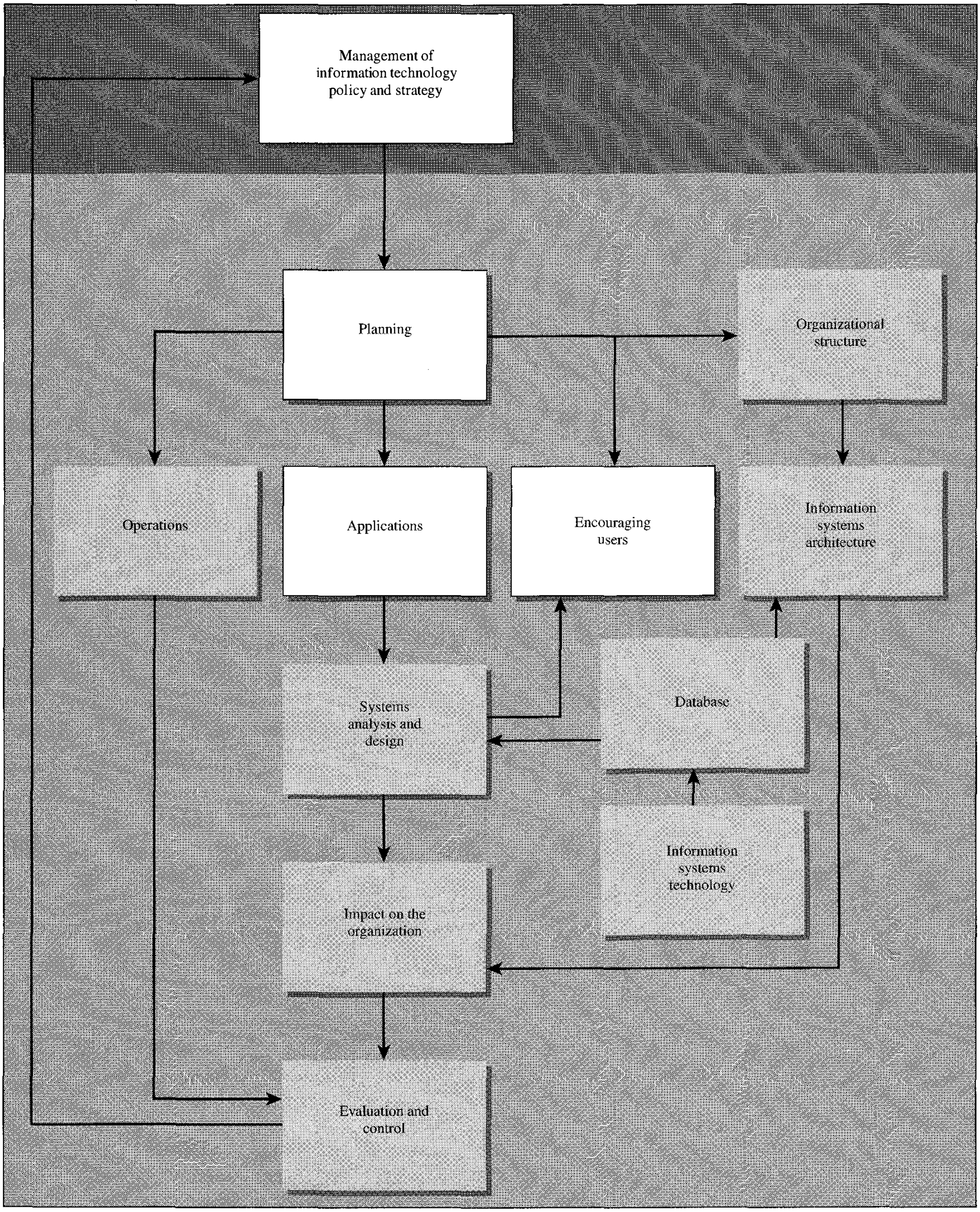
The user will evaluate experience directly from the application. The expert system should come up with a value for overall academic performance as good, average, or poor by combining the results of the GMAT and GPA. The rules are as follows:

GMAT	GPA	Performance
> = 575	> = 3.3	Good
> 525	< = 2.8 GPA < 3.3	Average
< 525		Poor
	< 2.8	Poor
525 < = GMAT< 575	> 2.8	Average

The rules for acceptance are as follows:

Academics	Experience	Action
Good	Good	Accept
Good	Average	Accept
Good	Poor	Waiting list
Average	Good	Waiting list
Any other combination		Reject

Use an expert system shell on a PC to develop this expert system and run several examples to demonstrate how it works.


Management of information technology policy and strategy
Planning
Organizational structure
Operations
Applications
Encouraging users
Information systems architecture
Systems analysis and design
Database
Information systems technology
Impact on the organization
Evaluation and control

PART SIX

ISSUES FOR SENIOR MANAGEMENT

We conclude the book with an examination of special management concerns about information technology. What are the special problems of managing IT? What do future trends in management and technology mean for the organization? How will new technologies affect the firm? To enjoy all of the benefits from IT we have discussed to this point, you have to be able to manage the technology.

The last chapter expands the boundaries of information systems beyond the organization to include society at large. What social issues should the manager consider when making decisions about information technology? What does responsible computing require?

CHAPTER 23

Management Control of Information Technology

Outline

Focus on Change

Information technology can provide novel ways to control the organization, making possible new organizational structures and alliances with external firms. Virtual firms, or firms with extensive outsourcing, face problems of control and communications. How can the manager be sure that a virtual partner or firm in an alliance is meeting their obligations? How do you control an international organization where employees can commit the firm without any review?

Managerial control and coordination are closely related. New organizational forms must address the issue of how management can control the organization.

MANAGEMENT CONTROL

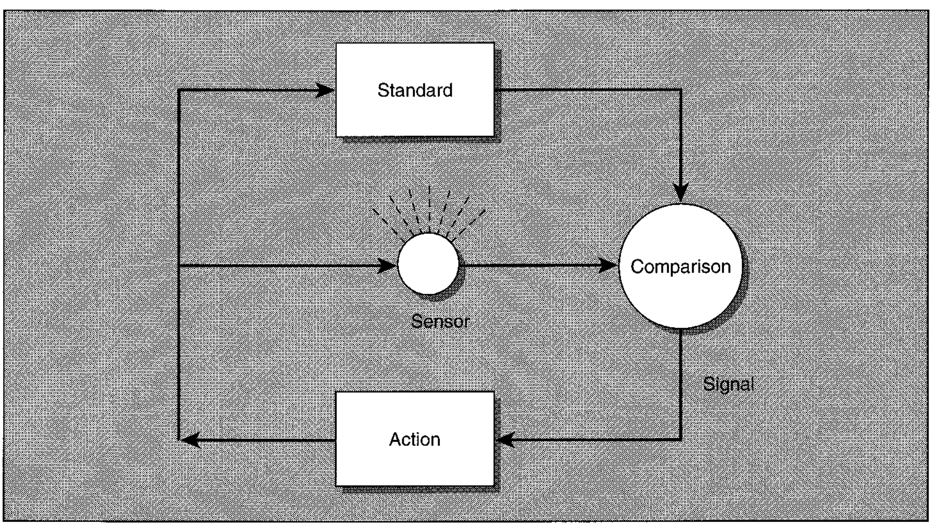
One of the fundamental roles of management in an organization is control. What is control? How do managers control the organization? This chapter seeks to answer these questions, particularly with respect to information systems.

Control Theory

Process control offers a useful model for thinking about control in general. Consider Figure 23-1, which shows a typical control system. In this system, a sensor determines actual conditions, and a comparison device compares the standard with what actually exists. If the difference between reality and the standard is too great, the comparison device sends a signal to take action. The action taken in turn affects the sensor and standard, and the cycle continues until the comparison device finds agreement between sensor and standard, and stops signaling for action.

A real example of this model may be found in an automobile's cruise control system. We set the adjustable standard—the speed we desire—using the cruise control button. A sensor determines the car's speed, and a control unit compares the desired setting and the current speed. If the difference between the two is too great, the cruise control system increases or decreases the throttle appropriately.

FIGURE 23-1
A control system.



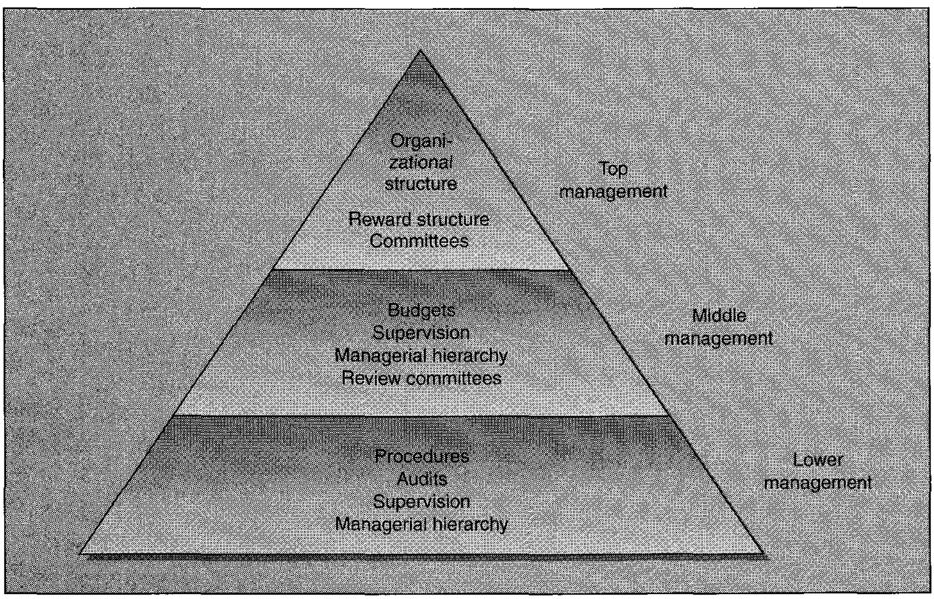
This example shows how a basic control system functions. In an organization, we can apply the same concepts. Managers have a notion of a standard, and they must become aware of deviations from the standard. Given that some indicator deviates from the standard, management must take action to bring the organization back into control.

Control in the Organization

Figure 23-2 shows some of the tools available to managers at different levels for controlling the organization. Top management can create control through the structure of the organization. For example, management can decide to decentralize and to have local managers responsible for comparing their performance with the goals the managers set for the year. As an alternative, top management can opt for a high degree of centralization so it can set policy and review all decisions.

Our discussions of the T-Form organization suggest that in the future, management will have a more difficult time using traditional methods such as structure for control. Hierarchical structures are in retreat, and managers will have to trust subordinates and come up with new ways to exercise their responsibility for control. An example shows how Mrs. Fields Cookies uses technology and IT to develop a unique control system.

FIGURE 23-2
Tools of management control.



Taurus—The Project that Couldn't

In 1989 the Bank of England started a working group to design a new paperless system for processing settlements on the London Stock Exchange. The Exchange had become electronic in 1986. The cost of a centralized clearing system was estimated at 60 million pounds, so the committee came up with a design based on distributed databases at hundreds of sites, with many different kinds of hardware and software linked to the Stock Exchange through a network. Work started on the system in 1990 with an estimated budget of 50 million pounds. A software package from a New York firm, the market leader, was to be the base of the system; the design would use a structured methodology.

The date for completing the system gradually slipped and its costs rose, first to 75 million pounds. By the fall of 1992 it was clear that the basic architecture of the system had not been completed. A full review in January of 1993 determined that its underlying problems were so serious that it would take another three years to complete and that its cost would double. In March of 1993, the Stock Exchange announced that work on Taurus was to be abandoned. By this time costs had reached 400 million pounds! The failure of Taurus was significant enough that the head of the London Stock Exchange resigned because of its failure.

Management has to control the organization, but it also needs to control individual projects, especially when they are critical to the organization. Taurus cost a huge amount of money and cost a senior executive his job.

Top management also exerts control through a reward structure. Several brokerage firms suffered control breakdowns, partially, we suspect, because of a reward structure encouraging heavy risk taking in bond trading. The firms paid bond traders very large bonuses based on performance because bond trading is highly competitive among firms. More than one firm found it lost well over $100 million in a few weeks when the market turned. There was a highly motivating reward system and almost no managerial control over the traders. Two banks recently found losses of over one billion dollars in unauthorized trading, forcing one bank into a merger.

One form of managerial control that is used frequently and probably could have helped ameliorate the bond trader problem is the management committee. For many years banks have employed loan review committees. The lending officer has a certain limit he or she can approve on a loan. Any loan larger than the limit must be discussed and ultimately approved by the committee. The committee serves as a review and control role in the firm.

The most frequent middle-management control device is the budget. Many managers in the organization receive periodic budget reports that inform them of actual versus targeted performance. Budgets are extremely important tools for controlling expenditures.

Middle managers are also expected to exert direct supervision over their subordinates, though more remote work makes this difficult. When in doubt, they can refer problems up through a managerial hierarchy. The entire structure of management serves to control the organization and keep it on course. Middle managers can also establish review committees to foster greater control.

At the lowest levels of management, we find procedures describing how operations should be done. Procedures were particularly evident in paperwork transactions processing departments. If one visited an accounts payable operation, it was possible to see clerks who carefully looked up each bill the firm received to find the purchase order that authorized the purchase. The clerk saw that the goods or services purchased actually arrived and delivery was satisfactory. Then the clerk authorized the payable and put all the documents relating to the payment into a voucher, which was filed for a number of years.

This kind of manual accounts payable operation is rapidly vanishing, which creates new control problems for the organization. Consider Chrysler's Pay as Built program where it calculates what it owes suppliers based on each day's production and sends an electronic payment. How do Chrysler and its suppliers know that the calculations and payment are correct? At some point in time, the number of components shipped to Chrysler should match the payments, but verifying these transactions could be a formidable task.

Regular, routine audits help to establish control by showing that control is important and by sending the message that there is a form of quality control over all the firm's procedures, or at least those affecting financial statements. Lower-level managers also have direct supervision responsibilities. They too can make use of the managerial hierarchy to obtain approvals or additional guidance.

Failure of Control

What happens when management control fails? Very often, a firm fails as a result of a control breakdown. In the computer industry, there are notable examples of firms with very few controls. In one case, while the single product the firm sold was in demand, it was possible for high sales to mask the lack of budgets and the absence of controls over expenditures. However, when demand for the product dropped, the failure to have budgets or control expenditures pushed the firm into bankruptcy.

Information and Control

One contribution of information systems is to strengthen control systems. A manager needs information about the deviation of actual from standard, or targeted performance. Computerized budget systems help managers identify exceptions and take action. Executive information systems, discussed in Chapter 21, monitor critical indicators for management. Senior management may be able to take immediate action if sales are falling below projections. Managers may alter production schedules, emphasize different products, and/or begin to reduce expenditures.

Control through IT at Mrs. Fields

Mrs. Fields Cookies is an oft-cited example of a firm that has used information technology as part of its organization structure. Mrs. Fields Cookies is a chain of small retail outlets, typically found in shopping malls, which sell several varieties of cookies and a few other selected food items. In 1988 there were approximately 500 retail stores worldwide. Stores follow a formula of consistent, uniform quality and price regardless of location. However, Mrs. Fields Cookies has a unique structure. It has two parallel organizations, one of which has a traditional hierarchy and another which has a flat organization structure.

The traditional hierarchy is formed by 500 store managers, 105 district sales managers, 17 regional directors, four senior regional directors, a VP of operations, and finally Debbie Fields. The span of control of this hierarchy is about 1:5.

The second organization is a formal reporting relationship for control purposes; here 500 store managers report to six store controllers, who report to the vice president of operations. The span of control between store managers and controllers is 35 to 75: 1, which represents a very flat organization structure. The "human" side of management at Mrs. Fields is through a traditional hierarchy. The "numbers" side is a flat organization made possible through information technology.

Until recently, every shop was wholly owned by the company rather than franchised, and the company was under the strong centralized control of Mrs. Fields and her husband. The unique organization of Mrs. Fields Cookies allowed the owners maximum flexibility in adapting its offerings to the changing tastes of customers in a "fad" business.

IT is an integral part of the structure of Mrs. Fields Cookies. Each store is connected on-line to a central database, and there is extensive automation of production quotas, sales volumes, etc., based on recent daily sales records for each store. In fact, each store is given hourly sales projections and reports hourly sales results. All ordering of supplies (e.g., chocolate chips) is done automatically from the central database with direct delivery to the store.

Each store's product mix, sales quotas, and special promotions are customized by an expert system that adapts to hourly sales. The company also uses IT for coordination through voice mail and electronic mail so each store manager has direct personal interaction with Mrs. Fields herself. Company-wide announcements are frequently broadcast to each store by voice mail, significantly personalizing the announcement compared to memos and reports. (Debbie Fields was a cheerleader in high school, and voice mail seems a natural way to rally the troops.) Each manager may send Mrs. Fields electronic messages for particular problems and expect a personal response within 48 hours.

There have been management problems at Mrs. Fields. The firm expanded rapidly, possibly encouraged by the success of its

Although information systems can help to improve managerial control, they create a tremendous control problem themselves. Information systems are very complex. For example, it is likely no one person understands everything about a large system like SABRE. So although managers do not necessarily understand the technology, they are often responsible for seeing that information systems are under control.

Control through IT at Mrs. Fields—Continued

technology, and ran into difficulty integrating its acquisition, La Petite Boulangerie, with its traditional cookie stores. While Mrs. Fields can change its mix of cookies easily, the original cookie operation is basically a one-product business. The firm is also reported to have had difficulties with its product and market mix when it entered international markets.

Unfortunately, Mrs. Fields' high debt created problems in 1991. Trading of its stock was suspended pending restructuring of its $70 million debt. Undeterred by debt, in 1992, Mrs. Fields Cookies and Pastereleria el Molino announced a leasing agreement to open 50 stores in Mexico over five years. In May of 1992, Mrs. Fields launched Fields Ice Cream. The company also started Mrs. Fields Mini Cookie Store, a cart equipped with a cookie baking oven designed to be set up in grocery stores.

The March 1, 1993, issue of *Business Week* reported that Mrs. Fields "is throwing in her apron."

> On February 17, Debbie Fields, who started her cookie-making empire in Palo Alto, CA, back in 1977, stepped down as president and chief executive officer. Fields, who retains her position as chairwoman, turned over nearly 80 percent of the company to four lenders led by Prudential Insurance Co.

Mrs. Fields' problems probably did not stem from its control system. Rather, it appears that Mrs. Fields as an organization became overconfident regarding its abilities to manage businesses that were not a part of its core. A bakery chain like La Petite Boulangerie is different from a cookie store. Did the technology lead management into a false sense of confidence and invulnerability?

The example shows that you can use technology to personalize and control the business. All Mrs. Fields stores look alike and suffer from high labor turnover. Mrs. Fields was very concerned about control and about quality. The technology helped her manage these two aspects of the business. First, store controllers are a control mechanism. Second, the control of quality is an important issue for Mrs. Fields. The combination of in-store computers and uniform recipes, cooking instructions, and ingredients help provide quality control. Voice mail and e-mail helped motivate and, to some extent, control employees. At Mrs. Fields, control comes from a combination of structure and technology; there is no single IT variable for control. A group of design variables and the structure of the organization together provide control.

The technology allowed Debbie and Randy Fields to create different types of organization structures within the same firm. They could also "micromanage" what was happening at individual stores through the controllers at headquarters. The unanswered question is whether the technology helped lead top management away from their core business into ventures they did not understand well.

CONTROL OF SYSTEMS DEVELOPMENT

An important area in which organizations face loss of control is in the development of new information systems, which, as discussed in Part Four, is similar to conducting research. It is hard to predict how long it will take and how much it will cost to develop something new. Since most systems have components that are new, there is a great deal of uncertainty in their development.

Control in the Air

We have seen that elaborate computer networks help you make a plane reservation and help the airlines manage all aspects of their business. What happens when you get on the plane and the air traffic control (ATC) system takes over? What is supposed to happen is that the airport tower assumes control for takeoff and hands the plane off to a Terminal Radar Approach Control (TRACON) facility, which directs planes at low altitude and around airports. TRACON passes control of the plane to a Control Center when it reaches a high altitude.

For a variety of reasons from government procurement policies to poor project management, plans to upgrade the ATC system have left us with an antique system. The good news is that it seems to work most of the time. However, at least 11 times in 1994–1995, air traffic control centers have had problems or broken down completely. Random outages continue to occur. Some of the computers that help track planes are 25 years old. Unfortunately, much of the original software was written in assembly language or a special language called JOVIAL. This code must be updated before the computers can be replaced.

When the main computers fail, a backup system from the 1980s takes over to provide radar data to the controllers. However, they do not have the full information provided by the first-line system. For example, in backup mode, the system can no longer project a plane's route, warn when planes are too close or might collide, or provide a minimum safe altitude warning. When the backup system fails, the amount of information provided to the controller is even less.

Right now, the system causes frustration for controllers and pilots, and results in expensive delays. The FAA claims that safety is never compromised, but the combination of failure-prone equipment, reductions in the maintenance staff, shrinking ATC budgets, and an increasing number of flights seems like a disaster waiting to happen. A multibillion dollar effort began years ago to upgrade the system, but progress was so slow that the Clinton administration stopped the program and asked for a redesign. Technology had changed so much during the project that its original design no longer made sense. For example, the airlines have installed Global Position Systems (GPS) in most of their aircraft providing location data within 100 meters. Because of this kind of information plus onboard collision avoidance alarms that are available to pilots, it was necessary to rethink the entire system.

It is interesting to compare the airlines' huge investment in technology with an air traffic control system running on computers that may be older than the reader!

It is quite possible that the majority of information systems developed to date have suffered from being over budget, from going beyond their targeted completion times, and/or from not meeting their specifications. How can general management control systems development?

Some of the development techniques discussed earlier, especially the alternatives to traditional design examined in Chapter 17, help provide control. The use of a package, if carefully selected, should reduce uncertainty because we can view the package and we know code exists that has been executed before installation. In addition, prototyping should help in forecasting the kind of effort required to develop a system, and the use of fourth-generation languages can reduce programming time, given that the language meets performance requirements.

Managers can also help control development projects by attending review sessions and providing input. Projects slip for a number of reasons, including lack of user input, too few resources, too few individuals working on the project, and lack of management support. Managers who stay in close contact with the progress of a project are in a position to allocate new resources or to influence development priorities.

It is also important to be sure that the information services staff is concerned about project management. There are many programmers and analysts who view their profession as a craftlike trade. They feel that time spent managing a project is wasted and could be better spent in doing analysis or programming. Management must demonstrate that it wants projects to be controlled. One approach is to insist on the use of project management tools like the critical path method (CPM). Another is to consider the use of tools like designers' workbenches and computer-aided software engineering (CASE) tools to help manage and control projects.

CONTROL OF OPERATIONS

In addition to controlling systems development, management must be concerned about controls over the operations of systems.

- At least twice before the collapse of the Soviet Union, air defense alarms signaled the launching of Soviet missiles aimed at the United States from both land bases and submarines. The first time, officers in charge of the system suspected something was wrong with the data. In flight, the missiles supposedly appeared on only one sensor and not on others. However, the defense command remained on alert status for more than five minutes, and fighter planes were sent aloft while the data were checked.

  The monitors were wrong. Through a human error, a connection was made between an off-line computer running a simulation exercise of the firing of land- and submarine-based missiles and the on-line computer monitoring air defense at the time. Because the test did not simulate data from all sensors, the officers in command were suspicious. What would have happened if the simulation were complete? (No details were released on the second incident.)
- Near the end of 1985, a computer problem at the Bank of New York nearly halted the treasury bond market for 28 hours. The computer program had a transaction number counter that could reach as high as 32,000 items. On the day of the failure, the number of transactions exceeded 32,000 for the first time. The computer then stored each record on top of the last one, losing data and corrupting the database.

  This control failure rippled through the financial system. Because the Bank of New York did not know its position, it could not demand payment from customers to settle trades. The bank had to borrow the cost of carrying the securities from the Federal Reserve and asked for $20 billion overnight. The interest on this loan was $4 million per day!

fectively. Is the network operating system reliable and secure? Can outsiders gain unauthorized access to company systems through the Internet?

Since other banks were expecting to pay for the bonds, they had an extra $20 billion on hand overnight, causing the federal funds' rate to plummet from 8⅜ percent to 5½ percent. When there are rumors of problems in the bond market, traders buy platinum. The price for January platinum delivery rose $12.40 per ounce on a volume of nearly 12,000 contracts, a 29-year record at the New York Mercantile Exchange.

- Programmers in a financial institution computed interest calculations on savings accounts as if there were 31 days in every month. In the five months it took to discover the error, the institution paid more than $100,000 in excess interest.
- Programmers and analysts in a large mail-order house designed a "perfect" system. It would operate only if all errors were eliminated. After installation, auditors discovered that errors were occurring at the rate of almost 50 percent. The system collapsed and had to be abandoned after an investment of approximately a quarter of a million dollars.
- A student at a major university introduced a virus, or, more correctly, a worm, into one of the major networks connecting various computers. He is thought to have exploited a little-known opening in systems software to send a program to other computers. The program replicated itself and slowed the computers to a near standstill.

These examples all represent failure of control in the organization. For a control system to work, the organization must have a model of its desired states. Often, this model is in the form of routine procedures or generally accepted accounting practices. For problems like controlling a sales representative, standards are less clear, as is our ability to influence behavior.

All levels of control in the organization are the responsibility of management. The Foreign Corrupt Practices Act makes operational control a legal as well as a normal management task. This act requires that publicly held companies devise and maintain a system of internal accounting controls sufficient to provide reasonable assurances of the following:

- Transactions are executed according to management authorization.
- Transactions are recorded as necessary to permit the preparation of financial statements according to generally accepted accounting principles.
- Records of assets are compared with existing assets at reasonable intervals, and action is taken when there are differences.

Information technology gives organizations the ability to process large numbers of transactions in an efficient manner. These same systems create significant control problems and challenges, however. With thousands of transactions processed in a short time, an error can spread through an immense number of transactions in minutes. Control failures can become costly, and firms have been forced out of business because of their inability to control information processing activities.

There are many opportunities for errors to occur in computer-based processing. Figure 23-3 is a diagram of the most difficult case: a client-server system

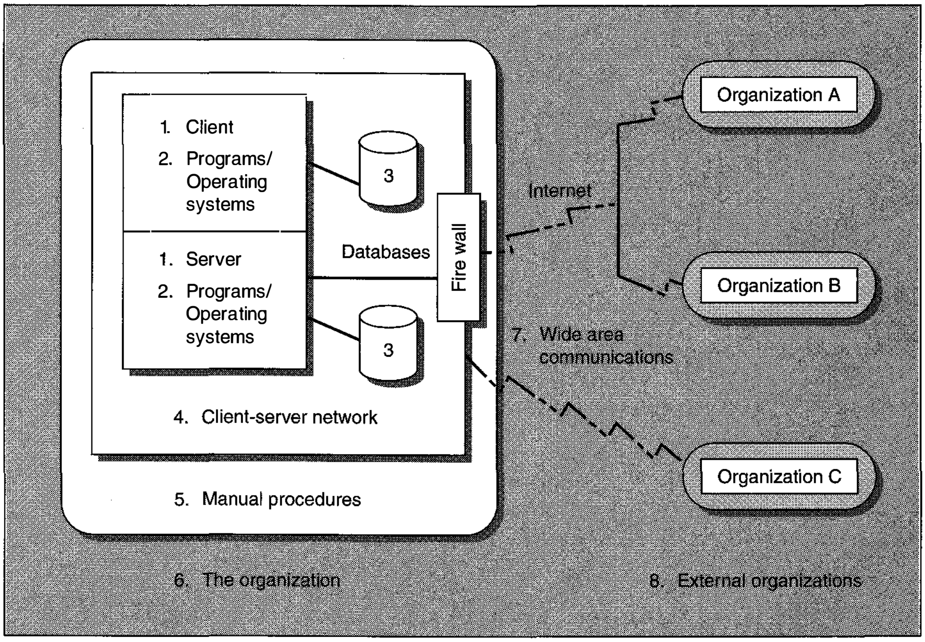


FIGURE 23-3
Components of a client-server system.

with widespread connections outside the organization. The figure highlights eight areas where the system is vulnerable.

1. The operating systems for the client and server control the operations of the computers and allocate computer resources. Operating systems can and have been penetrated. They also have errors in coding, as does any other program. Someone who is unauthorized could gain access to a network through the operating system of the server, or possibly through a client machine. An intruder would masquerade as a legitimate client in order to gain access to the server's operating system.
2. Applications programs contain the logic of business processes in the organization. These programs may have errors or may be incomplete in their editing and error checking for input and processing. The programs may execute entirely on the client computer or on some combination of the client and the server. The server might replicate an error across all the clients using a certain program.
3. Databases exist on the server, and there may be local user data on the clients. Data are often proprietary or confidential within the organization. Are the data safe from accidents? Are crucial data files on the server backed up?
4. The entire network must operate reliably if transactions are to be processed effectively. Is the network operating system reliable and secure? Can outsiders gain unauthorized access to company systems through the Internet?

5. Many applications have a number of associated manual procedures for the submission of input and the processing of output after it has been produced by the system. These procedures must be developed with adequate controls to ensure the accuracy and integrity of processing.
6. At a higher level than the individual user, the organization itself must be structured with control in mind. Management must take its responsibilities seriously and emphasize control.
7. Networks provide connectivity. Wide area communications links are subject to failure, penetration, and sabotage. This is especially true with the Internet, which opens the firm to access by millions of people.
8. Many systems are also available to external users from other organizations. These individuals may make mistakes or intentionally try to misuse a system. Controls must protect the system from these users and the users from themselves.

CONTROL AND ELECTRONIC COMMERCE

To what extent is concern over security on the Internet inhibiting electronic commerce? Some experts feel that **Web security** is a major issue, while others dismiss security as unimportant. The major issue concerns the transmission of credit card information to a merchant when you order merchandise over the Web. What are the chances of your credit card number being intercepted and misused? What are the chances that someone will figure out how to break into a computer file containing thousands or millions of credit card numbers and misuse them?

There are several responses to these questions. First, some credit card companies have said that they will not hold a customer liable for unauthorized charges on a credit card number used in electronic commerce. Their objective is to encourage electronic commerce (and the use of their credit cards).

Next, the major Web browsers support encrypted transmission of sensitive data. A server must run corresponding software so that the browser can communicate with it using encrypted data. (Encrypted data are coded in some way that is difficult for someone intercepting the message to decode without knowing the key that was used for encoding.)

Credit card companies have developed a standard for secure transmission called SET (secure electronic transmission), which offers stronger protection than the encryption currently found in browsers. There are also various firms that offer secure payment schemes including First Virtual and DigiCash. Other vendors, such as Open Market, provide servers designed especially for electronic commerce. This company has a payment scheme for the Web that makes it economical to charge very small prices for products such as the permission to use a copy of an article.

It appears that there are sufficient options to provide confidence in electronic commerce. This situation is in contrast with paper-based transactions where many people are relatively careless with the second copies of their credit card charges, eventually discarding them without tearing them in pieces. It would be far easier to find these discarded copies than to obtain your credit card number as it travels over the Web, particularly if it is encrypted in any way. The possibility of someone breaking into a server containing lists of credit cards is probably more serious, and vendors must be careful to protect such information. One company's strategy is to make the credit card information available only to internal computers and not to provide a connection to the Web.

AUDITING INFORMATION SYSTEMS

Accounting firms developed procedures for conducting an audit of information systems because so many of their typical clients' transactions are processed by computer. The auditors are most concerned about systems that affect financial statements, the balance sheet, and income statements. Auditors also render an opinion about the viability of the firm. If "mission critical" information systems are not well controlled, the future of the firm is in doubt.

The auditor examines a system as a whole, focusing on controls and their effectiveness. Typically the auditor runs programs to examine databases and transactions. These programs verify the logic used in processing. Many large organizations have internal auditors who continually examine information systems. Based on the above discussion of organizational vulnerability, it can be seen that auditing a technologically complex system is not a trivial task. Many managers are concerned about the threats posed by a system that has a major breakdown but continues processing and producing erroneous results.

MANAGEMENT PROBLEM 23-1

The T-Form organization stresses electronic communications and linking, electronic customer-supplier relationships, and strategic alliances with other organizations. In the future, firms will increasingly be interconnected, not just to send messages but also to actually provide input to each other's computers. For example, a supplier might update a customer's production control system to indicate when parts are to arrive. The supplier might even be entrusted to check the customer's system and send reorders automatically without involving a purchasing agent.

This kind of connectivity has a number of ramifications for security. Clearly you have to be able to trust the organizations with whom you establish links. A number of transactions will have their own controls. For example, if you end up with a lot of leftover parts or in-process inventory, then a supplier is not performing as expected. However, there will undoubtedly be opportunities for employees of partner firms, or even your own firm, to put you at risk of a major loss. Not only can this happen from partners, it is possible for outsiders to penetrate the network you are using for links to other organizations.

What kinds of control need to be considered by the manager who is using IT design variables to develop a T-Form organization?

MANAGEMENT ISSUES

Many of you will eventually be responsible for systems in your functional areas of business. What are the issues you will confront in this role?

- *Backup.* It is extremely important to have **backup** for systems, including off-site data storage. When terrorists bombed the World Trade Center in 1992, firms with backup data quickly set up systems in other parts of the East Coast and were back in business. Firms without backup had a much more difficult time recovering from this disaster.
- *Security.* Personal computers have created a host of **security** problems because they are so accessible. Users routinely leave diskettes containing important data lying around, and few users physically lock their computers or use start-up password-protection programs. As a manager, you will have to decide how much security is necessary to safeguard the data and systems for which you are responsible.
- *Keeping to the budget.* The appetite users have for technology seems to be insatiable. Computer sales consistently exceed manufacturers' projections. Yet, the organization cannot afford to buy all the technology users want, at least not in any one year. How will you exert budgetary control and set priorities for acquiring hardware and software, and developing new systems?
- *Project management.* As mentioned earlier, IT projects frequently lose control. If you have the ultimate responsibility for a development project, you will need to be sure the project is under control. Consider using a project management system to track and monitor progress so there will not be unpleasant surprises in place of a finished system.
- *Control over data.* The accuracy of data used in making decisions is always an important management consideration. As we develop more distributed databases, accuracy and consistency among different copies of the same data will become a critical control issue.

SECURITY ISSUES: VIRUSES, WORMS, AND OTHER CREATURES

The proliferation of personal computers and the development of communications networks gave rise to a category of programs that can only be called malicious (see Figure 23-4 for a classification of these programs). It is difficult to develop controls to thwart these programs.

On March 6, 1992, the five hundred and seventeenth anniversary of Michelangelo's birth, a virus bearing his name damaged software on PCs. The virus randomly overwrote the computers' hard disks. It was estimated that some 65,000 computers were infected with the virus. It is not clear how many viruses there are, but a test center in Germany has identified more than 300 types that attack PCs.

As shown in Figure 23-4, not all of these malicious programs are viruses. A **Trojan horse** is hidden in a useful piece of code. Once this bit of hidden code is inside a user's computer, it becomes active in some way and executes malicious

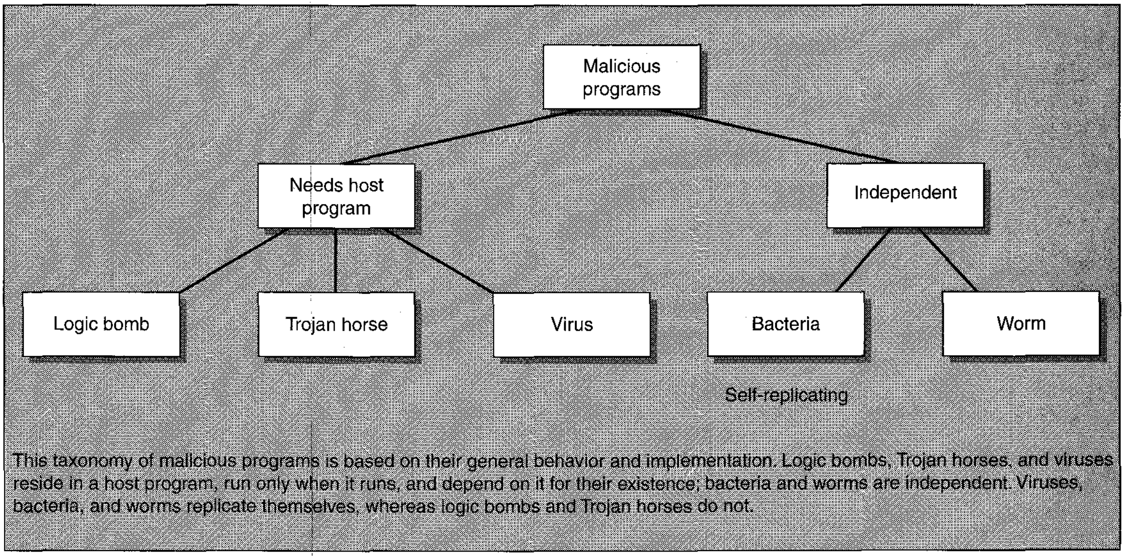


FIGURE 23-4
Taxonomy of bad code.

acts or subverts the system. One Trojan horse application subverts security in a computer so an unauthorized user can gain access to it.

A **virus** is usually a small program, say, 2 or 3 Kbytes of code. This program attaches itself to other programs and executes as the first few instructions of the host program. During replication the virus makes copies of itself, but does not harm the system. In its active phase, it changes character and generally damages the computer in some way.

Most viruses leave a string of characters to show that a program is infected. Usually the virus replicates by randomly selecting an executable file. It looks to see if the character string is present. If it is, the file is already infected. If not, the virus infects this file by inserting itself into the program contained in the executable file. The virus tries to infect as many program files as possible, since it can cause damage only when an infected program is run. Usually the virus has a triggering condition, like the date or the number of times the program has been run. If it is not triggered, the virus remains in the program. When triggered, of course, it does its damage to the system. A number of programs are available to detect viruses and to disinfect systems.

In 1995, a new type of virus appeared, one attached as a macro (piece of executable code) to documents in Microsoft Word. Prior viruses were always found in executable code. This new Concept virus exists in documents as well as code. In addition, most present security systems will not be able to detect this virus since it travels on documents and through e-mail.

Controlling Financial Risk

Financial institutions and their customers have to be concerned with the control of risks. Individuals trading financial instruments can create significant exposure for their employers. The following is a list of traders and some problems they created:

The combined total of all these "problems" is over $3.5 billion in losses for the companies involved! Barings Bank had to merge with a Dutch company, which dismissed the senior management of the bank. General Electric sold Kidder Peabody, partially because of the trading losses above, and the head of Daiwa Bank resigned after its loss became public.

In addition a number of client companies are suing banks for losses they incurred trading derivatives. A derivative is a complex financial instrument whose value is linked to, or derived from, an underlying asset. This asset might be a stock or bond, a foreign currency, or a commodity, to name a few.

Banks and brokerage firms are working to install systems to value complex derivatives, both to help them determine the prices of these instruments and to help control risk. Management wants to know the extent to which the firm is vulnerable if certain events happen, for example, an increase in the prime rate or the devaluation of a foreign currency.

Name	Loss	Employer	Explanation
Bing Sung	$162 million (problem in 1996, reported in 1998)	RhumbLine (Boston Investment Advisor) (1998)	Charged with unauthorized options trading for the pension funds of AT&T and the state of Massachusetts.
Yasuo Hamanaka	$2.6 million	Sumitomo Corp. (1998)	Off-the-book copper trading and inventing fictitious deals to hide losses; pleaded guilty with prosecutors seeking 10-year sentence.
Toshihide Iguchi	$1.1 billion	Daiwa Bank (1995)	For 11 years hid bond trading losses trying to make up an original $200,000 loss.

IBM has proposed a product called Immune System that uses several virus detection tools, including a neural network program, which is installed on a network that an organization wants to monitor. When the program detects a suspicious file, it sends a sample to IBM's T.J. Watson Research Center. There, dedicated computers examine the virus and devise a way to destroy it. The Watson computers inject the virus into a test program and then analyze the results. Then the software matches the virus against profiles of known viruses and finds a suitable antidote. Finally, the software sends the virus's profile and a cure back to the original network.

A program with a **logic bomb** "explodes" when some event triggers it. This explosion usually destroys the host computer's files. The logic bomb gets into the computer through a Trojan horse or by a virus. Logic bombs are the favorite tool

Controlling Financial Risk—Continued

Name	Loss	Employer	Explanation
Nicholas Leeson	$1.4 billion	Barings P.L.C. (1995)	Had control of trading records as well as doing trades; used futures contracts to bet on a rise in Japanese stocks. Barings P.L.C. was forced to merge; Leeson was sentenced to 6.5 years in Singapore.
Joseph Jett	$350 million	Kidder, Peabody (1994)	Fooled the accounting system into crediting him with $350 million in profits from fictitious trades, while real trading lost $100 million—he denies wrongdoing.
Victor Gomez	$70 million	Chemical Bank (1994)	Trader over-reached authority in trading Mexican pesos; loss occurred after devaluation of the peso.
Howard Rubin	$377 million	Merrill Lynch (1987)	Ignored instructions and took a risky position of $500 million in mortgage-backed securities.
Paul Mozer	$290 million	Salomon Brothers (1991)	Ignored new rules limiting the amount of securities a single dealer could buy at Treasury auctions by submitting false orders in the names of clients; served four months in jail, and chairman of firm resigned.

of disgruntled employees who want to get back at their employers. Logic bombs can also be used for ransom. The person planting the bomb will reveal its location if the organization meets his or her demands.

A **worm** travels through a network from one computer to another. If the computer containing a worm is on a network, the worm searches for other computers that are connected. Finding a victim, the worm establishes a communications link and downloads itself to the new computer. Although the worm may do no overt damage, it can quickly overload a network. The only known remedy is to shut down the network, expunge the worms, and restart the network.

Some people consider **bacteria** to be a virus, but bacteria do not require a host program to infect a system. A bacterium program replicates itself. It acquires as

Robbing Citicorp (Now Citigroup)

One day a trader at a company in Buenos Aires was startled by information on his computer screen showing that company funds were being transferred from Argentina through Citicorp (now Citigroup) computers to an account in San Francisco. The trader knew the transfers were unauthorized. He was witnessing an international plot designed to loot Citicorp's customers around the world.

Citicorp had known something was wrong and had called in the FBI. The trader in Argentina notified the bank, and this lead gave the investigators the break they needed to track down the suspects. With the help of Russian police, the trail led to a computer operator in St. Petersburg, Russia.

Citicorp was extremely concerned; it transfers $500 billion a day. Fast action by governments and banks limited the scheme to accessing $12 million in customer accounts and to actual losses of only $400,000. The investigation led to arrests in the Netherlands, Tel Aviv, San Francisco, New York, and Britain in addition to Russia.

Citicorp maintains this is the first time its systems have been breached; it has upgraded security even further after the suspects broke into the system 40 times over five months. The Russian suspect managed to break into Citicorp's computers masquerading as a customer and then transferred money to accounts opened by confederates who began to withdraw the funds. Citicorp does not know or will not reveal how the suspect managed to gain access.

This example, though rare, illustrates the problem of securing systems that process high volumes of payments or perform other critical tasks.

much computer time as possible and in doing so, slows down the host system. The bacterium program may also try to fill up disk space. The Christmas bacteria got into a university network called Bitnet a few years ago. It displayed a Christmas tree on the infected machine and used the mail distribution system to send a copy of itself to every user currently connected to the network. The bacterium program grew geometrically and quickly slowed the network to a crawl. Again, the solution was to shut down the network and find and purge each copy of the program.

Our defenses against malicious programs are weak, particularly in a university environment where we want systems to be easy to use and available to all members of the community. Passwords on systems are the major defense against unauthorized access. There are also programs that can be run on Unix systems to check for places where the system is vulnerable to penetration. As mentioned above, there are virus-detection programs that can be run periodically to check for system intruders.

On a stand-alone computer, you have a better chance of avoiding infection. If you are very careful about the source of programs or data you add to your system and run a virus checking program (known as practicing "safe computing"), you can probably avoid contracting a virus. On a network, we are all more vulnerable. The best insurance is to maintain a backup copy of crucial programs and data that are not accessible during normal computer operations.

CHAPTER SUMMARY

1. At the highest level, management control over technology deals with planning, organizing, and monitoring information processing.
2. At this highest level, management establishes plans and policies, assesses the technology, and looks for ways to apply information processing creatively.
3. Coordination across the corporation is one major control problem for senior management.
4. Middle-level managers in various divisions and locations share many of the same problems as top management. These local managers need to devise organizational structures and management policy for information processing in the areas for which they are responsible.
5. Both groups of managers also must relate to information processing managers. In some corporations, there will be a chief information officer (CIO) to provide coordination and help local management obtain more from its investment in computing.
6. All levels of management are responsible for operational controls, although usually the details will be left to middle and lower management in the firm.
7. Information processing systems process vital transactions for the firm. They must have adequate built-in controls. There are many places where things can go wrong in processing.
8. The information services department must have control over the ongoing operation of systems.
9. Management issues for controlling IT include backup, security, keeping within the budget, and project management.
10. As an individual and as a manager, you need to be concerned about malicious programs that can damage computers, networks, and, ultimately, the organization.

IMPLICATIONS FOR MANAGEMENT

Control is not a very exciting subject, yet it is important for managers to see that the organization is well controlled. You have a trade-off here between excessive control and the risk that some disaster will befall the firm. You can use technology to help control the company as Mrs. Fields did, but at some point you have to trust your employees. As your company becomes more dependent on technology, and more networked, the firm can be exposed to various kinds of electronic threats. In addition to managerial control, you also have to worry about control of the technology.

KEY WORDS

Backup
Bacteria
Logic bomb
Security

Trojan horse
Virus
Web security
Worm

RECOMMENDED READING

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Lederer, A.; and J. Prasad. "Nine Management Guidelines for Better Cost Estimating," *Communications of the ACM.* 35, no. 2 (February 1992), pp. 50–59. (This paper discusses cost estimating, an important part of controlling projects.)

Meinel, C., "How Hackers Break In . . . and How They Are Caught," *Scientific American.* October 1998. (The first article of several in this issue about computer break-ins and security.)

Weber, R. *Information Systems Control and Audit,* Upper Saddle River, NJ: Prentice-Hall, 1999. (An excellent text on audit and control.)

DISCUSSION QUESTIONS

1. What are senior management's problems in controlling information processing?
2. Why should users worry about a virus?
3. How can users avoid getting a virus on their PCs?
4. What is the difference between a virus and a worm?
5. Why is control over systems important for users?
6. What are the issues in managing and controlling data, given today's trends in technology?
7. Will controls ever completely protect systems?
8. What are the major control systems that exist in most organizations?
9. What are a manager's concerns with respect to a budget for IT activities in his or her department?
10. What kind of backup plan would you recommend for fellow students?
11. What are the threats to an interorganizational system?
12. To what extent do security concerns inhibit electronic commerce? What are some solutions?
13. Have computer systems made fraud easier? Do you think that more or less can be embezzled from a computer system than from a manual system?
14. Is there any way to detect fraud if there is widespread collusion among IS personnel and management?
15. Why do you think viruses are created and spread?
16. What problems can viruses cause a PC user?
17. What kind of file backup procedures are needed in the average organization?
18. Can a worm hurt a LAN that operates only within a company?
19. Why audit a system?
20. Why do companies create "fire walls" between their systems and the Internet?
21. Can an information system be overcontrolled? What might happen under such conditions?
22. Describe how a virus actually works. What kind of files does it want to infect?

23. What do you think of computer "break-ins?" Are they harmless pranks, or do they cause serious damage?
24. What devices does management have to control the organization?
25. How does organizational structure influence control?
26. How do budgets exert control?

CHAPTER 23 PROJECT

Organizational Control

In 1995, Barings Bank in London went out of business because of a trader in Singapore who made a large number of risky, unauthorized trades; that is, the individual lost money and then continued to trade beyond the trading limits set by the firm. The trader was evidently convinced he could "make up" the losses by more trading. Unfortunately, more trading led to more losses until someone finally noticed the problem. Barings, a venerable British bank, was purchased by a Dutch financial institution that replaced all of Barings' senior officers. See the box on page 644 in this chapter.

Since these events, "risk exposure" systems have become popular. First, describe the organizational control problem faced by a securities firm. Then consider to what risks the firm is exposed. Finally, develop a high-level design for a system to monitor those risks and report to management. What kind of control does your plan represent? How can information technology help management reduce risk?

CHAPTER 24

Information Technology Issues for Management

Outline

Focus on Change

We have discussed how various firms use IT to transform themselves and their industries. The key to making this happen is management. Management must lead the IT effort and see that technology is used to make the kind of changes that will keep the firm competitive in the future. An important message for management is to view information technology as a resource to be used in managing the organization. Rather than seeing IT as an expense to be minimized, consider how technology can be used as a part of strategy to change existing businesses and to undertake new initiatives. Information technology has become an integral part of the way organizations function. Success in the future may well depend on how well the organization manages information technology.

MANAGEMENT IN A TECHNOLOGICAL ENVIRONMENT

No matter what their functional area, managers today and in the future will face a highly technological environment. The costs of processing logic and communications networks are so low, and the potential of this technology so high, that the proliferation of technologies will continue to accelerate. How will we manage under this increased level of technology? What are the management challenges?

What Do CEOs Think?

CEOs, according to surveys, want their IS departments to produce fast and flexible systems that impress customers and increase markets. The majority of CEOs report using a PC and almost 50 percent of companies do some outsourcing for IT services, the major reason being cost savings. Unfortunately, about half of the CEOs and CFOs surveyed said they are not getting an adequate return from their investments in IT. This level of dissatisfaction is a serious problem given the huge amounts of capital invested in technology. What can management do to improve the effectiveness of the technology effort?

A Political Model of Information Technology

Table 24-1 describes a political model of information technology in the organization (Davenport et al., 1992).

Firms characterized by **technocratic utopianism** are fascinated with the technology. There is an assumption in the firm that technology will solve all problems. The firm will develop databases, desktop workstations, and networks, and purchase large amounts of software. This organization often lacks a vision of how all of this technology will be used to further its objectives.

Anarchy results when technology is not managed. Management abrogates its responsibilities to control IT and "lets a thousand flowers bloom." This strategy may encourage the bold to acquire computers and connect them, but as the firm matures, the lack of overall planning and standards will create tremendous problems. Many firms practiced this style of management in the early days of PCs, letting users purchase whatever equipment they pleased. As a result, these firms found it very difficult and expensive to connect their diverse computers to a network.

In the *feudal* model, powerful executives control technology within their divisions and departments. These executives determine what information to collect and choose the technology for their fiefdoms. They also make the decision on

TABLE 24-1

INFORMATION POLITICS

Technocratic utopianism	Reliance on technology; model the firm's IT structure and rely on new technologies
Anarchy	No overall information management policy
Feudalism	Management of IT by individual business units; limited reporting to the corporation
Monarchy	Strong control by senior management; information may not be shared with lower levels of the firm
Federalism	Management through consensus and negotiation about key IT decisions and structures

what information to forward to higher levels of management. This model is most often found when the firm stresses divisional autonomy. Because it is unlikely that two chiefs will follow the same model, again it can be very difficult to coordinate different feudal systems if senior management decides that coordination is a more appropriate technology strategy.

In a **monarchy,** the CIO becomes the CIC, the chief information czar. Instead of playing the consultant role, the CIO establishes and enforces standards that will be followed throughout the corporation. The monarchy often emerges when the firm finds that it has suffered too long from the feudal model. A possible halfway point between **feudalism** and a monarchy is a *constitutional monarchy,* in which a document sets out the powers reserved to senior management and those that fall to the divisions.

In today's environment, the **federal model** may be the most appropriate. The firm tries to reach a consensus on which IT decisions belong at each level and how information should be shared. The emphasis is on which policies make the most sense for the corporation as a whole, not just for a specific department or division. Senior management recognizes that local divisions need some autonomy; local managers recognize that information belongs to the company and may often be of great strategic value.

In most cases, it makes sense for infrastructure like networks to be designed and operated centrally. If there are many opportunities to share systems across divisions, corporate management will encourage a strong role for a central IS group. Also, if the divisions have line managers who have little knowledge of IT, a central group has a major role to play in helping the divisions. In the case of very dissimilar divisions where there is little opportunity for sharing, we would expect to see the local unit have a lot of responsibility for IT decision making. A central IT group will provide some coordination, but most decisions will be left to local managers. This decentralization will be more pronounced if local managers are very knowledgeable about information technology.

A Job and a Career

The information technology industry is helping to drive the American economy; technology stocks have been responsible for a steady, dramatic increase in the stock market. One expert estimated that technology is responsible for 5 percent of the Gross Domestic Product in the U.S. Jobs in this area are growing rapidly as well. Manufacturing firms are busy downsizing while entrepreneurial companies are adding employees.

A good example is United HealthCare (UHC), a $2.5 billion Minnesota healthcare company. UHC does not employ physicians or own the hospitals in its net. The company facilitates relationships among health care providers, insurers, and patients; its objective is to achieve the highest possible care at the lowest cost. One officer described the firm as a "brokerage service" and a "technology company."

A major system interconnects almost 25,000 independent physicians and UHC facilities in North America. The company has won a patent for applying AI techniques to monitoring clinical databases. The company is in the throes of designing a new architecture for client-server computing with distributed Unix-based applications. The company is steadily expanding and adding workers.

Other technology companies are experiencing similar growth; knowledge of IT can add a great deal to your resume when you are looking for a job!

The Chief Information Officer

The increased importance of IT to the firm has led to the creation of a **chief information officer (CIO)** position. This individual, of course, is in charge of information technology in the firm. However, the chief information officer is also an influential member of senior management and is usually a vice president or senior vice president in the firm. In addition to traditional information processing, this individual is responsible for voice and data communications and office technology. The job demands someone who can assume a role in planning, influencing other senior managers, and organizing information activities in the organization.

The issues discussed in this text are the concerns of the CIO. He or she must worry about strategic planning for the corporation and how information technology can provide a competitive edge. The executive in this role must provide leadership and control over processing. It is important that planning, systems development, and operations are all undertaken successfully.

The CIO is a relatively new position in organizations, but more and more firms are expected to create such a post. A large firm might spend in the hundreds of millions or even more than a billion dollars a year on information technology. A manager, not a technician, is needed to obtain a return from this kind of investment.

Earl and Feeny (1994) describe ways in which CIOs should try to add value to their organizations. They found two types of CEOs, those who see IT as a strategic

TABLE 24-2

PERCEPTIONS OF *IT*

Issue	IT, a Cost/Liability	IT, an Asset
Are we getting value for money invested in IT?	ROI on IT is difficult to measure; the organization as a whole is unhappy with IT.	ROI is difficult to measure; the organization believes IT makes an important contribution.
How important is IT?	Stories of strategic IT use are dismissed as irrelevant to this business.	Stories of strategic IT use are instructive.
How do we plan for IT?	IT plans are made by specialists or missionary zealots.	IT thinking is subsumed within business thinking.
Is the IS function doing a good job?	There is general cynicism about the track record of IS.	The performance of IS is no longer an agenda item.
What is the IT strategy?	Many IT applications are under development.	IS efforts are focused on a few key initiatives.
What is the CEO's vision for the role of IT?	The CEO sees a limited role for IT within the business.	The CEO sees IT as having a role in the transformation of the business.
What do we expect of the CIO?	The CIO is positioned as a specialist functional manager.	The CIO is valued as a contributor to business thinking and business operations.

Source: Earl and Feeny, 1994.

resource and those who see it as a cost. Table 24-2 presents various issues in managing IT as seen by CEOs in these different positions.

If you are the CIO of a firm whose CEO holds the views in the middle, liability column, then the job will indeed be challenging. Earl and Feeny argue that the CIO must find a way to add value to the corporation from its use of IT so the CEO will view IT as an asset.

One role of the CIO is to determine if success stories from other industries or from competitors are relevant to the company. In one chemical company, managers dismissed stories of competitive advantage from IT saying they were not applicable in their industry. Unfortunately, at the same time a competitor was developing technology that gave it a competitive advantage.

It appears the most successful approach to obtaining benefits from IT is not to identify *separate* IT and business strategies; rather, business strategy subsumes IT strategy. The job of the CIO is to build relationships with other functional managers so IT requirements become a part of business strategy. This approach means the CIO has to be involved in planning and strategy meetings across the company.

To provide confidence in technology, the CIO must build a track record of delivering IT as promised, on time and within budget. Users quickly become cynical when delivery dates, cost estimates, and functional specifications do not meet expectations.

TABLE 24-3

ADDED VALUE OF THE CIO

1. Obsessive and continuous focus on business imperatives.
2. Interpretation of external IT success stories as potential models for the firm.
3. Establishment and maintenance of IS executive relationships.
4. Establishment and communication of IS performance record.
5. Concentration of the IS development effort.
6. Achievement of a shared and challenging vision of the role of IT.

Source: Earl and Feeny, 1994.

Rather than scattering the development effort, a well-run company focuses its IT efforts on opportunities and areas where the firm is weak. The task of the CIO here is to determine not how to use IT, but rather where it should be used to most benefit the organization.

The CIO has to be a promoter, marketing the potential of IT to transform the organization. A track record of delivering what has been promised will increase this manager's credibility as will good examples of organizations that have undergone technology-driven transformations.

Table 24-3 summarizes the characteristics Earl and Feeny found among CIOs for firms that considered IT to be an asset rather than a liability. This table shows how the CIO can add value to the organization.

The CIO of Time Warner spoke at a recent NYU class about his role in the company, and his comments provide further insights on adding value. According to this CIO, he adds value by finding new business opportunities for the company and using technology to conduct business in new ways. The company manages IT in a federal structure so he takes responsibility for infrastructure like a worldwide network. IT managers in each division develop systems for their divisions and worry about the day-to-day operation of their systems.

A central IS group is likely to function in several capacities, as these examples illustrate. First, it will be a brokerage for applications packages. In some cases it will choose a standard, for an office suite for PC applications or a groupware product. It may also encourage the organization to adopt one enterprise software package such as the ones offered by Baan, SAP, PeopleSoft, or Oracle. The central group may also act as a systems integrator, making the hardware and software systems from different vendors work together. The role of the CIO will differ among companies, but first and foremost this person has to be a manager concerned with the business as well as someone who understands information technology.

The Corporate IS Department

Many organizations have a corporate information services department and separate IS departments at different physical locations. What are the responsibilities of such a department? First, it is staffed with operations, maintenance, and development personnel. The operations group is responsible for the ongoing operation of the infrastructure, including computers and communications networks. They run "production" jobs that process transactions and produce financial reports. This group installs new computers, expands networks, and keeps software up to date. We have discussed systems development and the tasks of developers. Maintenance staff members make changes to existing applications to enhance them, and they repair errors that appear in programs.

There has been a shift in the activities of the corporate IS department over time as the technology has moved from a focus on mainframes to the desktop. Originally, the corporate group controlled almost all of the firm's IT budget. Today they may be responsible for 50 percent or less of technology investment as other managers purchase technology from their budgets. Most organizations are content to have a central group provide and maintain infrastructure, the underlying network of computers and communications networks, for the firm. The role of a central group in developing applications of technology varies among organizations as discussed earlier in the chapter. A firm can decentralize and leave applications development to users, it may centralize this activity, or it may adopt a combination approach in which the central group consults with users who undertake their own development projects.

A Vision and Plan for IT

One task of a CIO is to be sure there is a vision in the firm for what IT can accomplish and a plan to provide a guideline for management decisions about technology. A vision is a general statement of what the organization is trying to become. A vision might describe, possibly in scenario form, the environment seen by a user. "We will use information technology to support our strategies of providing the best customer service in the industry and becoming a global firm. Our first priority is to develop electronic links with customers and suppliers. Next, product brand managers will be furnished with a client workstation that can access the sales database. They will be provided with decision-support tools to conduct their own analyses of global data. Product development engineers will have workstations capable of running the CAD/CAM software . . ." A vision might include a statement about the kind of technology architecture the firm hopes to provide, say, a client-server environment and a global network for communications. The vision needs to be sufficiently compelling that it creates enthusiasm for the plan to achieve it.

In Chapter 5, we suggested that it was important for IT strategy to be subsumed as a part of overall business strategy. Corporate and IT strategic planning should be part of one planning effort. The IT plan expands the IT component of the strategic business plan and describes how to execute the agreed-upon strategy. This plan must combine the vision of IT with strategy to produce a document that guides IT decision making. Suppose the overall strategy of the company is to become the low-cost producer in its industry. This strategy is to be achieved by reengineering existing processes and installing automated production equipment in manufacturing plants. The vision of the firm in five years is to have process owners in charge of business processes that have extensive technology support. The overall architecture is client-server, with a network connecting all plants and office locations. In addition, to pursue its low-cost producer strategy, the company will establish electronic links with key customers and suppliers.

Thus, the vision and strategy provide the goals for an IT plan that will describe how to achieve them. This more operational plan will depend on the company and its strategy, but in general it will discuss hardware and software, communications, and individual applications. Continuing the example above, the plan would detail the equipment needed to move toward the client-server model and a schedule for implementation. This section would also discuss networking, including the hardware and services required to provide communications.

A key role of the plan is to identify the most important new applications of technology and prioritize them. It is important to focus efforts on applications that contribute to achieving the vision and strategy of the company. For the example above, do not be too concerned about routine applications. Management will probably decide resources should be applied to one or two reengineering projects and an effort to develop EDI with customers and suppliers. The plan would describe each of these projects in some detail including cost, time, and staff requirements for completion. If management decides it wants to undertake more applications than there is staff available, some of the development will have to be outsourced.

Having a plan makes managing IT requests easier for the CIO and for management in general. The rapid diffusion of technology has led to a flood of ideas and requests for how to use IT. The typical organization cannot afford to undertake every application suggested. A manager can evaluate applications against the plan. Does this suggestion help us achieve our vision and strategy? Where does it fall given the priorities of our other projects? A well-prepared plan can create enthusiasm for IT, focus the technology effort on business imperatives as suggested above, and help manage and evaluate technology. The plan is a fundamental management tool for seeing that IT makes the maximum contribution to the organization. Table 24-4 is an example of the contents of one corporate plan for information technology.

We recommend that a representative group of managers work together to develop a plan for information technology and the organization. A plan developed by a CIO alone will probably not be acceptable to other managers. The CIO should act as a resource, consultant, and tutor for the planning committee. The idea is for technology not to be a separate plan, but to be integrated, and to some extent subsumed, in a corporate plan.

Bad Trips

In 1993 Greyhound was under a great deal of pressure to show progress to financial analysts. Senior executives had promised investors, lenders, and securities analysts that Trips, a computerized reservations system for bus travel, would be ready for the 1993 summer travel season. The vice president in charge of Trips tried to warn the company's chief financial officer that a gradual rollout was necessary given problems on a test run of the system in four cities in Texas. Management would not listen. In fact, the vice president's report was destroyed, and its mention purged from computer files.

In April, senior executives flew to Europe to promote a stock offering that was based on the promise of Trips. Greyhound rolled out the system that summer, and as the vice president in charge predicted, it was a disaster.

In the old days, Greyhound allocated buses and drivers with data that was months old. It needed quick, reliable ridership data to determine how to set prices and how to allocate buses to routes. Margins were very thin, and the company could not afford to send almost empty buses on trips. Unfortunately, a bus reservations system is more complicated than it sounds because of the number of possible stops. An airplane passenger flying from Baltimore to Los Angeles might make one stop, but the bus passenger on that route could make 10 or more stops. A bus reservations system must account for many more segments than an airline system does. Systems analysts estimated Trips would have to manage 1800 vehicle stops a day, about 10 times those of an average airline. Because of heavy cost cutting, there was high turnover. Personnel using the system would probably have little experience with the company and only have a high school education.

Greyhound gave the 40-person Trips development group $6 million and a little over a year to develop a system. Contrast this to American's SABRE system which has been developed over 30 years by a large staff and probably represents an investment of over a billion dollars. An outside contractor developed the original software. Learning to use it took 40 hours of training for ticket clerks. The system did not include all Greyhound destinations, so clerks had to fall back to old log books at times. In tests, the new system took twice as long to generate a ticket as the old system.

The systems group wanted to redesign the software, but was pressured by management to press on. When the system had been installed at 50 bus terminals, it froze terminals unpredictably. At the same time,

TABLE 24-4

CONTENTS OF AN INFORMATION SYSTEMS PLAN

- Executive summary
- Goals—general and specific
- Assumptions
- Scenario—information processing environment
- Applications areas—status, cost, schedule, priorities
- Operations
- Maintenance and enhancements
- Organizational structure—pattern of computing
- Effect of plan on the organization—financial impact
- Implementation—risks, obstacles

Bad Trips—Continued

Greyhound decided to change its long-distance phone service provider and set up a toll-free number for reservations for the first time. The reservations center opened with 220 terminals connected to Trips. The combination of the bus terminals and 400 operators in Omaha taking reservations seriously degraded the performance of the central Trips computers in Dallas. Some days the system took 45 seconds to respond to a single keystroke and five minutes to print a ticket. Crashes occurred so often that many agents wrote tickets by hand. Passengers standing in line at bus terminals to get computer-issued tickets often missed connections. Callers had to try up to a dozen times to get through to the toll-free reservations line. The slow system meant that operators had to spend 150 seconds on average on a call compared to 109 seconds before the system. By early September, Greyhound stopped using Trips west of the Mississippi River.

At the end of the summer, Greyhound announced a 12 percent decrease in ridership and that earnings would trail projections, causing its stock to plunge 24 percent in value in a single day. The vice president in charge of Trips was relieved of this responsibility. A new vice president was assigned to Trips, and he was forced to resign in January of 1994. Executives now admit that by introducing the ill-fated reservations system at the busiest time of the year, they drove away passengers instead of attracting them.

The company failed to learn much from the summer of 1993. In May of 1994 it offered riders the chance to go anywhere for $68 with a 3-day advanced purchase. Thousands of customers responded, and Trips went down. Buses and drivers were in short supply, and some bus terminals were so swamped that agents just stopped selling tickets. By the fall of 1994, the chief executive and CFO of Greyhound were forced to resign. A new executive from American Airlines is now in charge of Trips; it is working in 248 locations and beginning to provide planning data for the first time. Training time to use the system has been reduced from 40 to 16 hours, but even the new manager in charge of Trips reports trouble when he tries to use its cumbersome interface.

Trips is a sad tale of bad technology decisions, but first and foremost, bad management decisions made by people who did not understand the limits and problems of technology. More discouraging is the fact that these senior managers did not try to learn from and did not listen to warnings from people in a position to know the risks.

Outsourcing as a Strategy

Outsourcing involves turning over responsibility for some part of a firm's technology effort to an external company. We discussed this option earlier in Part Four when we looked at the problem of selecting alternatives for processing. In addition to obtaining services like systems integration for developing a specific application, a firm can outsource all or part of its IT effort. For example, a large brokerage firm outsourced the operation of part of its communications function to a common carrier. The brokerage firm did not want to maintain the internal expertise to operate and continually update the configuration of the network.

MANAGEMENT PROBLEM 24-1

The Chairman of Raffles in Singapore, in addition to being concerned about the structure of the organization, wonders about the role of a CIO and how to deliver information technology across the company's subsidiaries. The CIO needs to be a manager and a leader, but how much does he or she have to know about technology? What advice can you give Tek Meng Neo on this question? How much technical knowledge should he look for in a CIO?

Given that the firm creates and fills a CIO position, how much control, Neo wonders, should this person have? "I want to be sure that we take advantage of commonalities, yet our businesses are all quite different. If we are contemplating a new organizational structure with more responsibility delegated to lower levels of the firm, isn't it inconsistent to provide central control over technology decisions?" What structure for information technology would you recommend to Neo? Right now, the company would fit the "feudal" model, with each subsidiary responsible for its own IT. How much coordination should a CIO try to provide? For what technological and management issues should the CIO provide leadership?

Loh and Venkatraman (1992) have identified some of the factors that lead a firm to outsource:

- A firm that feels it is spending more on technology than it should (or more than the competition) may adopt outsourcing if it feels this option provides a lower-cost alternative than internal management. Even if the firm does not feel at a disadvantage compared to others, it may see outsourcing as a way to reduce IT-related costs in general. Several firms claim cost savings by turning their IT function over to an external firm. Another possibility is that large outsourcing agreements are motivated by companies' trying to return to profitability by cutting employment. (A company outsourcing all its IT operations generally gets an immediate cash inflow when it sells equipment to the outsourcer, and the outsourcer usually hires a large percentage of the company's staff, reducing its salary expense.)
- A firm with a high-debt structure may not wish to invest in technology. It may view outsourcing as a way to lease technology instead of buying it.
- An organization may feel its IT function is not performing adequately. Outsourcing can be a way to arrange for a more professional and better performing IT operation in the company.

Turner and Kambil (1993) have added to this list:

- An organization has decided to return to its core competencies. Managing IT is not one of these, so it outsources this task to another firm.

- The organization is interested in technology transfer from the expert outsourcing firm. It will learn from the outsourcer. Xerox outsourced the operation of its legacy mainframe systems to EDS in order to concentrate on developing new client-server applications.
- A firm may outsource "commodity" processing to free its staff to develop new applications of technology.

How can outsourcing accomplish these objectives? The outsourcing firm must have a high level of expertise in technology. This firm should also be able to create economies of scale. For example, the telecommunications outsourcer can probably provide network services for a number of clients with a smaller staff than the sum of the networking staffs of its clients.

What are the arguments against outsourcing? The outsourcing firm may have a high-cost structure because of its need to employ highly skilled personnel. The need to have a contract with the outsourcing firm can lead to conflict and misunderstandings. Some companies are surprised at the cost of using an outsourcing firm to develop applications.

Probably the biggest deterrent to outsourcing is the question of control. If you regard technology as a competitive factor in business, you may be reluctant to turn control of it over to an outside firm. The brokerage firm described earlier examined the option of outsourcing all of its technology effort, but decided that only one part of it was not sufficiently strategic to be outsourced.

Lacity and Hirschheim (1993) studied a number of firms that outsourced. Their criticism of outsourcing provides a cautionary note. Their study identified two myths of outsourcing.

Myth 1: Outsourcing vendors are strategic partners.

The outsourcing vendor cannot be a partner because the outsourcer's profit motive is not shared by the customer. The outsourcer makes more money if it is able to charge the customer higher fees. If the outsourcer can reduce service levels and collect the same fees, that also contributes to its profit margins. You might want to consider some kind of a cost-reduction sharing arrangement with an outsourcer so that both the services firm and the client benefit from more efficient operations.

Myth 2: Outsourcing vendors are inherently more efficient than an internal IS department.

The outsourcer's argument here is that economies of scale help it to be more efficient. Today hardware costs do not favor huge installations. As we have seen, the cost/performance ratio for smaller computers is better than for mainframes. It is possible that the outsourcer can do some tasks more efficiently because it has done them before or because it can afford to share highly paid specialists among a number of clients.

An outsourcing agreement will probably extend for a number of years in order to justify the transition effort involved. All experts in this field suggest that developing a contract between the outsourcer and the client is crucial. Since an agreement may be for five or ten years, the contract must be highly flexible. Business conditions and technology are expected to change during the life of the agreement. General Dynamics, which has an outsourcing agreement with Computer Sciences Corporation, is reported to have eight contracts covering divisions that may each evolve in a different way (McFarlan and Nolan, 1995).

After entering a relationship with an outsourcer, the company still has to manage information technology! You will still need the equivalent of a CIO to manage the partnership and contract with the outsourcer. Xerox reportedly has a dozen people managing its $3 billion, 10-year contract with EDS. The client still must look at emerging technologies and plan for its technology architecture. Creative applications are most likely to come from users rather than the outsourcer, and there must be mechanisms for turning ideas into new applications of the technology. Outsourcing can be an excellent alternative for some companies, but you should not enter into an outsourcing arrangement with the idea that you will no longer have to manage IT.

How Much to Invest in IT

Most firms are not in the business of developing technology. They have a product or service to offer, and the technology helps them accomplish the mission of the organization. Overall in the United States, the Department of Commerce estimates that 45 percent of capital investment is for information technology. Still, managers ask how much they should invest in IT. A better question is how much benefit can the organization obtain from its investment in technology? The first question looks at IT as a cost, the second as an investment.

You will undoubtedly be asked to justify an IT investment at some point in your career. In Chapter 3 we presented the Investment Opportunities Matrix, Table 3-4, which describes different types of investments the firm might make in IT. This discussion also suggested that each investment has a different probability of producing the benefits anticipated from the IT innovation. The probability is fairly high of getting a return from an investment like Chrysler's EDI/JIT efforts; the firm is unlikely to obtain a return from producing a report required by OSHA.

Estimating Value

Chapter 16 introduced the notion of conversion effectiveness and made the point that we are not always 100 percent successful in turning an IT investment into a finished application. This reasoning suggests that the probability of successfully obtaining a return must be weighted by the probability that an IT investment will have a return and the probability of conversion success. If we assume that the probability of a return on an IT initiative based on the investment type is independent of the probability of converting the investment into a successful application, we get the following *IT Investment Equation:*

$$P(\text{Success/Return}) = P(\text{Return on Investment Type}) \times P(\text{Conversion Success}) \quad (1)$$

where P means "probability of." The IT Investment Equation says that the probability of obtaining a return on an investment in information technology equals the probability that the type of investment you are making has a return times the probability that you will be successful in converting the investment into a working IT application. Equation (1) calculates the SR index, the probability of a successful return.

A few examples will help to illustrate what the equation means. In Table 24-5 there are four columns. The first is the type of investment. The second is an estimate by management and the IT staff of the probability that there will be a return given the nature of the investment. The third column is the probability of a successful conversion of the investment into a functioning system. According to our reasoning and the IT Investment Equation, the product of these two probabilities gives the overall probability of obtaining a return from this investment.

The table illustrates how difficult it can be to obtain a return from IT investments. For a hypothetical budgeting system, management feels there is only a 50 percent chance the organization will obtain any return since the new application replaces an old budgeting system. It has a nicer interface and better reports, but managers could not honestly say the system will help them make more money. The 50 percent figure is based on the belief that there will be some labor savings. The IT staff thinks the package will be easy to implement and estimates a 100 percent chance of successful conversion. The probability then of a successful return on this investment is 0.5×1.0 or 0.5.

In the second example, management is sure from seeing the results at other companies, that an EDI/JIT system for its factories will have a significant, measurable return. They are certain enough to estimate the probability .95. The IT staff, however, is a little concerned with the scope of the project and is only willing to estimate a probability of .75 that it can implement the system so all the benefits occur. The probability of a successful return, then, is $.95 \times .75$ or .71.

TABLE 24-5

EXAMPLES OF USING THE *IT* INVESTMENT EQUATION

Type of investment	Management and IT staff estimate of probability of a return based on the type of project	Estimate of probability of successful conversion effort	Overall probability of a return: the SR Index
Budgeting system	0.5	1.0	0.5
JIT/EDI system	0.95	0.75	0.71
Infrastructure network	0.5	0.7	0.35
Package tracking system	0.2	1.0	0.2
Groupware	0.9	0.8	0.72
Web order entry	0.9	0.7	0.63
Web home pages	0	1.0	0

The rest of the table illustrates other hypothetical scenarios, an infrastructure investment, an overnight delivery firm investing in a package tracking system, order entry on the World Wide Web, and Web home pages. Note the probabilities and how each one has a substantial effect on the probability of a successful return from investing in IT. *Anything less than a probability of 1 for a return on the type of investment and a probability of 1 for conversion success dramatically reduces the probability that you will be successful in obtaining a return on an IT investment.*

Almost all IT initiatives involve some estimate of costs and benefits so that those making the decision to invest have a sense of the dollars involved. Managers are in the position of having to predict the return for specific investments in technology proposed by various actors in the organization. If we look at Table 3-4, the difficulty of making these estimates is evident.

For applications that offer a direct return, estimates, by definition, are not too difficult, particularly when compared with the case of indirect returns. It has been suggested that infrastructure investments provide you with the opportunity to undertake some initiative in the future; you are buying an option to invest again. But how much is that option worth? What is its price and where is the market for it? What is the estimated return for a system that is a competitive necessity? For technology when it is the only way to do the job?

Some experts suggest that you should look at the *cost of not investing.* What would happen to a new bank that failed to deploy ATMs? Could it remain in business? Would it end up being unable to build market share? If a valued customer says you must implement an EDI package, the cost is clear: losing the customer's business. Does that amount of business become the return on the investment in IT?

Managers usually do not think in terms of probabilities; they prefer dollar estimates. However, if there are probabilities involved, the decision maker should weight the dollar estimates with the probability of actually realizing the dollars. If a geologist tells an oil company executive that there is a 60 percent probability a field contains oil that is worth $100 million, what revenue should the executive *expect* to receive from the field? The executive's *expected value* is the probability the field has oil times the value of the oil, or .6 × $100 million, which is $60 million. In general, **expected value** is the amount expected times the probability that you will receive that amount.

In addition to estimating the probability of a return in the Investment Opportunities Matrix, most companies would try to estimate the dollar returns from investing in technology. Typically, these returns are cost savings, cost avoidance, and/or new sources of revenue. If you estimate that the EDI/JIT system in Table 24-5 will save the company $1 million in its first year, then the actual expected savings will be your estimated savings times the probability of a return times the IT staff estimate of conversion success, or $1 million × .95 × .75 = $712,500. This reasoning leads to the *IT Value Equation:*

$$\begin{aligned}\text{Expected Return} &= \text{Estimated Return} \times P(\text{Return}) \times P(\text{Conversion Success}) \qquad (2)\\ &= \text{Estimated Return} \times P(\text{Success/Return}) \text{ or}\\ &= \text{Estimated Return} \times \text{Equation 1}\end{aligned}$$

where P means probability. *The IT Value Equation shows that the expected return from an IT investment is rarely the amount estimated by those involved; it must be weighted by the probability of obtaining the return and the probability of successfully converting the investment into a working application.*

Making the Investment Decision

Table 24-6 presents information for making decisions about IT investments. This spreadsheet combines information from the Investment Opportunities Matrix, the IT Investment Equation, the IT Value Equation, and capital budgeting techniques. The table is an example of the information that management could use in making IT investment decisions. There are two capital budgeting techniques that have been used or proposed for making IT investment decisions. The first is the well-known **net present value** approach or NPV, which figures out the net present value of income and expenses using the firm's cost of capital, and compares the two to see if the result is positive or negative. A project with a positive NPV returns a value in excess of the firm's cost of capital. A second approach is to use an **options pricing model** that looks at an investment in IT as providing an option for making a future investment. This approach is new and somewhat controversial; it presents an interesting framework for thinking about IT investments.

Table 24-6 identifies IT initiatives in a hypothetical example and describes their type. (One initiative might fit into more than one type, which makes for a slightly more complicated analysis; however, the same approach applies.) The fourth column of the table is an estimated return from the project. The next two columns are probability estimates, the first being the probability that this project, given its type, will have a return. The second probability is for conversion effectiveness; what is the risk of this initiative? How likely is it that the organization can implement it successfully to meet specifications?

The S/R index comes from the IT Investment Equation: It is the product of the probability of a return and the probability of successful conversion and represents the likelihood of a successful return. The expected value comes from the IT Value Equation; it is the Estimated return × the Probability return × Probability Conversion Success (or Estimated return × S/R index).

The Capital budget model column contains the results of applying a budgeting technique to the data in the table. Note that these techniques do not necessarily apply in every instance. The rightmost column in Table 24-6 comments on the possible upside benefits of the investment.

The table contains a variety of projects for a rather diversified, hypothetical holding company. The company convenes an IT steering committee as needed; one of its tasks is to approve suggested projects. One can look at present IT investments from the budgeting system to Web home pages and the proposed IT investment for an Intranet shown in Table 24-6 as a portfolio of IT projects. Management should try to balance this portfolio on several criteria. For example, it is unlikely that one will obtain great value if all conversion probabilities are very low, or if all expected values are small. The S/R index provides an

TABLE 24-6

A DECISION WORKSHEET

Name	Type	Cost	Estimated return	Probability of return	Probability conversion success	Probability S/R	Expected value	Capital budget model	Upside
Budgeting system	Required	$ 20,000	$ 20,000	0.50	1.00	0.50	$ 10,000		None
JIT/EDI system	Direct	$300,000	$ 500,000	1.00	0.75	0.75	$375,000	$ 957,058	Expand $5 million savings
Infrastructure network	Infrastructure	$100,000	$ 75,000	0.60	0.80	0.48	$ 36,000	$ 120,678	Allow future applications
Delivery tracking	Competitive necessity	$750,000	$1,000,000	0.40	1.00	0.40	$400,000		Prevent market share loss
Groupware	Indirect	$100,000	$ 50,000	0.90	0.80	0.72	$ 36,000		Restructure firm?
Web order entry	Direct	$100,000	$ 500,000	0.90	0.70	0.63	$315,000	$1,055,929	Reduce costs $500,000
Web home pages	Competitive	$ 50,000	—	0.00	1.00	0.00	—		Experience for e-commerce
Proposed Intranet	Infrastructure	$160,000	$ 60,000	0.80	0.90	0.72	$ 43,200		Internal Intranet
								$ 144,813	Present value 5 year savings
								$ (15,187)	NPV original proposal
								$ 37,608	Options Price experiment

overall evaluation of the opportunity to create value from IT. Comparing a proposed project with the existing portfolio provides a picture of its contribution to the firm's efforts to obtain value from IT.

In the past, the steering committee made decisions on all the projects in Table 24-6 except the last one, the proposed Intranet. We review two past decisions to set the stage for discussing a new initiative for an Intranet.

The budgeting system falls into the "required" category of application. Both the company's accounting firm and its controller argued persuasively that the old budgeting system was no longer suitable. The cost of this system is rather low since the company identified a package for $10,000, and it estimated that no more than another $10,000 would be required to implement the package. The controller estimated an annual saving of $20,000 in reduced clerical costs once the package is implemented. However, she lacked confidence in her estimate given this type of investment and the required nature of the application; she estimates a 50 percent probability of a return. The IT staff was very confident that it could successfully install the system; they rate the probability of conversion success as 1. The steering committee approved the system because its cost was low and because the controller made a strong argument that such a system was required for the business.

The JIT/EDI system for one of the company's manufacturing subsidiaries required lengthy discussion because of the size of the investment. Based on visits to other companies using this approach, the IT staff felt that their company could expect to get all the estimated returns (probability of a return = 1.0); they also estimated a 75 percent probability of successful conversion. Given a project with an expected annual value of $375,000 ($500,000 × 1.0 × .75) and a $300,000 investment, there was no question about the economics of the proposal. The capital budget column shows a present value of a little under $1 million using a five-year planning horizon and a 15 percent cost of capital; the NPV is $957,058 – 300,000 or $657,058. The major issue for the steering committee was the $300,000 investment and the demands this system would place on the IT staff. A system of this size, done in-house, might preclude some other IT initiatives, or force the firm to go outside for them. The steering committee approved this proposal because of its favorable financial projections and the upside possibility of even larger savings from expanding the system in the future.

The steering committee held similar discussions about the other projects in the table, using the information provided as a basis for evaluating the projects and making a decision. How might they approach the proposed Intranet? The proposal looks very attractive compared to the projects already under way or completed. It has a high S/R index with a good probability of conversion success and of obtaining a return. The subsidiary requesting the Intranet classified it as an infrastructure expense. The subsidiary would gain from making information available throughout its operations and estimated that it could save $60,000 a year in paper and publishing costs. The NPV analysis shows a five-year value of $144,813 using a 15 percent cost of capital; the NPV is this amount less $160,000, or –$15,187. The NPV in this case is negative.

The subsidiary then recast its analysis of the Intranet in an options pricing model, even though it recognizes that this approach to IT investments is controversial. First

A New Way to Manage the Supply Chain

The supply chain provides the materials that a company needs to produce a product or service. It consists of the vendors with whom the company does business. Supply chain management is the process of acquiring needed materials and services from vendors, coordinating deliveries, assuring quality, and trying to minimize costs. One way to better manage the supply chain is to provide vendors with information rather than just orders for goods.

Cisco Systems, a leading manufacturer of communications equipment for the Internet, is providing its suppliers with access to its product database over the Internet. Instead of viewing the supply process as a single chain, the company is trying to create a "web of suppliers" that is an extension of Cisco itself. One consulting firm estimates that the cost of planning production levels, finding raw materials, handling inventory, and delivering products to market cost the average manufacturer over 14 percent of revenues. Using the Web to coordinate the supply chain can streamline or eliminate manual processes. However, the real benefits of automating purchasing and moving it to the Web come in attracting more competitive bids and reducing inventory.

With Internet connections to customers and suppliers, a manufacturing firm can avoid bringing some components into its own inventory. If you order a PC from Dell with an HP printer and a set of speakers, the computer comes from Dell and the other components come directly from their manufacturers. Dell has a "virtual" supply chain for these additional products. Information and communications technologies are powerful tools for the manager who wants to change business processes.

the analyst determined that the company could develop a prototype for $30,000. This test Intranet would give enough information for deciding if the original proposal should be undertaken. At the end of the prototype development in a year, the company would need to invest another $100,000 to develop the full Intranet. The final results of her calculations in Table 24-6 show the value of the option as $37,608, which is more than its cost of $30,000.

Given this additional information from the options pricing model, it is likely that management will approve at least the prototype Intranet. Given the amount of money at risk, the firm might decide to proceed with the full project because the evidence for benefits from Intranets in general is very positive. In addition, the steering committee has been very supportive of Internet-type initiatives.

Table 24-6 shows that different criteria apply to project approval, depending on the type of investment. In some cases, quantitative analysis is very appropriate; in others, decision makers responded to qualitative factors. There are some companies that insist on a positive net present value before undertaking any IT project. While this rule probably sounds good to management and shareholders, Table 24-6 suggests that these companies may be missing a lot of opportunities (at least if they are being honest in their NPV analysis).

If a firm insists on a cost benefit, NPV, or even options pricing analysis, it is likely to ignore proposed investments in several of our categories and some opportunities with considerable upside potential. In particular, it is hard to come up with credible quantitative evaluations of infrastructure, initiatives with indirect returns, strategic applications, and investments that may transform the organization. Every proposal should be evaluated, but decision makers have to use criteria that are appropriate for the type of investment proposed.

A Summary of Issues in Managing IT

This book is about information technology and management. At this point we summarize some of the key management issues discussed in the text:

- The personal involvement of management in making decisions about technology is crucial, especially given the huge investments most companies have made and continue to make in information technology.
- You can use information technology to transform the organization. IT design variables let you develop entirely new structures like the T-Form organization.
- Information technology should be an integral part of a firm's corporate strategy. Managers and other users are the most likely source of strategic applications of the technology.
- Senior management needs a vision of how technology can be used in the firm.
- A corporate plan should include planning for IT.
- Management has the responsibility for designing and managing an IT architecture. It has to provide the basic infrastructure needed to take advantage of technology.
- There are a number of different structures for managing IT. Today the federal structure is probably the most popular in a large organization.
- Management is also responsible for developing new applications of technology. It needs to focus development resources where they are most needed.
- Systems development is one of the most creative activities in modern organizations. Managing development projects has been a continuing challenge for companies.
- Reengineering focuses attention on business processes instead of functions. It also contrasts radical redesign with incremental improvements in processes.
- Management must decide on the source of IT services; for example, there is the option of outsourcing to another firm.
- Managers determine what level of support to provide users working with technology, and how much time users should spend developing applications themselves.
- Managers are in the business of change. Nowhere is change more evident than in implementing new technology and using IT to redesign organizations.
- Information technology, while easy to use in some respects, is constantly growing more complex. There is a continuing need for IT professionals in the organization.

THE CHANGING WORLD OF INFORMATION

The percentage of IT expenditures controlled by the professional IS group has steadily dropped. A corporate IT group is likely to be responsible for "legacy" systems (older systems, often for mainframes), corporatewide applications, and infrastructure technology such as networks. More and more, the responsibility for IT management is shifting to users and line managers.

The challenge for senior management in this changing world is to exert the proper amount of influence on and oversight of an increasingly complex technological environment. The hardware and software infrastructure is expanding rapidly as networks of servers and workstations grow (our business school has a network with more than 1000 nodes). It is difficult to keep track of, much less manage, all the software and applications that local units develop for their own benefit.

Senior management will continue to struggle with the balance between what appears to be critical for the organization and should be controlled centrally, and what is best left to local management. The trends that are likely to continue are the declining cost of hardware, the explosive growth of networking, the Internet, interorganizational communications, the development of more sophisticated software packages, and the desire of users to do more computing under their own control.

ACTION PLAN

It is very difficult to reduce suggestions for managing something as complex as information technology to a few outline points. However, the following suggestions have proven helpful as guidelines.

MANAGEMENT PROBLEM 24-2

Cookwell is a manufacturer of cooking utensils. Its products are sold in department stores and specialty stores throughout the world. The company has a large information services department and many applications in accounting, production, and sales. Historically, there have been a number of problems with IT at Cookwell—and five different IS department managers in the past four years!

Systems seem to be late or are never implemented at all. Users in all departments are highly dissatisfied with technology services. Reports are always late, and there seem to be an inordinate number of errors. The IS staff generally blames users for all the problems.

Users, on the other hand, say the information services staff is the most arrogant group of people in the company. Whenever we ask them to do something, there is always some excuse why it cannot be done. Every new suggestion is rejected. If an application looks good, they come back with such an unrealistic cost estimate that no one would pay for it. We would be better off doing everything ourselves on PCs.

The president of the company has avoided these problems for as long as possible. However, things have become so serious that some action is required. Rather than fire the present manager of the department, who has been on the job for only four months, the president has decided to try a new strategy: He has hired a chief information officer. What should the new CIO do to solve IT problems at Cookwell?

Use IT Design Variables to Structure the Organization

One of the most exciting attributes of modern technology is your ability to use it in designing innovative and highly effective organizations. You can use this technology to design components of an organization or to structure an entirely new type of organization.

- IT design variables, in conjunction with conventional organization design variables, provide you with tremendous flexibility in designing an organization.
- The most likely outcome from using these variables will be a flat organizational structure with decentralized decision making. The firm will use electronic communications and linking, as well as electronic customer-supplier relationships to form alliances with other firms, and in general it will resemble the T-Form organization described in Chapter 4.

Determine and Communicate Corporate Strategy

If you and others in the organization are to help the firm achieve its strategy, you must know what it is!

Develop a plan for how to use information technology. The plan should include:

- A list of opportunities for your business unit.
- A vision of how your unit should function and the role of IT in that vision.
- A survey of current business processes that are good candidates for major improvement through process reengineering.
- A catalog of areas for applying IT, including priorities.

Develop a long-range plan for the technological infrastructure.

- Plan for hardware-software architecture for your unit given the constraints of the corporation, that is, what technology already exists.
- Plan for the evolution of a network that forms the backbone of your technology.
- Invest in infrastructure.
- Investigate the use of standards to facilitate connection and interorganizational systems.

Develop ongoing management strategies for IT.

- Support users in your unit and encourage them to work with the technology.
- Develop mechanisms for allocating resources to IT.
- Encourage innovation and reward it.

Manage systems development.

- See that design teams are formed for new projects.
- Participate in the design process.
- Be sure you understand what IT applications will do.
- Review and monitor development projects.

Be a user of technology.

- Use IT to improve your own productivity.
- Use technology to set an example for others.

Information technology is so pervasive in modern organizations that any manager will encounter it throughout his or her career. You will have the most success if you (1) look at IT as something that allows you and your colleagues to be more effective, and (2) actively manage information technology.

CHAPTER SUMMARY

1. The future of the modern organization is inextricably intertwined with information technology. A successful general manager cannot afford to leave decisions about information systems to a group of IS professionals.
2. A political view of the IT organization suggests that the federal model is the most favored in today's medium-to-large organization.
3. The chief information officer serves as a liaison to link the professional information services staff with top levels of management.
4. Senior managers tend to fall into two groups: those who view IT as a cost and those who see it as an asset.
5. For either group, it is important for the CIO to find ways to add value to the corporation through the use of IT.
6. Outsourcing is an increasingly popular option for managing IT. It is important to negotiate an outsourcing contract carefully and continue to manage IT with your outsourcer.
7. There are few guidelines on how much to invest in technology. This decision continues to be one of the most difficult for management to make.
8. When considering proposals for investments in new technology initiatives, management should recognize that the likelihood of a return depends on the type of application; the estimated return from the investment should be weighted by this probability and the probability of conversion success to obtain an expected value.
9. A key message from the text is that managers need to be knowledgeable about IT and involved in managing it in the organization.
10. The pervasive nature of the technology means managers at all levels in the organization, not just senior management, will use and make decisions about IT in the firm.
11. The role of management working with IT is to bring change to the organization. Implementing change is one of a manager's most formidable challenges.

IMPLICATIONS FOR MANAGEMENT

The typical reader of this book will be planning a management career rather than a career in IT. However, before you dismiss our discussions as not relevant to your career plans, you should realize that a number of CIOs actually are former users of technology rather than IT professionals. If you look at the qualifications and duties of the CIO, the reason becomes more obvious. The CEO wants a CIO who understands the business, someone who can figure out how to apply technology to achieve the goals of the company. At some point in your career, you could end up as a CIO. Patricia Barron was CIO of Xerox for a number of years. Her background was as a user, and she moved from CIO to president of one of Xerox's divisions. One of the things she did during her tenure as CIO was to learn as much about technology as she could, which is good advice for all of us.

KEY WORDS

Anarchy
Chief information officer (CIO)
Expected value
Federal model
Feudalism
Monarchy
Net Present Value (NPV)
Options pricing model
Outsourcing
Technocratic utopianism

RECOMMENDED READING

Brown, C.; and S. Magill. "Reconceptualizing the Context-Design Issue for the Information Systems Function," *Organization Science*. 9, no. 2 (March–April 1998), pp. 176–194. (A difficult article that describes some of the considerations in the debate about centralizing or decentralizing IT decision making.)

Davenport, T. H.; R. Eccles; and L. Prusak. "Information Politics," *Sloan Management Review*. 34, no. 1 (Fall 1992), pp. 53–65. (An insightful article on how different organizations approach IT management.)

DiRomualdo, A.; and V. Gurbaxani. "Strategic Intent for IT Outsourcing, *Sloan Management Review*. 39, no. 4 (Summer 1998). (An article that discusses three motivations for outsourcing and the appropriate relationship with an outsourcer for each.)

Earl, M., and D. Feeny. "Is Your CIO Adding Value?" *Sloan Management Review*. Spring 1994, pp. 11–20. (An excellent discussion of the challenges and actions for a CIO.)

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McNurlin, B.; and R. Sprague. *Information Systems Management in Practice,* 4th ed. Upper Saddle River, NJ: Prentice-Hall, 1998. (A well-written book covering many of the topics of IT management.)

Weill, P., and M. Broadbent. *Leveraging the Infrastructure*. Boston: Harvard Business School Press, 1998. (Results of a study of how market leaders develop and manage their technology infrastructure.)

DISCUSSION QUESTIONS

1. What do you think a CEO wants from information technology?
2. What is the role of the chief information officer?
3. Why do you think organizations have established the CIO position? What kind of individual should fill it?
4. Describe how at least one firm gained a competitive advantage with information systems.
5. How should corporate and IT planning be coordinated?
6. What is meant by the statement that a key challenge for management is the integration of information technology and the business?
7. Give an example of how information systems can constrain the opportunities available to management.
8. What are the motivations for outsourcing?
9. What are the "myths" of outsourcing? Do you agree with them?
10. What are the options for structuring information processing in an organization?
11. How do managers react in a firm that views IT as a liability compared with a company where it is seen as an asset?
12. How should you manage an outsourcing relationship?
13. Why is a flexible contract important in outsourcing?
14. If you became the CEO of a firm, how would you evaluate its information technology effort?
15. Why should a manager insist on seeing different alternatives when a new system is being designed?
16. What kind of organization might want to follow a different political model of IT than the federal model?
17. Describe how a manager provides leadership with respect to information technology in the organization.
18. Discuss the problems with the different political models of IT in the organization presented in Table 24-1.
19. How should a firm decide on proposed investments in IT?
20. What kind of changes does information technology either create or facilitate within and between organizations? What other changes are associated with IT?

CHAPTER 24 PROJECT

The CIO

Find an organization that is willing to let you interview the top information services manager in the firm. Develop a set of questions about what this individual does. In particular, ask him or her what the three most significant problems are for the top information services person in that company today. Based on the discussion in this text, include questions about the actions of top management and users' reactions to information technology. Prepare a written report of your findings and discuss whether you think the firm you visited would be typical with respect to systems.

CHAPTER 25

Societal Implications and the Future with Technology

Outline

Social Responsibilities

Technology
Applications of IT
The Impact of IT
Some Suggested Solutions

Ethics and Information Technology

The Future with Information Technology

Change Revisited

Focus on Change

The governments in developing countries know that they need to embrace the Internet if their business organizations are to be competitive. Yet many of these governments control information and avoid the openness associated with democratic, postindustrial societies. These governments run the risk that exposure to the free-wheeling information of the Internet will undermine their support. Can a technology like the Internet change the characteristics of highly controlling governments?

A manager has to ask what impact an application that transforms the organization might have. What will happen to the industry and the customer? Airline computer reservation systems transformed the industry, and the Department of

Transportation issued rules regulating these systems to avoid unfair competition. Is it in the public interest to allow a totally unregulated stock market in which buyers and sellers negotiate with each other at a Web site? How does one prevent failed transactions and fraud? What is an appropriate government and firm response to applications that change the way an industry operates?

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Information technology has an impact beyond any one organization. A user of systems may be affected directly as a member of an organization or indirectly as a citizen. Systems can transcend the boundaries of an organization. In this chapter, we discuss some of the social responsibilities associated with information systems. We also look at the future of the technology to understand better how to prepare for it today.

SOCIAL RESPONSIBILITIES

There are a number of issues for public policy concerning information technology. In this chapter, we consider some of the most important topics for an informed manager and citizen. Table 25-1 summarizes the issues according to the following categories:

- *Technology.* Issues that relate to the nature of the technology itself
- *Applications.* Problems that arise from applying technology
- *Impact.* Issues regarding the impact of technology on individuals, the organization, and society

Technology

Complexity and Integrity Society in general is becoming more complex, as is information technology. As you look at the confluence of computers and communications technology, the increase in technological complexity is evident. What is the interaction between IT and societal complexity? Will IT make things more complicated? Will IT help us cope with the growing complexity inherent in a postindustrial, information-based economy? The answer to the last two alternatives is probably yes. We may be able to trade off some organizational and societal complexity for information systems, but these systems in turn are likely to be complex in their own right.

The movement to client-server architectures and networking create greater complexity and dependence on machines. PCs bring power to the user's desktop, but at the cost of a more complicated environment. It takes considerable effort to learn a graphical user interface like Windows 98 and to operate five or six applications packages. Using a networking environment is more complex than using a standalone computer. All of this complexity can result in problems with the technology: Software does not run right, there is downtime on the network, users encounter problems accessing data or programs on the server, and there can be printing difficulties. Because the environment is more complex, it can take longer to diagnose the problem and fix it compared with the days of simpler technology. The Internet is a huge, decentralized and distributed network with over 150 million users.

TABLE 25-1

SOCIAL ISSUES

Issue	Concern
	Technology
Complexity and integrity	Are systems so complex that we cannot understand and manage them?
Reliability and failure	What are the risks if systems are not reliable; what if critical systems fail?
Piracy	What is the impact of piracy on the economy, trade, and international relations?
	Applications
Securities markets	Has technology made securities markets more unstable? Has it negatively affected the small investor?
Monitoring	Should management use technology to monitor individual workers? What about workgroups?
Harassment	How can we prevent systems from harassing individuals?
Defense	Could "Cyberwar" disrupt the economy?
	Impact
Education	Is the U.S. educational system preparing students for the technology they will face as adults?
Technology gap	Are individuals who do not learn about technology at a significant disadvantage?
Employment	Does technology make it more difficult for the unskilled to get jobs? What is its impact on middle managers?
Privacy	Do we have a right to privacy? Does technology make it possible to violate that right?
Security	What harm can result when the security of systems is compromised? What is the risk to the U.S. infrastructure of security violations?
International business	Can IT policies be used to inhibit the activities of firms trying to conduct business in foreign countries?

These problems are exacerbated by the extent to which we have become dependent on technology. Organizations use technology to process most transactions, to operate infrastructure systems used in transportation and communications, and to assure safety in air travel. The head of Synopsys, a company that sells software, spoke of this dependence. Almost all computers in a company are linked to an Intranet, the Internet, and to the public phone network for remote logons from anyplace in the world. At his company, if the Internet goes down, they cannot book an order, enter a purchase order, or process salaries. The software his

MANAGEMENT PROBLEM 25-1

The president of the Cambridge Group, a 500-person consulting firm, came to the conclusion that the firm must use technology to reduce its overhead. She said, "We mark our consultants up five times what they earn, and it is getting very difficult to sustain the 15 percent a year increase we have had in overhead. Clients are beginning to use our competitors." Her plan is to adopt much of the technology described in this text for knowledge workers. In particular, she envisions a substantial number of consultants working out of their homes using notebook computers, faxes, and cellular phones when on the road.

She also plans to implement Lotus Notes to act as a coordinating device among consultants, especially those working together on a project. The president hopes Notes will also form a kind of corporate intelligence of the skills and experience of the individuals in the firm.

She knows there will be a major impact on the work force from these changes. Consultants will have to adapt to new physical working conditions and to using a lot of technology that is foreign to many, especially longer-term staff members. More troubling is the need to lay off about 20 secretarial and clerical staff members who will not be needed in a high-tech environment. "These people are generally not highly salaried and they have few options—I am very concerned about how to handle the layoffs."

What do you recommend to the president of the Cambridge Group? How should she approach her implementation problems?

company develops is 100 percent dependent on the company Intranet. Web pages contain product data sheets, marketing data, and general corporate information. A program allows users to search a knowledge base looking for articles; there are 15,000 registered users inside and outside the company. Customers and company engineers download 23,000 articles a month. Many of the examples in the text demonstrate this kind of dependency on technology, a dependency that will only continue to grow.

Reliability and Failure We have discussed some of the problems of control and system reliability. Information technology is extremely complex. Although systems in the future are expected to feature more redundancy and lower failure rates, there is always the possibility of a system failing. The results of such a system failure range from inconvenience to catastrophe. There is serious public concern about seeing that systems are designed and installed with adequate considerations of reliability and backup. For example, critical on-board systems in airliners have long featured redundancy, that is, several separate and independent hydraulic systems.

For the most part, the IS profession has not yet approached such levels of redundancy. Some systems have extensive hardware redundancy, but very few systems have software that is independently developed and executed on separate machines to provide reliability and backup. Obviously, such an approach is costly, but for certain kinds of systems envisioned in the future, it may become necessary.

More research is needed to conduct the cost/benefit analysis necessary for selecting the proper design for reliability. The profession in general does not have a well-developed procedure for analyzing the risks of various types of system failures. Without this assessment capability, it is difficult to determine the steps necessary to achieve acceptable levels of reliability for any given system. There are also many problems related to the prevention of system failure. In 1989, the SABRE airline reservation system failed for 12 hours, the longest period ever, creating problems for travel agents, airline personnel, and travelers.

Piracy The technology industry in the U.S. is a strong engine for growth and jobs. Yet this industry is threatened by piracy, primarily of software. Piracy is highly organized with factories and distribution channels. It is a violation of what is often referred to as **intellectual property** rights. The Asia/Pacific region is considered by most companies to be the largest center of piracy. Estimates of piracy in the People's Republic of China run as high as 98 percent! The score for Russia and Latin America is estimated to be 90 percent. An attorney for Microsoft estimated that the company is losing half its revenue worldwide to piracy. By his calculation, pirates are stealing another whole Microsoft. Given the U.S. dominance in software, piracy is a serious threat to the economy.

The violation of intellectual property rights is not confined to individuals selling pirated copies of software. Anytime you borrow a program a friend purchased with a licensing agreement and install it on your computer, you are probably violating the licensing agreement. (There are many programs that are available without charge on the Internet and through various "shareware" bulletin boards.) Software companies offer a variety of licensing arrangements. Frequently universities are licensed to use software in a computing lab at a very low fee in order to introduce students to the programs. For the software vendor, the misappropriation of its intellectual property rights is a major problem.

Applications of IT

Electronic Securities Markets On October 19 and 20, 1987, the stock market came close to what was later described as a "meltdown." There were a number of investigations of what happened during this market collapse. Two investment and trading strategies that are possible only because of computers were given a significant amount of blame for the problem.

One strategy, called portfolio insurance, involves the sale of futures to offset a falling stock market. In addition, the insurer sells stock while the market is falling, thus contributing to a decline in the price of stock. Arbitrageurs look for differences between stock index futures prices and the prices of the underlying stocks. Investigations of the October 1987 crash suggest that this arbitrage, combined with portfolio insurance, drove the market down and was responsible for much of the volatility in the market following October 19.

These strategies require computers to perform calculations and alert the trader or to actually send trades to brokers. In addition, computerized trading systems at the New York Stock Exchange help the arbitrageur, who must simultaneously trade stocks and futures before a price change eliminates an arbitrage opportunity. The end result of investigations into the crash was a series of "circuit breakers": When different averages move by a certain amount, trading is halted for some period of time to allow the market to adjust.

There are concerns that technology contributed to a lack of stability in the market, and this may discourage individual investors from investing. However, even with these concerns, stock exchanges are moving to develop electronic markets and sometimes closing the comparable physical exchange. There are thousands of individuals exchanging financial instruments in on-line markets through the Internet. Electronic brokers have experienced tremendous growth, accounting for 35 percent of retail stock trades. The speed and low cost of these trades have encouraged "day trading"—where investors buy and sell the same stock in a short period of time. ECNs, or electronic computer networks, offer a place to exchange shares of stock off the traditional stock exchanges. What will the impact of this technology be on the financial markets?

Monitoring Computer systems offer the opportunity to monitor worker performance closely. An insurance company can determine how long it takes a representative to serve a customer on the telephone. An airline can tell how long a reservations agent takes on each call and how many calls the worker handles in each shift. On the production line, errors are traced back to the individual making them. Control systems also track individual worker productivity.

Many individuals respond negatively to such monitoring. For example, one employee sued her employer for monitoring her e-mail messages. It is possible employees will refuse to work with or that they will try to sabotage systems that closely monitor their work performance. One solution, adopted by an automobile manufacturer, was to form workers into teams; the firm publicizes the performance of the entire team rather than that of individual workers. Team members discuss the team's performance and try to figure out how to do better. Coupled with a team bonus system, this approach to monitoring lets management keep track of production without the severe negative effect on individuals who resent having their performance measured by a computer system.

Harassment Too many times, it appears we are harassed by computers. Systems are designed to automatically send second, third, and even further overdue notices when a customer has a legitimate complaint about a bill. Computers connected to automatic dialing machines harass consumers via the phone. Systems appear unresponsive to an individual's problems because of the need to process large volumes of information quickly. Some systems may be flexible but require cumbersome manual procedures to update records and keep them accurate. If a clerk makes an error or omission, the computer will continue sending letters to the customer. In other situations, employees learn to rely on systems and do not provide customer service when a system is unavailable. One bank installed an on-line inquiry system for tellers cashing checks. For backup, the tellers were provided with the same hard-copy microfilm used before installation of the on-line system. However, when the new computer system became unavailable because of a malfunction, many tellers refused to cash checks and told customers to come back when the computer was working.

Defense Since so much of the economy of developed countries depends on technology, these nations are vulnerable to electronic warfare. In a recent popular novel, a war with the United States begins when the aggressor country's banks make massive sales of Treasury bills through electronic markets, driving down the value of the dollar and affecting the U.S. stock market. A recent issue of *Time* had a cover story on **"Cyberwar"** in which the magazine interviewed officers at the Army Intelligence and Security Command who plan electronic offenses against enemies and defenses for the U.S.

As an example, a country might try to insert a computer virus in an enemy's telephone switching stations to cause a nationwide failure of communications. If you insert logic "bombs" in enemy communications networks, you can set them off to disrupt rail and air transportation as well. Other scenarios describe various kinds of electronic mischief to disable an IT-intensive economy without firing a shot.

The Impact of IT

Educating for Technology The education of individuals for the following roles is an ongoing challenge:

- *Knowledge workers.* Probably the largest group we consider will be those who use technology—individuals in firms whose primary responsibilities are not in the IS field. These employees need to be able to use computers as a part of their work. The typical professional has some type of managerial workstation, a powerful PC connected to a network. The knowledge worker needs to understand something about computers, networks, and different kinds of software. He or she should be familiar with using the Internet for commerce and to search for information. At the next level, the user needs to understand how to use this technology to improve his or her performance.
- *IS professionals.* These individuals will work with the technology. The category includes programmers, systems analysts, managers, and other staff members. Systems professionals must have an in-depth understanding of the technology and its applications. Some of these employees will develop hardware and software packages, and others will apply combinations of hardware, packages, and custom programs to the problems faced by organizations.
- *Interface personnel.* Between the IS professional and the user is an interface staff. These individuals have functional knowledge of how computers and software work but do not have a command of all the technical details. They need to be conversant with the kinds of problems faced by organizations and understand business and management.

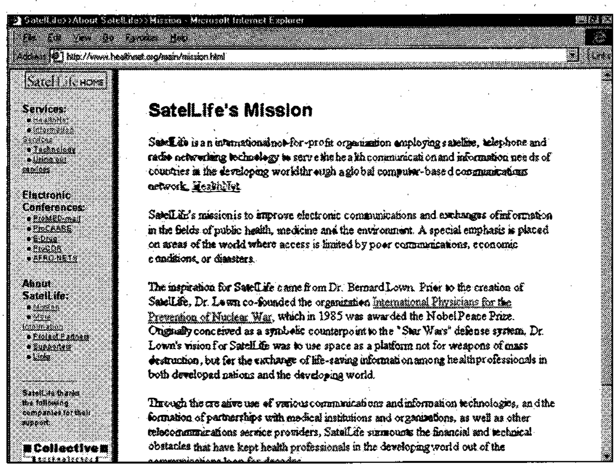
Sharing Medical Knowledge and Alerts

Healthnet is a global network for sharing medical knowledge. A few years ago a Swiss doctor posted a message on the network telling of the death of a yellow fever patient. Officials at the Pan American Health Organization noticed the message and followed up; they found the patient had recently traveled through Manaus, Brazil, a city with a large mosquito population. The agency contacted Brazilian health authorities who moved quickly to immunize the entire city to prevent an epidemic that could have killed thousands.

There are many similar stories. A Tanzanian physician retrieved enough information on burn treatment to save a child who had fallen into a cooking fire. A New Delhi doctor posted a request for help in dealing with a possible epidemic of dengue. Within 24 hours a World Health Organization team arrived to train hospital staff.

The network has high-speed lines, satellites, e-mail, on-line forums, and Internet connections, all run by a nonprofit corporation called SatelLife. One of the advantages of the network is that civilians control it; there is no government influence. Some governments are embarrassed by the conditions leading to disease and epidemics; they would rather deny the problem than advertise it and seek help. Healthnet is free of government control. In addition to helping physicians, the founders of the network hope it can play a role in education, especially in developing countries. Consider a forum devoted to the increasing incidence of cardiovascular disease in developing countries. This forum could be the first step in providing health care workers in remote areas with programs to educate patients about the risks of tobacco and lack of exercise.

The SatelLife web site.



Automating Automobile Design

Today's automobile design is often a large distributed effort involving thousands of engineers and technicians around the world. Information technology is helping to coordinate this process and eliminate paper. A typical car consists of from 10,000 to 15,000 individual parts from up to 200 suppliers. The 1998 Chrysler Concord and Dodge Intrepid are the largest successes to date of paperless design.

Chrysler's digital design effort is based on a program called Catia (computer-aided, three-dimensional interactive applications) from Dassault Systemes of France. This system packages the entire vehicle digitally, including engine, suspension, mechanical components, and interior. It provides aerodynamics calculations, impact simulations, fluid dynamics calculations, heat transfer calculations, and the design of the electrical system. To check out digital representations, users "print" the design in three dimensions using fabricators, for example, an ink–jet-like process in which tiny droplets of plastic are deposited on one another to build up an object.

Virtual reality is one of the latest additions to the design process. The user can explore relationships and movements of objects in three-dimensional space. An engineer at Chrysler wearing a headset connected to a virtual reality system running on a supercomputer, and holding a real steering wheel, sees the inside of the automobile and the road from the driver's perspective. Virtual reality is a natural extension to the "digital vehicle" design process; it helps to visualize the design, check to see that controls are ergonomically acceptable, study color combinations, and see how difficult it is to remove and insert parts during service.

On the assembly line, virtual reality is creating a new discipline called computer-aided production engineering (CAPE). An engineer uses VR technology to design a manufacturing process, checking the feasibility of assembly steps in three-dimensions by examining sequences and movements. Engineers can explore various ways of packaging parts into assemblies and explore insertion and extraction paths for parts.

- *Factory and office workers using computer equipment.* Factory jobs that used to require minimal education now require skilled workers. One factory has undergone dramatic changes over a 10-year period. A decade ago, the plant could operate with a largely unskilled and uneducated work force. Today parts of the plant have been replaced by a "clean room" for production. Parts bins are tracked using computers and bar codes. In one room, a machine operator uses a touch screen on a computer-driven testing device to enter testing parameters.

Some of the best and highest paying factory jobs today are at semiconductor plants. At one of Intel's newest plants making Pentium processors, the minimum educational qualification for a job is an associate's degree from a two-year college. A factory worker with this background needs a far different educational experience than the steelworker or autoworker of 20 years ago.

Are primary and secondary schools preparing students for these types of jobs? Where will skilled employees come from in the future for clerical and factory jobs? Will business itself have to educate its workers? In a number of cities, companies are "adopting" local schools, especially in the inner city, in order to improve the quality of education. Businesses provide funding for special programs and encourage their employees to volunteer in the schools.

While not the sole answer, there have been a few experiments in which schools provide personal computers at home for disadvantaged students. Teachers, parents, and students communicate about schoolwork, and the results look very promising in terms of motivation and reducing dropout rates. A special tax on long distance calls is being used to finance an effort to connect all schools in the U.S. to the Internet. A massive investment would be required to provide these kinds of technological resources for every student in the U.S. or any other country.

The Technology Gap There is a serious concern over whether computer and communications technology will accentuate the gulf that exists between the "haves" and the "have nots," among both individuals and nations. Will those who are able to acquire computer systems or knowledge of how to use them become the new elite? Will individuals who are not computer literate find themselves relegated to a second-class existence? It is unlikely that such extremes will evolve, but it is likely that significant segments of the population will become less able to deal with an economy that depends on information technology.

More than half of U.S. homes do *not* have a personal computer; to the extent that there are children in these homes, will they be disadvantaged compared to those who have easy access to computers? Fewer households have an Internet connection than have computers; will access to the Web at home and school be required to obtain an adequate education in the future? Outside of the U.S., the situation is even more

Your Toaster on the Web

A variety of appliances may soon show up in stores with the capability for connection to the Web. Manufacturers are exploring ways to integrate http software into their products; the idea is to allow for remote monitoring and control. You might see Web technology in appliances such as VCRs, vending machines, door locks, or your toaster. With compact server software, it is now cheap for a vendor to integrate a Web server into just about any product. Xerox plans to embed a server in its copiers to allow status and job monitoring. Another company is working on Web-enabled door locks.

The advantage of these devices is that one can control them from a central location. If the gas company incorporated web technology in gas meters, the meters could use push technology to send usage information to the company, eliminating the need for meter readers. You could command your Web-enabled microwave to start cooking dinner from your office before leaving for home. With Web-enabled door locks, you could unlock your house from the office at the time children are due home from school. *Business Week* estimates that over 20 percent of the devices on the Internet within a few years will not be PCs.

While you can question whether consumers will pay for some of the gadgets under development, there is no question that appliances on the Web will make the Internet an even more pervasive part of modern life.

bleak. There are countries in the Middle East and Africa that have *no* Web servers; they are cut off from access to the Internet and Web. Will a global economy that depends heavily on information continue to leave these countries behind? It is possible that developing a technological infrastructure is as important as building roads and other physical infrastructure in underdeveloped countries.

Employment Labor leaders are extremely concerned about the possibility of wide-scale unemployment because of information technology. The computer and communications industries are two of the largest in the United States, and have created hundreds of thousands of jobs. Naturally, the implementation of some information systems eliminated or modified jobs, though few statistics indicate the overall impact on employment.

It does appear that the continued introduction of automation will reduce employment in manufacturing. The extent to which this effect will be offset by the creation of jobs assembling and servicing new manufacturing equipment is unknown. However, increased technology will certainly require a more highly skilled, better-educated workforce.

The implementation of information systems also has implications for the pace of technological evolution, employment security, and the importance of retraining workers when jobs change. Have computers enhanced or reduced individual initiative and workers' interest in their jobs?

Finally, there is speculation that firms' investments in technology are finally affecting middle management. With electronic communications, GDSSs, and groupware, individuals can communicate easily. There is no longer a need for a layer of middle management as a conduit for information between the next-lower and next-higher level in the organization. Many middle managers who lost jobs in the recession of the early 1990s were unable to find other work. There is no hard evidence that IT is reducing these middle-management jobs, but many labor experts and economists suggest it is contributing to the reduction of middle-manager ranks. The T-Form organization uses IT design variables to create a flat structure with minimum overhead; requiring fewer employees than a traditional organization. The remaining employees will use IT as an integral part of their jobs.

Privacy Certainly, one of the most widely debated topics relating technology to society is the issue of an individual's right to **privacy.** The U.S. and Europe have quite different views of privacy. The European Union has a law that prohibits the purchase and sale of personal data, something quite common in the U.S. The law basically makes it illegal to use information about a customer in ways the customer never intended, which means that a firm cannot sell data to another company for marketing purposes. A key provision of the law is that any company doing business in the European Union is prohibited from transmitting personal data to a country that does not guarantee comparable privacy protection—namely, the U.S. The United States has a much more relaxed policy, relying primarily on industry self-regulation. One fear is that this kind of legislation could have a chilling effect on electronic commerce.

At what point does the right to privacy conflict with other rights? Society certainly has the need and the right to have certain kinds of information that contributes to the general welfare. Demographic information and information on income levels are vitally important in establishing national policy. Information on wages and financial conditions, however, is considered to be extremely sensitive by most individuals.

Current thinking is that individuals should have the right to ascertain whether information held about them is correct and to enforce the correction of errors. There is less agreement on the penalties imposed for misuse of private information maintained in some type of data bank. Other questions arise as to whether individuals should have the right to know who requested information about them from a data bank. Some countries are very concerned about this trend. For example, Sweden enacted a comprehensive program to regulate the development of data banks.

Some legislators in the U.S. are concerned about the practice of state governments selling data. A number of states sell access to automobile registration data. Direct-mail marketing organizations use auto registration information to target mailings. In other instances, individuals have obtained the license plate numbers of a group attending a meeting and use that information to harass the attendees.

The Web introduces another privacy concern: companies collecting information about people who visit their Web site without the visitor's knowledge. The FTC conducted a recent survey; a group of agency lawyers surfed the Web for two weeks, visiting some 1400 sites. Of these, more than 90 percent collected personal information from visitors, but only 14 percent of them disclosed how the information would be used. The FTC concluded that some form of formal regulation is needed and that self-regulation of the Internet had largely failed.

A number of solutions have been proposed; the federal government passed legislation affecting only federal agencies. There have been suggestions to extend the federal law to the private sector. As it stands now, the legislation requires a large amount of record keeping about the pattern of access to records containing any personal information. There are fears that the proposals for the private sector may prove extremely costly for organizations. One important issue, then, is what the balance should be between the individual's rights and the burdens and costs of protection and record keeping.

Security Closely related to problems of privacy is the issue of system security. There are many possible threats to the security and integrity of computer systems, particularly those with open access by individuals external to the organization. There have been a number of well-publicized penetrations of various computer systems, including a major cancer research hospital's on-line system. Researchers in the field are working on methods of encrypting data so they cannot be intercepted and decoded by an unfriendly user. Such concerns are very important, given the existence of highly sensitive data in on-line databases and the need for a secure payments system for electronic commerce.

There are a number of approaches to safeguarding credit card numbers sent to merchants over the Internet, generally involving some type of encryption.

Alternatives to a credit card like "digital cash" and electronic script are available. The President has a Commission on Critical Infrastructure Protection out of recognition that our quality of life is highly dependent on our physical and electronic infrastructure. This Commission has addressed potential vulnerabilities in water supplies, emergency services, government operations, energy, banking and finance, information and communications including telecommunications and the Internet, and physical distribution.

Growth of International Business One of the major changes in the global economy in the past decade is the growth of international business. The United States, Canada, and Mexico are reducing and eliminating most tariffs. Europe has created one market and currency to facilitate trade. Major corporations view themselves as worldwide global firms that happen to have a headquarters in a particular country. What are the implications of internationalization for information technology?

One major problem for the multinational is restrictions on the flow of data across borders. A related problem is the need for standardization, which may be antithetical to a management climate that stresses local control and initiative. Why might we need standards for information technology? Most headquarters operations collect financial data from various subsidiaries. If there are no standards for reporting, the task at headquarters will be much more difficult. Standards also make it easy to share applications among a firm's locations.

During the latter part of the 1990s Asia and Latin America have had major currency problems, partially because funds are moved quickly around the globe electronically. Political leaders in the U.S. have tried to make the point that business and commerce have truly become global and that we are all interconnected. Many people, especially politicians, fail to realize the extent of international trade and the degree to which the world's financial systems are linked through computer networks. The Internet, Intranets, and the proprietary networks of global companies cover the world, as do networks for banking and securities trading. From a communications standpoint, people all over the world become instantly aware of events in distant locations.

Some Suggested Solutions

Education The excitement over the Internet highlights the different opportunities available to students from homes with PCs compared to homes without them. A $500 netsurfing computer that doubles as a TV set might help reduce this disparity. Connecting every school in the U.S. to the Internet is an excellent goal, but much more is needed. Schools and students need personal computers, and we must help teachers integrate into their curriculum the tools provided by technology. There have been suggestions that technology will change the nature of education. Teachers will spend less time in front of a class and more time working with individual students who are using the Web to conduct original research. Is this a good model for teaching? Is it appropriate across students and subjects?

It is suggested by some that multimedia will revolutionize education. For this revolution to take place, schools will need to redesign and develop new curricula in which the capabilities of technology are exploited to provide new ways of learning. And of course the necessary funding for this will have to be found. If this revolution occurs, children will learn to work with the technology as a part of their entire educational experience.

Some companies are using computers to help illiterate workers function on the job. In one warehouse, forklift drivers who cannot read get instructions from the "talking computers" they wear on their belts. At a Raytheon plant, inspectors looking at circuit boards through microscopes dictate reports into a voice-recognition computer instead of writing the report. This system makes it possible to employ workers whose native language is not English.

Building an International Infrastructure The Internet is increasingly important for education and business, yet there is little access to the Net in less developed countries and the Middle East, except for Israel. There are very few Web hosts in Africa outside of South Africa. The U.S. has begun to train Peace Corps volunteers in the use of the Internet (you might think volunteers just out of college would know a lot about the Net already). Peace Corps volunteers will be encouraged to use the Internet to modernize remote areas. The announcement of this program did not indicate how a volunteer in a remote village in Africa could arrange for Internet access, but maybe that will come in a future program.

The Agency for International Development is trying to help Africa "go online." AID will extend this program to eight other countries, including Haiti, Egypt, Morocco, and Paraguay. Certainly one approach to help development in these and similar countries is to build a communications infrastructure and encourage the development of the Internet. However, there are many problems that must be solved for programs to be successful. In some countries, for political or religious reasons, government leaders do not want the population to have greater access to the uncensored, uncontrolled information on the Internet. Once they've gotten beyond this problem, teachers and managers have to learn how to incorporate the Internet into their activities. Many of these countries have a low level of literacy, or at least of technological literacy, which makes effective use of the infrastructure a challenge.

One solution might be to create an international agency whose sole purpose is to expand the Internet and Web. This agency would be staffed with experts on both networking and implementation. The network staff would help develop a network infrastructure, and the implementation staff would educate potential users of the Net. An objective in each country would be to build an indigenous industry capable of developing applications for the Web. Through a concerted, multinational effort, the Internet could become a powerful tool to help underdeveloped countries improve education and commerce.

Technical Safeguards Some problems involving misuse of information systems are technical in nature. We should attempt to make systems as secure as possible to avoid penetration by hackers. Thorough testing is needed to prevent programs from inadvertently disclosing sensitive data. There should be technical checks on procedures to prevent accidental entry by unauthorized individuals.

A more difficult challenge is to design a system that is secure from skilled agents or individuals attempting to commit fraud through the system. Protecting a system from malicious programs such as viruses is also not easy. Protection may take the form of monitoring to keep track of users or introducing special encoding algorithms to maintain security.

Controls Some of the controls discussed in the previous chapter can help prevent certain problems from occurring. Requiring several individuals to authorize changes in programming and databases, and checking input carefully help maintain data integrity. Controls requiring all data to be processed help solve such problems as data not updated to reflect payments. Controls are important to the extent they ensure accurate processing and screen out requests in which access is aimed at fraud or mischief.

Legislation Another solution to some of these social issues, particularly privacy and abuse of power, is legislation. In 1973, Sweden enacted a law regulating how and where personal data are maintained about individuals. The act established a data inspection board that grants permission to keep a data bank of personal information. Sensitive data, such as records of criminal convictions, can be maintained

The Modern Detective

The modern detective relies on electronic dossiers to find information about people under investigation. Web sites with names like Dig Dirt and SpyForU sell unlisted numbers, bank account numbers, and salary information. Governments eager for funds sell digitized public records to commercial database companies. The state of Illinois makes $10 million a year from the sale of public records while Rhode Island sells its motor vehicles data alone for $9.7 million. Other available records range from real estate data that list the number of bedrooms and last sale price of houses to divorces and bankruptcies. While much of this information used to be available in courthouse records, now you can easily access it from anyplace in the country using your computer.

One company collects and massages data to produce a product for sale to investigators, insurance agents, bill collectors, and journalists. A user types in a name and receives back the person's social security number, date of birth, and telephone number for a cost of $1.50. For a few dollars more, the user obtains other personal details such as past and current addresses; names and phone numbers of neighbors; names and social security numbers of relatives; in-laws, and business associates; civil judgments, and property tax data. While these services and web sites are probably legal, investigators often hire law enforcement officers to access confidential data stored on government computers.

Companies involved in conflicts and litigation are interested in obtaining information on their adversaries. Is there a right to privacy? Should there be legislation to prevent the collection and sale of personal information? With so much personal data available in different electronic dossiers, is it too late to prevent the collection and sale of personal data?

only by an agency charged by statute with the job of keeping these records. Once permission is granted, the data inspection board issues regulations to prevent undue encroachment on privacy. Responsibility for maintaining the correct data lies with the organization maintaining the data bank, not with the individual whose records are in the bank. Organizations whose key records are in error must make corrections demanded by the individual. Damages are specified for violations of these regulations. The recent European Union law described earlier in this chapter also offers strong privacy protection, potentially in conflict with business practices in the United States.

In 1974, a comprehensive Federal Privacy Act was passed in the U.S., requiring government agencies to keep elaborate records of the use of personal information. Records of inquiries by those whose records are kept must also be provided. To extend these requirements or a similar set to private-sector firms, some of the following topics are usually proposed in privacy legislation:

- Notifying the subject about the existence of a record
- Responding to inquiries on the contents of data and the use of records
- Investigating complaints
- Obtaining consent for each use of the data
- Checking authorization for requests
- Keeping a log of all accesses
- Providing subjects' statements when disputed data are released
- Sending corrections and/or subjects' statements to past recipients of information
- Ensuring accurate compilation of records
- Providing additional data to give a fair picture
- Providing a secure system

Although many of these requirements would prevent abuses of data, the regulations are potentially expensive to implement.

System Design Some of the preceding solutions will be implemented and will help solve some of the societal problems with information systems, but are they really sufficient? To a large extent, many social implications are determined during the system design process. By asking appropriate questions during the design process, we can assess some of the potential problems regarding the impact of the system on society. For example, we can ask the following questions about each application:

- Is the application a potential threat to anyone's rights? What could go wrong? For example, do the files contain rumors, hearsay information, or unevaluated reports on individuals?
- Is there a built-in incentive against using the system? For example, does it police workers who contribute the data?
- Is it difficult for someone to use the system? That is, could an unauthorized individual fill out the forms, understand the input, enter data through a terminal, or do whatever is required?

- How many ways could someone find to defraud or penetrate the system?
- If someone wanted to misuse the data in the system, how could he or she evade the procedures that safeguard them? What could someone do to misuse the data?
- Is the system sufficiently reliable?

The design team should encourage independent attempts to penetrate the system along these lines to verify the completeness and viability of the design. A well-designed system is the best guarantee against harassment, abuse, privacy violations, and alienation.

ETHICS AND INFORMATION TECHNOLOGY

There is a professional code of conduct for computer professionals developed by the Association for Computing Machinery, a society of individuals who teach and work in the field. This code applies only peripherally to users and managers who may work with technology but who do not consider themselves professionals. Does IT create any new ethical dilemmas for management?

The discussion of social problems at the beginning of this chapter raises some ethical issues associated with IT and management. Ethical considerations include concerns that:

- Data in the organization should be used for its intended purpose and the intended purpose should be legitimate.
- Monitoring of workers should be undertaken with their consent, and the data should be used to help rather than punish the workers involved.
- Systems and services made available to individuals external to the firm should behave as specified and cause no harm to others.
- Systems within the firm should not be guilty of harassment.
- Appropriate privacy should be maintained; for example, e-mail files should not be read by individuals not involved in the exchange of messages.
- Appropriate software copyrights should be observed and there should be respect for intellectual property.
- Systems should be secure and well controlled.

Ethical decisions arise frequently when dealing with information technology. Mason (1995) suggests how we can identify and approach a situation where ethical considerations arise.

> The crucial point occurs when a moral agent—one that by definition has choices—decides to change the state of information or information technology in a human system. Changes in hardware, software, information content, information flow, knowledge-based jobs, and the rules and regulations affecting information are among the many things that agents do that affect others . . . [W]e must use our moral imagination to guide our choices so that we can contribute positively toward making the kind of ethical world in which we want to live and want to bequeath to our future generations. How can we do this? . . . [F]undamental is our conscience, aided by our understanding and expertise in information technology. If we have an inkling our behavior . . . might in

MANAGEMENT PROBLEM 25-2

Julia Reed is the vice president of sales for SV Semiconductors, a manufacturer of applications specific integrated circuits (ASICS). Customers design chips for special purposes like engine controls and SV produces the chips in volume. The company has a proprietary chip design program and manufacturing process. Customers use the chip design program, and it is one of the company's major selling points.

The company president, Ken Larson, heard from a customer that a sales representative was offering to provide company documents on the program and on SV's manufacturing process. He was very angry since the company has generous compensation and stock options for almost all employees. Larson viewed this incident as a case of extreme disloyalty and a threat to the firm. He demanded that Julia arrange to have the e-mail of the entire sales force monitored; that is, she should obtain copies of all messages from computer files and read them to see if she can figure out who might be offering to give away company secrets.

Julia is very concerned about this request. It comes from the president, which makes it hard to turn down. On the other hand, she is troubled by the idea of invading every salesperson's privacy on a suspicion that one person may have done something wrong. She thought, "We don't even know for sure that an offer was made—what did the sales rep say and what did the customer think he heard?"

What advice would you give to Julia? What would you do in her place?

some way harm others, we probably should examine our decisions a little more carefully and from an ethical point-of-view.

The facts of an ethical situation can be summarized by four factors. The first factor is to clearly identify the moral agent. Whose actions will bring about the technology-induced change? The next factor is the set of alternative courses-of-action available to the agent. These are the real world acts that will have an effect on the human system under consideration. Acts have consequences, hence the third factor: . . . delineation of the results that are expected to occur if each act is taken. Finally, it is essential to identify the stakeholders who will be affected by the consequences of the acts . . . stakeholders have an interest in what the agent does.

It is easy to choose ethical behavior in a classroom setting when discussing a case study. It is much more difficult when working in an organization and facing budgetary constraints and pressure from peers, customers, top management, and stockholders. Kallman and Grillo (1993) suggest several informal guidelines for ethical behavior:

- *The family test.* Would you be comfortable telling your closest family members about your decision or action?
- *The investigative reporter test.* How would your actions look if reported in a newspaper or on a television news program?

- *The feeling test.* How does the decision feel to you? If you are uneasy about a decision or action but cannot understand why, your intuition is telling you it is not the right thing to do.
- *The empathy test.* How does this decision look if you put yourself in someone else's position? How would it look to another party affected by your actions?

Significant lapses in business ethics in the U.S. and around the world create a new awareness of the need for ethical behavior in highly interdependent societies and economies. The ethical issues surrounding technology are probably easier than most, and we hope your knowledge will help you make the right decisions. You can find a significant amount of material on ethics at http://is.lse.ac.uk/iswnet/profact/ethics.htm.

THE FUTURE WITH INFORMATION TECHNOLOGY

The last half of the twentieth century has seen a revolution in information technology. Looking at the first mainframe computers, no one seriously considered the possibility of having a machine that was more powerful sitting on their desk or in their briefcase. It has taken many years for information technology to make such vast changes in organizations and society. However, the pace of change has increased dramatically with innovations like the Internet. What can we say about the future of technology? How will new applications of information technology change the way we work and live?

The most recent and fastest growing innovation is the Internet and the World Wide Web. New models for business generally involve the Web and include ideas like electronic commerce, streamlined supply chains, electronic markets and even web-enabled appliances. The Internet provides, for the first time, a worldwide network infrastructure. Over 100 million people around the world can access applications and information placed on the Web.

This same technology allows knowledge workers to access vast amounts of corporate information online using an Intranet. All kinds of information access is possible through a single program, your Web browser. No longer is it necessary to create or use a custom interface for each application. By allowing customers and suppliers to access data on an Intranet and thus creating an Extranet, organizations change their business models.

The combination of computers, databases, and telecommunications, especially the Internet, provide the manager with an incredible number of options for improving the way an organization functions. Your challenge will be to choose appropriate technology, implement it successfully and continually manage change.

Change Revisited

In Chapter 1 we asked the question, in what way can and does technology change the world around us? Information technology has demonstrated an ability to change the following:

- Within organizations

Create new procedures, workflows, workgroups, the knowledge base, products and services, communications

Filling Your Tank with RAM

It may be a relief to turn off the computer in your office, get in the car, and head home. The trouble is that there is likely to be more computer power in your car than on your desk. The Volvo S80 sedan has an unusual accelerator, one that is likely to become standard equipment. In most cars, when you press down the accelerator, there is a direct connection to the engine and the car responds. In the Volvo, pressing on the accelerator sends a digital signal to an engine management computer to open the throttle on the engine. Volvo claims this new process results in smoother operation and lower fuel consumption and emissions.

The electrical system of the car is a communications network of 18 computers with central control units and 24 modules for electrical functions. The engine compartment network transfers data at 250 Kbits/second and the passenger sector of the network transfers at a rate of 125 Kbits/second. A central electronic module joins the two subnets. The car contains some 4000 feet of wiring! The electronics modules are:

- Upper electronic module—controls mirrors and map lights
- Electronic throttle module—controls engine power
- Transmission module—senses driving style and changes gear settings in the transmission
- Engine—has controls for fuel injection to increase or decrease torque in response to commands from other computers in the vehicle
- Antilock brakes—controls brakes, traction control, and dynamic stability to reduce skids
- Steering wheel module—controls radio and climate control functions located on the wheel
- Central electronic module—master computer that also coordinates diagnostic functions
- Restraint system—controls the safety system, which includes driver and passenger airbags, side impact air bags, two inflatable curtains, and seat belt tensioners
- Climate control—maintains interior temperature
- Audio module—controls the sound system
- Driver door module—controls driver power locks and windows
- Driver information module—controls the instrument panel
- Sun roof module—opens and closes the sun roof
- Phone module—controls cellular phone
- Passenger door module—controls passenger door locks and windows
- Rear electronic module—controls functions such as rear window defroster
- Power seat module—controls seat functions, adjustments, heating

Many of these modules enhance comfort, but several are important additions to safety. A good example is a stability control system. This system receives data every 40 milliseconds from a series of sensors, including one for the position of the steering wheel, wheel speed, sideways acceleration, and the rotation of the vehicle around a vertical axis (yaw). A computer compares the car's dynamic performance with a model in memory and the driver's intentions. If the computer detects a likely out-of-control event, e.g., the car is understeering or oversteering, it orders the engine computer to reduce power or applies the brakes on one or two wheels to keep the car going in the direction the driver has pointed it. The system can do things a driver cannot, such as applying the brakes on only one wheel.

All these computers add complexity, but they include enhanced diagnostics as well. The diagnostic system will keep track of failures, so that even an intermittent problem is stored in memory. A good technician should be able to find the specific problem your car had at 6 P.M. last Tuesday.

- Organization structure

  Facilitate new reporting relationships, increased spans of control, local decision rights, supervision, divisionalization, geographic scope, and "virtual" organizations

- Interorganizational relations

  Create new customer-supplier relations, partnerships, and alliances

- The economy

  Alter the nature of markets through electronic commerce, disintermediation, new forms of marketing and advertising, partnerships and alliances, the cost of transactions, and modes of governance in customer-supplier relationships

- Education

  Enhance "on campus" education through videoconferencing, e-mail, electronic meetings, groupware, electronic guest lectures

  Facilitate distance learning through e-mail, groupware, and videoconferencing

  Provide access to vast amounts of reference material; facilitate collaborative projects independent of time zones and distance

- National development

  Provide small companies with international presence, facilitate commerce

  Make large amounts of information available, perhaps to the concern of certain govemments

  Present opportunities to improve education

The study of information technology is the study of change. Throughout the text we have seen examples of these changes. As a manager, you will have the opportunity to take advantage of what technology offers. The Internet provides you with a worldwide infrastructure that can deliver information and applications to almost every place in the world that has a functioning economy. The smallest organization can think and sell globally. You can create a virtual organization using technology to coordinate and communicate the actions of your partners. Information technology provides incredible opportunities to change the world, from the nature of work to the nature of national governments.

> And let it be noted that there is no more delicate matter to take in hand, no more dangerous to conduct, nor more doubtful in its success, than to set up as a leader in the introduction of changes.
>
> —*The Prince, by* Niccolo Machiavelli, *early 1500s.*

CHAPTER SUMMARY

1. There is no question that information technology is becoming more complex, especially the combination of computer and communications technologies.
2. Society and its institutions are becoming more dependent on technology every day. The reliability of IT is a constant concern.

Do You Want to Vote on the Web?

The first suggestions to allow voting over the Internet were met with a singular lack of enthusiasm. Now, however, the Pentagon is sponsoring a test for the 2000 general election in which 6 million Americans overseas, both military and civilian, will be able to vote over the Internet. These individuals will join five states, Florida, Missouri, South Carolina, Texas, and Utah, that are participating in this experiment. An auditor in the Florida Division of Elections, on first hearing the idea, responded "That's a stupid thing to do." After investigating approaches to on-line security, he became a leading proponent of Internet voting. After all, electronic voting machines cost from $5000 to $7000 each.

There are two major technical safeguards needed. The first is a digital signature to be sure that you vote once, unlike the practice often attributed to a very strong Chicago mayor that you should "vote early and vote often." Second, it is extremely important that the way a person votes is not known to anyone; thus the digital signature has to be verified and discarded, without anyone being able to match the signature and vote at any point in processing.

Internet technology could facilitate voter registration with even fewer technical problems than voting. In this case, you simply want to verify that the person registering exists and lives at the address specified. However, voter registration is a highly political issue. A larger voter turnout generally favors one political party, so not all politicians are eager to see voter registration made easier.

Registration and voting via the Internet offer one way to help increase the voter turnout at elections. The U.S. is one of the most democratic countries in the world, and that democracy is threatened by low voter turnouts. Internet voting would solve problems caused by waiting lines at the polls and by bad weather. A large number of people could vote from their place of work, and a significant number could vote from home.

3. Software piracy is a threat to many companies, depriving them of revenue they need to continue to refine their products and remain in business.
4. Key applications of technology include the securities market, banking, and transportation.
5. Technology can be used to monitor workers, something most employees find unattractive.
6. There have been instances where systems appear to harass.
7. The U.S. is increasingly concerned about electronic warfare in which an opponent tries to sabotage crucial computers and communications networks.
8. The successful use of IT requires an educated population, yet there are questions about the quality of education throughout the world.
9. A dangerous technology gap may be developing between those who can afford and learn about IT and those who have no exposure to it.
10. Using IT to transform organizations is likely to lead to unemployment unless greater efficiency from technology is able to expand the economy to absorb displaced workers.
11. Technology, especially databases, can compromise privacy; there are various protection mechanisms suggested for individual privacy.

12. System security is a major concern, especially as computers become more interconnected through networks.
13. IT is an important facilitator of international business, yet countries sometimes raise barriers to the free use of technology within their borders.
14. It is important to consider the ethical implications of designing a system.
15. Information technology facilitates change, and change is a manager's greatest challenge.

IMPLICATIONS FOR MANAGEMENT

The picture that emerges from our discussions throughout the text about the future of information technology suggests that IT, the organization, and the economy are inextricably intertwined. Organizations have depended on technology for many years to process basic transactions. Today the technology is responsible for new organizational structures. Communications and workgroup technology create virtual organizations and electronic communities. Members of the organization are connected through networks that extend worldwide, allowing people to communicate easily, form unofficial virtual departments and subunits, and coordinate their activities. A modern organization is connected electronically to customers and suppliers. Physical proximity no longer needs to be a constraint in defining workgroups and collegial relationships.

The challenge for you and for all managers is to understand the tremendous potential of information technology to change and improve the way organizations function. A powerful technology exists. The ability to effectively manage IT is the key to maximizing its value to organizations.

KEY WORDS

Control
Cyberwar
Encryption
Fraud
Intellectual property
Internet
Misuse of information
Monitoring
Privacy
Virtual reality

RECOMMENDED READING

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DISCUSSION QUESTIONS

1. Why is the use of a system the responsibility of the systems design team and the organization?
2. Is there such thing as a right to privacy?
3. Does technology make it easier to violate an individual's privacy?
4. Is fraud easier with a computer system than with its manual predecessor?
5. What would be your response to a proposal for a national data bank of information on citizens for purposes of social science research?
6. What are the ethical responsibilities of an IS professional?
7. What solutions are there to protect a country's information infrastructure from attack?
8. In your opinion, would it be possible for a group to utilize computers to rig a nationwide election?
9. What steps are necessary to bring the benefits of information technology to the nation's schools?
10. Do computers make it easier to violate an individual's right to privacy? What are the dangers of keeping centralized government records on each citizen? What are the advantages?
11. Do employers have a responsibility to retrain workers replaced by information technology?
12. Why does an innovation like the Internet offer both an opportunity and a threat to developing countries?
13. What can be done to reduce the possibility of a computer-based fraud that would cause the failure of a business?

14. How could IT be used to solve some of the pressing problems of society, such as reducing the amount of energy consumed?
15. What priorities should be used by underdeveloped countries in trying to develop IT capabilities?
16. What are the implications of continuing decreases in the cost of hardware?
17. What options are there to help countries that are not on the Internet participate in it? What cultural considerations make adoption of this technology difficult in some nations?
18. What are the implications for technology education of the dramatically increasing home market for multimedia computers?
19. How is a highly technological society like the U.S. vulnerable to "electronic aggression"?
20. What kind of safeguards can a company or group of companies adopt to protect vital technology?
21. What does the statement mean, "the network is the computer"?
22. What are the drawbacks of workplace monitoring? Why might management want to monitor worker productivity?
23. What are a manager's responsibilities for information technology?

CHAPTER 25 PROJECT

An Information Technology Dichotomy

Some writers suggest that the United States risks falling into a system in which only a small elite with access to and an understanding of information technology will run the economy, while large numbers of undereducated and underemployed individuals perform menial jobs or subsist on welfare payments. Those who make this argument point to the poor quality of education and the lack of computer access in low-income areas. They also cite declining interest in mathematics and science, especially in poorer urban school districts.

Locate two or three essays by educators who discuss this problem, and critique them. Do you feel that the arguments have merit? Is the risk that is pointed out real? If so, what are the policy implications? What should government and private citizens do to prevent these dire predictions from coming true? Is an Internet connection for every school an answer?

Glossary

access time The time required to retrieve data from secondary storage and move it to primary memory.

address The location of a character or word in computer memory. Also the location of a track or record on a random-access device.

agents "Intelligent" software modules that perform some task for their human owner, like searching through a network looking for a particular product for sale.

algorithm An effective procedure for accomplishing some task. A set of repetitive steps that when followed terminates in a solution.

analog Resembling something; analog voice communications represent voice as a continuous wave form.

ANSI American National Standards Institute; develops industry standards for a number of technologies.

application The use of technology to accomplish a task, e.g., processing incoming orders.

application program A set of instructions that embody the logic of an application. It should be distinguished from a supervisory program, which controls the operations of the computer.

applications package A program or series of programs to accomplish some processing task.

architecture An organization's hardware and software pattern, e.g., a client-server architecture features servers with data, programs, and remote clients, usually with a graphical interface capable of accessing data and running programs to process it.

arithmetic/logic unit The portion of the central processing unit that performs computations.

arithmetic registers CPU registers that actually perform arithmetic operations on data.

artificial intelligence A field of computer science that attempts to develop computer applications that exhibit human intelligence in a limited domain.

artificial reality The use of technology to create an electronic representation of reality in which the user can manipulate the environment.

ASCII American Standard Code for Information Interchange; a 7-bit code used frequently for asynchronous (character-by-character) communications.

assembler A translator that accepts assembly language as input and produces machine language as output.

assembly language A language that closely resembles machine language, although mnemonics are substituted for numeric codes in instructions and addresses. Generally, one machine-language statement is produced for each assembly-language statement during the translation process.

asynchronous operation Any operation that occurs out of phase with other operations. For example, in certain CPUs, an instruction look-ahead feature, which fetches instructions before they are needed, operates asynchronously with regular instruction processing.

asynchronous transfer mode (ATM) A very high speed digital communications service used for connecting different computer networks.

audio response Vocal output produced by a special device that contains prerecorded syllables or synthesizes speech.
audit trail A means for tracing data on a source document to an output, such as a report, or for tracing an output to its source.
background program In a multiprogramming environment, a program that can be executed whenever the computer is not executing a program having higher priority. Contrast with foreground program.
backup Alternative procedures available for temporary or emergency use in case of system failure.
bacterium A program that infects a computer, replicates itself, and takes up as much time as possible.
bandwidth The range of frequencies for signaling; the difference between the highest and lowest frequencies available on a channel.
bar coding A series of bars that can be scanned and recognized by a machine; used to identify products and direct factory equipment.
batch computer system A system characterized by indeterminate turnaround time for output. Data and programs are collected into groups, or batches, and processed sequentially.
baud A measure of communications speed; the number of times the signal changes, which is roughly comparable to bits per second.
benchmark An existing "typical" program that is executed on a machine to evaluate machine performance.
binary A number system using the base 2 and the digits 1 and 0.
bit A binary digit, either 0 or 1; the smallest unit of information storage and transmission.
block mode Synchronous transmission in which characters are sent as a block with beginning and ending delimiters.
bridge A device to connect two networks.
browser A program for accessing information on the World Wide Web.
buffer An area of memory used for temporary storage of data.
bus A path used to carry signals, such as a connection between memory and the CPU in a microprocessor.
byte Generally, an 8-bit grouping that represents one character or two digits and is operated on as a unit.
cache A small, high-speed computer memory.
CASE (computer-aided software engineering) Hardware and software that help to automate parts of the systems life cycle.
case-based reasoning In Artificial Intelligence, programs that draw on a database of stored cases to locate problems similar to the one being faced by a user as a basis for recommending a solution.
cellular communications A type of communications in which low-power radio waves are transmitted to a stationary receiver. A computer "hands off" a conversation to an adjoining receiver as one of the communications devices moves toward it. An area is divided into many small cells so that a large number of connections are possible at one time using a minimum number of radio frequencies.
central processing unit (CPU) The part of the computer that controls its operations; it contains the logic of the machine; for PCs, the CPU is generally on a single chip or a small set of chips (Intel makes the 486 and Pentium chips that are CPUs).
channel A computer component with logic capabilities that transfers input and output from main memory to secondary memory or peripherals, and vice versa.

character Storing characters like the letter "a" as a code consisting of 7 or 8 bits; the common way most programs process data (like a word processor).
character mode Transmission that is serial, one character at a time.
check bit A word or a fixed-length group of characters to detect errors.
check digit A number added to a key as a result of some calculation on the key. When data are entered, the computation is performed again and compared with the check digit to ensure correct entry.
chip Small (6 × 6 mm) pieces of material, generally silicon, with various electronic components on the chip; the number of components is in the millions.
CIO Chief information officer of a firm.
circuit switching Communications in which a dedicated circuit is established between two devices, as with a conventional telephone circuit.
CISC Complex instruction set computers; the original strategy for developing processors featuring microprogramming and a large variety of instructions.
client The user's computer in a client-server system; contains local programs and storage.
client-server architecture A computer architecture in which a number of computers in the PC to workstation class are clients of a larger computer that acts as a server; the server provides data and programs for the clients and in some cases does calculations for a client.
COBOL A popular business computing language frequently used on mainframe computers.
cognitive style The individual's orientation toward approaching decisions in a particular way, for example, from an analytic or heuristic view.
compatibility The extent to which one can use programs, data, and/or devices of one computer system on another without modification.
compiler A translator for high-level languages. Generally, several machine-language statements are generated for each high-level language statement.
compression The use of an algorithm to reduce the amount of data that must be transmitted over communications lines.
concentrator A device with some local storage that accepts data from several low-speed lines and transmits them over a single high-speed line to a computer installation.
connectivity Related to having different computers and devices able to communicate with each other.
control of computer systems Techniques to ensure the integrity and accuracy of computer processing.
control unit (controller) A device that serves as an interface between channel commands and secondary-storage or peripheral devices.
core storage A medium of computer storage; for most second- and third-generation computers, the term is used synonymously with "primary memory."
CRT (cathode-ray tube) A terminal resembling an ordinary television set that can display a large number of characters rapidly; many also have graphics capabilities.
cycle time Either the time required to access information from primary storage and bring it to the CPU or the time required to fetch, decode, and execute an instruction within the CPU itself.
data definition language The language used with a database management system to describe the relationships among data elements.
data dictionary A component of a database management system that contains names of data elements and information about them.
data flow diagram (DFD) A graphical representation of an information system using a small set of symbols.
data structures The relationships among different fields of data on secondary storage.

database A comprehensive, integrated collection of data organized to avoid duplication of data and permit easy retrieval of information.
database administrator The individual in the organization with responsibility for the design and control of databases.
database management system Software that organizes, catalogs, stores, retrieves, and maintains data in a database.
debugging The task of finding and correcting mistakes in a program.
decision support system A system designed to support decision makers, generally involving interactive computing and focused on one particular business problem.
dedicated package A software package designed for a specific task, such as accounts receivable or payroll.
demodulation The process of decoding the information from a modulated carrier wave; the reverse of modulation.
digital Represented as a digit, usually a 0 or 1.
direct access The ability to access data without reading a large amount of irrelevant data; access from a disk is direct while access from a tape is sequential.
directory A dictionary or an algorithm for obtaining the address of logical records on a storage device.
disk A random-access magnetic device used for secondary storage in computer systems.
diskette A direct-access storage medium that is flexible; read/write heads of the drive actually touch the surface of the diskette.
distributed processing The dispersion and use of computers among geographically separated locations; the computers are connected by a communications network.
documentation Written descriptions of a system, usually with instructions on how to operate the system.
DOS The operating system used on many IBM personal computers.
duplex Data transmission occurs in both directions simultaneously using two separate paths.
EBCDIC Extended Binary Coded Decimal Interchange Code; an 8-bit code used by IBM to represent characters.
EDI Electronic Data (or Document) Interchange in which two organizations replace paper in transactions with electronic connections and transmission of data.
electronic commerce The use of electronic networks as a market for buying and selling goods and services.
electronic customer/supplier relationships The use of electronic connections like EDI to connect with customers and suppliers for processing transactions; these connections increase speed and reduce errors.
electronic mail A system in which computer users have an electronic mailbox and send messages using terminals; communications occur at the convenience of the user.
electronic workflows The routing of work like an insurance application electronically within a company rather than in paper form.
emulation Using a combination of hardware and software to make one computer device perform like another.
encryption The coding of a data stream to prevent unauthorized access to the data.
end-user programming Users of information employ very high level languages and other tools to access information without having a computer professional develop a program for them.
enhancement The process of making changes and improvements in operational programs.

entity-relationship (ER) diagram A data model in which data structures are conceived of as entities that are connected by relationships.
ethernet The most popular communications protocol on local area networks.
execute cycle (phase) The interpretation of an instruction and the execution of the operation it signifies, performed by the CPU.
executive information system A system designed to support the special needs of top management.
executive program The control program that schedules and manages the computer's resources.
expert systems An application of Artificial Intelligence in which a system captures the expertise of a human and makes it available to others.
fault tolerant Computer systems that diagnose faults and reconfigure themselves; used for on-line applications.
fetch cycle Retrieving data or instructions from memory and moving them to the CPU.
fiber optic Thin strands of glass that carry data as a series of light pulses representing a 0 or 1.
field A group of bit positions within an instruction. A subdivision of a record consisting of a group of characters.
firewall A hardware device, a computer, or a router, through which all communications packets into an organization must pass; the firewall disallows access to certain Internet Web sites.
firmware An algorithm or process that is part way between software and hardware; e.g., taking a well-understood program and encoding it on a chip to make it run faster.
fixed-length record A record in which the length and position of each field is fixed for all processing.
fixed point The representation of numbers as integers with no digits to the right of the decimal point.
floating point The representation of a number as a quantity times a base raised to a power; for example, the number 472 as 4.72 times 10^2.
floppy *See* Diskette.
foreground program The highest-priority program in a multiprogramming environment.
fourth-generation language A very high-level language that produces a number of high-level language statements for every statement in the fourth-generation language.
frame relay A high-speed packet switched-communications service that can be used to link LANs in different locations.
genetic algorithm An approach to problem solving that involves repeated cycles of selecting solutions, evaluating them, mutating the solution, and starting again.
graphics Output involving figures, graphs, drawings, and/or animation.
group DSSs Decision-support systems designed to support a group of managers who have to make a decision.
graphical user interface (GUI) A computer interface characterized by graphics in addition to text; windowing interfaces are graphical.
groupware The use of programs on a computer network to facilitate the sharing of information and communications between a group of people who have a common task in a shared environment.
hardware The physical components of the computer system.
heuristic programs Programs that are not guaranteed to arrive at an optimal or even an acceptable solution; nonalgorithmic coding.

high-level language A language closer to English than assembler language that, when translated, produces many machine-language instructions for each input statement.

home page The first page of material that an organization or individual presents on the World Wide Web.

HTTP, HTML Hypertext transfer protocol: the protocol for transmitting HTML documents. Hypertext markup language is the language used to create hypertext documents for the World Wide Web.

hub A device used in local area networks; computers in one location like the floor of a building all connect to the hub, which connects to the network.

hypertext The use of references embedded (hidden) in text to allow a user to follow a topic through a document or different documents.

icon A small graphical representation of a program or command that is displayed on a user's computer screen; clicking on the icon with a mouse causes the program to run or some action to be taken.

identifiers The mnemonic symbols assigned to variables in a program.

image Storing information more like a photograph than like coded characters; an image might be represented by a resolution of 300 dots per inch or 300 × 300 dots in a square inch; *see* character.

index Some type of table to relate keys to addresses in a direct-access file.

information Data that can be interpreted by an individual to provide meaning; a tangible or intangible entity that reduces uncertainty about a state or an event.

information resources management (IRM) The active management of information as a corporate resource.

information technology (IT) The combination of computers and communications including all types of computers from desktop workstations to supercomputers and all types of networks; also fax machines, pagers, and communications modes like cable, satellite, and wireless.

input/output Devices attached to computers that accept input, for example, a scanner, or that produce output, for example, a printer.

inquiry system A system in which inquiries are processed, but updating is done in batch mode.

inquiry-and-post system A system in which inquiries are made and data are entered and posted to a file for later updating.

instruction location counter A register in the CPU that points to the next instruction to be fetched for execution.

instruction register A CPU register that holds the instruction, decodes it, and then executes it.

instruction set The repertoire of instructions available on a computer.

integer A number without decimal places; e.g., 32 is an integer.

integrated circuits The ability to put many electronic circuits on a silicon chip; they made possible today's computers, which consist of processor chips and memory chips.

intelligent devices The addition of logic to a device or product, usually through the incorporation of an embedded chip.

interface The boundary between two entities that interact.

Internet A network of networks; a worldwide network linking millions of users on their own networks. At first used for exchanging information among scientists and academics, more recently being used commercially. Suggested by some as the beginning of a national information superhighway.

interorganizational system A system that connects organizations electronically.

interpreter A hardware or software program that examines an instruction and executes it.

interrupt A signal that causes the current program in the CPU to terminate execution. Depending on the nature of the interrupt, a different program may be loaded and executed.

ISDN (integrated services digital network) A network from common carriers that lets the subscriber send data and voice traffic over a digital network; the network provides a number of services to the user.

iteration A single cycle of a repetitively executed series of steps.

JIT Just-in-time inventory in which parts arrive just before they are needed for assembly into a product.

joint-applications development (JAD) An approach to systems design that stresses the use of a design team consisting of users and systems analysts.

key The part of a record used for identification and reference, for example, an employee number.

knowledge base Data and rules about the data form the knowledge base of expert systems.

latency The time required for a mechanical storage device to begin transmitting data after a request. For a movable-head disk drive, the seek time to position the read/write heads plus the rotational delay time.

legacy system Generally refers to an old mainframe application that has not been updated; typically it would be very costly to reprogram, and yet the system is probably outdated.

list A group of logically related items that are stored with pointers to the next item on the list. Also, a series of pointers running through a storage file.

loader A program that places a translated computer program in primary memory before its execution.

local area network (LAN) A collection of computers and other devices connected in a local area such as one floor of a building or an entire building; usually LANs are linked to form wide area networks.

logical record Fields associated on the basis of their relationship to each other.

logic bomb A program that waits for a particular event such as a given date, and then does some damage to a system.

machine language Computer programming languages have to be translated into machine language, the actual language the computer hardware is capable of executing.

mainframe The original kind of computer; associated today with large computers using proprietary hardware and software and often having cost/performance ratios that are worse than smaller computers.

maintenance The process of modifying operational programs to fix errors or add enhancements.

MAN (metropolitan area network) A network that connects LANs and other devices in campus of several buildings or in a city.

managerial control decisions Decisions primarily involving personnel and financial control, concerned with ensuring that resources are applied to achieving the goals of the organization.

megahertz A measure of transmission frequencies; megacycle or millions of cycles per second.

microcomputer A small computer, often for a single user or a small number of simultaneous users. Developed from advances in chip fabrication such that only a few chips are needed to produce an entire computer.

microprogramming Breaking down the machine language instructions of a computer into even finer steps that are used to create special, often complex, instructions.

minicomputer Originally developed to compete with mainframes, offering fewer features and a better cost/perfomance ratio; increasingly being called midrange computers.

mnemonics Alphabetic symbols used in place of numeric codes to facilitate the recognition and use of computer instructions.

model A tangible or intangible representation of some physical event, entity, or process.

modem (*mo*dulate and *dem*odulate) A device that converts digital computer signals into analog form and modulates them for transmission. Demodulation is the reverse process that occurs at the receiving point.

modular programming The subdivision of a system and of programming requirements into small building blocks to reduce programming complexity and take advantage of common routines.

modulation The coding of a digital signal onto an analog one, for example, by changing the amplitude of the carrier signal to represent a 0 or a 1.

monitor The control program that schedules and manages the computer's resources.

multimedia The use of more than one medium in presenting information, for example, the combination of graphics, video, and audio information.

multiplexing The combination of several low-speed signals onto a higher-speed line for communications.

multiplexor A device that combines signals received from a series of low-speed lines and transmits them over a high-speed line. No storage is provided, and signals must be demultiplexed on the receiving end.

multiprocessing A technique for executing two or more instruction sequences simultaneously in one computer system by the use of more than one processing unit.

multiprogramming The presence of more than one semiactive program in primary memory at the same time; by switching from program to program, the computer appears to be executing all concurrently.

MVS The most popular IBM mainframe operating system, a system that controls the resources of the computer; has matured into OS/390.

network A collection of communications devices, and often computers connected together via communications lines and/or satellites.

network interface card (NIC) A card, typically for Ethernet, that interfaces a computer to a network.

neural network An artificial-intelligence approach in which software (or hardware) is constructed to simulate the way in which the human brain is thought to function; used for pattern recognition after the user trains the network.

nonprocedural languages Languages in which the user tells the computer what to do rather than exactly how to do the task. Statements are more declarative of what is to happen than specific about the procedure to produce the desired results.

nonprogrammed decisions Decisions that are unstructured and for which an algorithm for solution cannot be specified.

normalization A procedure for simplifying relational databases and reducing the chances for updating errors.

object language The output of a translator, usually machine language.

object oriented A systems development and programming philosophy that views system components as objects that are manipulated by programs, advocates claim that object-oriented programming will save development time, effort, and cost.

OCR (optical character recognition) The machine recognition of certain type styles and/or printed and handwritten characters.

off-line Describes any operation that is not directly controlled by the CPU.

on-line system A system that has the capability to provide direct communication between the computer and remote terminals; files are updated immediately as data are entered.

on-line transactions processing (OLTP) Systems that process high volumes of on-line transactions such as credit card charge authorizations.

on-line updating Pertaining to a system in which the data entered are used to update the files immediately.

operating system A supervisory program that controls the resources of the computer.

operational control decisions Day-to-day decisions concerned with the continuing operations of a company, such as inventory management.

optical character recognition (OCR) The scanning of a document and recognition of the text in the document.

optical disk A disk that holds a great deal of data that is "burned" on with a laser. Most of today's optical disks can be written once and then read many times. Optical disks on which one can write more than once are also available.

optical storage Storage devices using laser optical disks, characterized by extremely high densities of data.

organization A rational coordination of activities of a group of people for the purpose of achieving some goal.

outsourcing The practice of contracting out major portions of a business, for example, outsourcing the communications activities of a company.

packet switching A communications device breaks a message up into standard-sized packets, each with an address; the packets are sent to their destination via the best available path through a network.

paging The segmentation of storage into small units that are moved automatically by hardware or software between primary and secondary storage to give the programmer a virtual memory that is larger than primary memory.

parallel testing The testing of a new system at the same time an existing system is in operation. The results from both systems are compared.

parse Separation of an input string of symbols into its basic components.

peripherals Input-output devices connected to a computer system.

personal computers The Apple Macintosh and IBM PC; desktop machines with commodity processor chips producing the most favorable cost/performance ratio of contemporary computers.

personal digital assistant (PDA) A small device that is designed to be portable and to help its user by storing and retrieving notes, addresses, phone numbers, and other information; can have communications capabilities.

physical record One or more logical records read into or written from main storage as a unit.

pipelined A central processing unit that breaks instructions into pieces and works on each piece in sequence like an assembly line in a factory.

pointer Data that indicate the location of a variable or record of interest.

point-to-point protocol A protocol used on serial lines to transmit network protocols like Ethernet; used by Internet Service Providers for telephone connections with customers.

primary memory The memory in which programs and data are stored and from which they are generally executed; main storage.

problem-oriented A language specifically designed for one particular type of problem, such as statistical computations.

problem program A user-written program that uses only nonprivileged instructions. It should be distinguished from a supervisory, or control, program, which may have privileged instructions.

procedural language A language designed to facilitate the coding of algorithms to solve a problem, for example, COBOL.

program A set of instructions that directs the computer to perform a specific series of operations.

programmed decisions Generally, decisions that can be made automatically by following certain rules and procedures.

protection Maintenance of the integrity of information in storage by preventing unauthorized changes.

protocol A set of rules or procedures for devices to communicate with each other.

prototype A model of a system or a version without all the final features desired used to get early feedback from users.

pure procedure A program in which no part of the code modifies itself. Because a reentrant program is not modified during execution, it can be shared by many users.

query language A language used to provide access to data stored in a database or file.

random access The ability to retrieve records without serially searching a file.

random-access memory (RAM) Memory that can be read or written under program control.

read-only memory (ROM) Memory that cannot be written under program control; used to store microinstructions.

reasonableness checks General range checks on data to be sure that values are within reason.

recognition The process of converting scanned images, which are represented by patterns of dots, into the character codes of the computer.

record, logical A collection of related data items.

record, physical One or more logical records combined to increase input-output speeds and to reduce space required for storage.

redundant array of inexpensive disks (RAID) A disk storage device consisting of many small disk drives such as those found on PC; various versions of RAID provide backup by writing data twice on different drives.

reengineering An approach to developing systems that focuses on major improvements rather than incremental changes; also known as business process redesign.

reentrant program Synonymous with pure procedure.

registers In general, storage locations capable of holding data. In particular, index registers that can be used to modify instruction addresses, or arithmetic registers that perform calculations.

relational database A database in which data are arranged in tables; columns in the table are fields in the database and rows are records.

report program generator (RPG) A class of languages used to prepare programs to print reports quickly from a set of files. Can also be used to program complete applications.

response time The time from submission of a request until the computer responds.

RISC (reduced instruction set computer) A computer in which the CPU has a streamlined set of instructions for the operations most often executed. The computer is not microprogrammed and performs most operations in high-speed registers.

rotational delay On rotating secondary-memory devices, the time required for a particular record to arrive under the read-write head.

router A hardware device that routes packets to different locations on a network.

satellite communications The use of orbiting satellites to receive, amplify, and retransmit data to earth stations.

scanner A computer input device that reads bar codes usually employing a laser of some type; also a device that reads printed text and in some cases, hand-printed characters.

scanning The process of "reading" or converting a document for storage in a computer; similar to taking a picture of a document.

secondary memory (storage) Random-access devices such as disks; programs are not executed from secondary memory devices but must be loaded into primary memory.

seek time For movable-arm disks, the time required for the reading mechanism to position itself over the track desired.

semantics The meaning of a programming language statement or group of statements.

semiconductor A small component having an electrical conductivity between the high conductivity of metals and the low conductivity of insulators.

server The computer that provides data and some programs in a client-server architecture.

simplex Data transmission in one direction at a time.

simulation The modeling of some process that often involves the use of a computer program and probability distributions.

simulator A software program used to execute programs written for one machine on another.

software Instructions that control the physical hardware of the computer system.

source language The input language to a translation process.

SQL (structured query language) A language that is becoming a standard for retrieving data from databases.

storage address register A register that holds the address of a memory location being referenced by the CPU or channel.

storage buffer register A register that holds data to be moved to or from main memory.

strategic-planning decisions Decisions of a long-term nature that deal with setting the strategy and objectives of the firm.

structured design An approach to design that attempts to provide discipline for the designers and to clarify the design itself.

structured programming A modular approach to program development that emphasizes stepwise refinement, simple control structures, and short one-entry-point/one-exit-point modules.

supercomputers Very large and fast computers designed for scientific computations.

superscalar The ability of a chip to process more than one instruction at a time.

supervisor The control program that schedules and manages the computer's resources.

synchronous Events that are coordinated and controlled.

syntax The physical structure of a programming language or statement.

systems programmer A programmer who works on the software associated with an operating or supervisory system.

TCP/IP The communications protocol used by the Internet.

technological infrastructure The shared technology in a firm that is used by all employees, as opposed to a system developed for an individual or small group; for example, communications networks.

technological leveling The use of information technology to reduce the number of levels of management in an organization.

technological matrixing The use of e-mail and groupware to create temporary work groups that cut across organizational boundaries.

telecommunications The transmission of signals over a long distance, through either private or public carriers.

terminal A device used to communicate with a central computer from a remote location, usually featuring a typewriter-like keyboard.

T-Form organization An organization enabled by IT organization design variables; typically an organization with a flat structure, extensive electronic connections to suppliers and customers, virtual components, matrixed management, and an advanced IT infrastructure.

throughput The amount of processing done by a system in a given unit of time.

time-sharing An on-line system that provides computer services (including computational capacity) to a number of users at geographically dispersed terminals.

top-down design Planning of a system by looking first at the major function, then at its subfunctions, and so on, until the scope and details of the system are fully understood.

trade-off The pros and cons of different alternatives; for example, one often is forced to trade cost savings for performance.

transaction A basic communication with a computer system, such as the receipt of cash from a customer.

transactions processing systems Basic systems that process routine transactions in an organization, such as the entry of customer orders.

translator A program that accepts a source language and produces an output, or target, language that differs in some respects from the source language.

trojan horse A program that attempts to disable security checks on a computer so that an unauthorized individual can penetrate the system.

turnaround document A computer-prepared document, usually a printed form, that is sent to a customer. When returned to the sender, the document frequently can be reentered into the computer without modification.

turnaround time The length of time elapsing between the submission of input and the receipt of output.

turnkey system A complete computer system with software installed for customer use.

uncertainty Lack of knowledge about a state or event.

universal product code (UPC) A bar-coded label found on many retail and grocery goods that uniquely identifies the product and its package size.

Unix A popular operating system first used on minicomputers; it is available for a number of computers, which makes programs running under Unix easier to move among machines.

URL (universal resource locator) The address of a web page.

variable-length record A record in which the number and/or length of fields may vary from those of other records accessed by the same program.

very large scale integration (VLSI) The production of computer chips with millions of components on each chip.

virtual Something that appears to exist, but does not exist in reality in the same way; for example, a group of workers looks like a physical department on an organization chart, but each member is actually in a different location and work is accomplished through electronic communications.

virtual machine The computer system as it appears to the user. The term was first used to refer to the extension of main memory to almost infinite capacity by the automatic use of secondary storage. The operating system automatically moves portions of a program that are too large for primary memory to and from secondary memory.

virtual memory Addressable space beyond physical memory that appears to the user as real; it is provided through a combination of hardware and software techniques.

virtual organization An organization that appears to an outsider to be complete, but is in fact composed of various components that do not necessarily belong to it, for example, its suppliers may actually have all its raw materials inventory and deliver goods as needed.

virtual reality The use of technology to create a simulated world; often used in games, but also in industry and medicine. A flight simulator is an example of the use of virtual reality.

virus A program that infects an executable program on a computer and causes it to do some unplanned activity, often damaging the files or programs on the machine.

wide area network (WAN) A network that spans a large geographic area such as several sites in a city or a number of sites in a country.

windows A graphical user interface that runs on top of DOS on personal computers. Windows 98 is the newest version and is a complete operating system in its own right. Windows NT is another similar operating system that is used often on servers and sometimes on desktops.

wireless Communications that does not require wires such as a conventional telephone; using radio frequencies for personal communications is an example of a wireless system.

word A combination of bits that forms a logical storage grouping. A word may be further subdivided into bytes, which can be addressed by instructions.

workstation A powerful computer generally assigned to one user; a desktop computer usually having at least a Pentium processor or better or a Sun Workstation; the workstation should have windowing software.

World Wide Web (WWW) A series of links among related topics among computers on the Internet; a browser lets the user access related topics automatically, and the user does not know that he or she is moving from one computer to another.

worm A program that wanders through a computer network looking for machines on which it can run; the program can quickly overload a network.

X.12 A standard for interchanging data among companies developed by the American National Standards Institute (ANSI).

zero-slot LAN A peer-to-peer LAN connected through existing ports on the computer and thus not requiring the use of a network interface card, which takes up a slot in the computer.

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