Harvard Business School
Case Selections (Reprint)

哈佛商学案例精选集
（英文影印版）

商务基础系列
Business Fundamentals Series

信息时代的管理

Information Technology Managers

Lynda M. Applegate 林达·M·阿普尔盖特
M.Bensaou M.本赛欧 等 编写
Michael Earl 迈克尔·厄尔

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INTRODUCTION

Welcome to the Business Fundamentals series from Harvard Business School Publishing!

The readings in this collection were developed for the MBA and executive programs of Harvard Business School. These programs rely heavily on the case method of instruction, in which students analyze and discuss firsthand accounts of actual management situations. Students also learn the fundamentals of what managers do: how they measure performance, make choices, and organize their activities. At Harvard Business School, the fundamentals are often taught through background notes, which describe business processes, management techniques, and industries.

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You can search for related materials on our Web site: www.hbsp.harvard.edu. We hope that your learning experience will be a rich one.

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MANAGING IN AN INFORMATION AGE: IT CHALLENGES AND OPPORTUNITIES

(L.M. Applegate / #9-196-004 / 19 p)

Summary

This note describes how information technology has evolved from a tool to support "back-office" transactions to a key strategic asset in most businesses. Applegate shows why this evolution requires companies to transform their outdated IT architectures and the IT organizations that support them. She also offers an approach to valuing an IT investment.

Outline

The Evolution of IT Architecture

Era 1 – The Mainframe (1950s to 1970s)
Era 2 – The Microcomputer (late 1970s and 1980s)
Era 3 – Distributed Information Systems (late 1980s to present)
Era 4 – Ubiquitous (emerging in the mid-1990s)

Value-Creation in a Distributed IT Environment

Measuring the Value of Investments in IT
Measuring the Value of IT Platform Investments
An Approach to Valuing IT Investment

Summary

Learning Objectives

After reading the note and completing the following exercises, managers should be able to:

- Identify how information technology can create value for their unit or firm.
- Assess the managerial implications of using IT systems from a previous era of information technology.
- Better understand how to value an IT investment.
- Evaluate how effectively their employees have been trained to use information technology.

Questions to Consider

- Are your employees equipped to exploit the potential of information technology to create value?
- Do you regularly evaluate the IT systems used in your unit? What might such an evaluation reveal?
- How does information technology enhance your unit's productivity and competitiveness?

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August 8, 1995

Managing in an Information Age: IT Challenges and Opportunities

by Professor Lynda M. Applegate, Harvard Business School

"This is the most turbulent market I have ever seen," a venture capitalist commented as he discussed a segment of the IT industry in 1994. As managers struggle with the potential and difficulties of assimilating and managing information technology (IT) in the 1990s, it is helpful to recall that computers were introduced into organizations only within the last 30-40 years; those computers filled a room, and a calculation could take several hours. By the mid-1990s, performance was measured in the billions of instructions per second, and "palm-top" computers far exceeded the performance of the 1960s mainframes at a fraction of the price (see **Figure 1**).

Consider this: in August 1993 Nintendo announced a videogame computer that will cost $250 when shipped in 1995 yet will contain computing power costing $14 million only *ten* years earlier.[1] Wireless technology and the integration of data, voice, video, and graphics capabilities over blindingly fast, yet cost-effective, networks now allow "any time, any place, and any form" communication and information sharing. These dramatic improvements in IT price/performance enable equally dramatic changes in organizational strategy, structure, people, processes, distribution channels, and work. But, despite IT's potential, many managers have found it increasingly difficult to successfully tap the power of this valuable tool.

The co-evolution of technology, work, and the workforce over the past 30 years has indeed dramatically influenced our concept of organizations and the industries within which they compete. No longer simply a tool to support "back-office" transactions, IT has become a strategic part of most businesses, enabling the redefinition of markets and industries and the strategies and designs of firms competing within them. Today's supersonic jets cross the Atlantic in three hours or less, and global communication networks carry information around the world in seconds. Distance and time have become much less significant determinants of market and organizational structures

[1] *Business Week*, March 6, 1995.

This note is based on a six-year research project entitled Managing in an Information Age.

and processes.[2] Moreover, information has become a major economic good, frequently exchanged in concert with, or even in place of, tangible goods and services. The 1990s also offer examples of IT-enabled "virtual" organizations, in which many small, independent agents (or firms) band together as nodes on an information network to achieve dramatic increases in scope and scale. Such arrangements challenge both our legal and social definitions of an organization. (See *Electronic Commerce: Trends and Opportunities*, HBS No. 196-006, and *Paving the Information Superhighway: Introduction to the Internet*, HBS No. 195-202, for a more in-depth discussion of the influence of IT on interorganizational market relationships.)

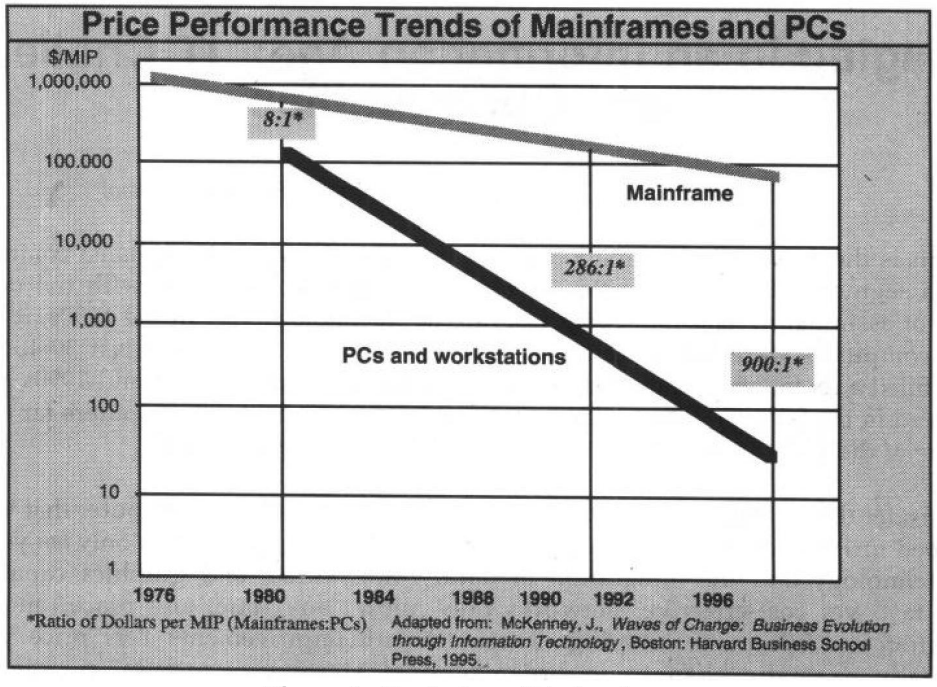

Figure 1: Evolution of Technology

Just as IT has radically altered how we view the relationships between firms, it also challenges our notion of relationships within them. As companies install sophisticated information and communication platforms with the potential to link everyone within the firm to a common source of organizational knowledge and a fully distributed network of relationships, the rigid walls around organizational layers and functions begin to deteriorate. In addition, personal portable technologies enable a new class of mobile worker and a new class of work—"Telework." (See *Managing in an Information Age: Organizational Challenges and Opportunities*, HBS No. 196-002, for an in-depth discussion of IT and organizations.)

These are but a few of the ways that IT is influencing industries, strategies, and organization designs in the 1990s. As it does so, IT plays a dual role: simultaneously helping to create the conditions that give rise to the need to change and providing the tools needed to support the change. But to achieve these information age benefits, companies must adopt information age technology architectures. Organizations must radically transform outdated IT architectures and

[2]Miles, R. and Snow, C., "Organizations: New concepts for new forms," *California Management Review*, 28:62-73, 1986; Malone, T., Yates, J. and Benjamin, R., "Electronic markets and electronic hierarchies: Effects of information technology on market structure and corporate strategies," *Communications of the ACM* 30(6):484-497, 1987; Johnston, R. and Lawrence, P., "Beyond vertical integration—the rise of the value-adding partnership," *Harvard Business Review*, July-August, 1988; Powell, W., "Neither market nor hierarchy: Network forms of organization," *Research on Organizational Behavior*, 12:295-336, 1990.

the organizations required to support them. This technological transformation is every bit as daunting as the organizational transformation.

This note explores the challenges that firms face as they attempt to create the IT architecture required to support an information age organization. It examines the "four eras" of computing that have marked the evolution of IT in organizations, showing how each introduced a new approach to IT architecture design and the administrative structures and processes used to manage it. Launching each era was a series of IT innovations that radically changed how IT could be used within the firm and the industry; in the hands of innovative managers who understood both the power of the technology and its potential business implications, new sources of business value-creation were possible.

The Evolution of IT Architecture

Just as the blueprint of a building's architecture indicates not only the structure's design but how everything—from plumbing and heating systems to the flow of traffic within the building—fits and works together, the blueprint of a firm's IT architecture defines the technical computing, information management, and communications platform of the firm; the structures and controls that define how that platform can be used; and the categories of applications that can be created upon the platform (see **Figure 2**). The IT architecture provides an overall picture of the range of technical options available to a firm—and, as such, it also implies the range of business options.[3] Decisions made in building the technical IT architecture must be closely linked to decisions made in designing the IT organization that will manage the architecture, which, in turn, must be linked to the strategy and organization design of the firm itself. The IT organization strategy, structure, incentives, and processes strongly influence how the technology will be designed, deployed, and used within a firm. Thus, while this note focuses on the design of the technical architecture and its evolution, it is important to remember that the technical design is influenced by—and influences—strategy, organization, and performance within both the IT organization and the firm. (**Appendix A** provides questions that can be used to assess the IT architecture of a firm.)

The IT architecture in place in most organizations in the 1990s represents a mix of old and new technologies that reflect the era in which they were introduced. Four eras have been identified, which, while somewhat overlapping, are nonetheless distinct: the *Mainframe Era*, the *Microcomputer Era*, the *Distributed Era*, and the *Ubiquitous Era*.[4] Each era was ushered in by a series of technological innovations that enabled a fundamental shift in IT architecture design. But, while each new era brought new technologies with dramatically different capabilities, many managers continue to evaluate business opportunities using the assumptions of the old models. In addition, many managers remain chained to administrative models more appropriate for earlier technologies. As managers attempt to benchmark their current IT architecture and plan for the future, they must understand the technological components, perspectives, and administrative practices associated with each of the four dominant IT architectures associated with the four eras of computing. **Table 1** summarizes the characteristics of the IT architecture during these four eras, each of which is described below.

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[3]See Keen, P., *Every Manager's Guide to Information Technology* (Boston, Mass.: Harvard Business School Press, 1991).

[4]Applegate, McFarlan and McKenney, *Corporate Information Systems Management* (Homewood, Ill.: Irwin, 1995); McKenney, J., *Waves of Change: Business Evolution through Information Technology* (Boston, Mass.: Harvard Business School Press, 1995).

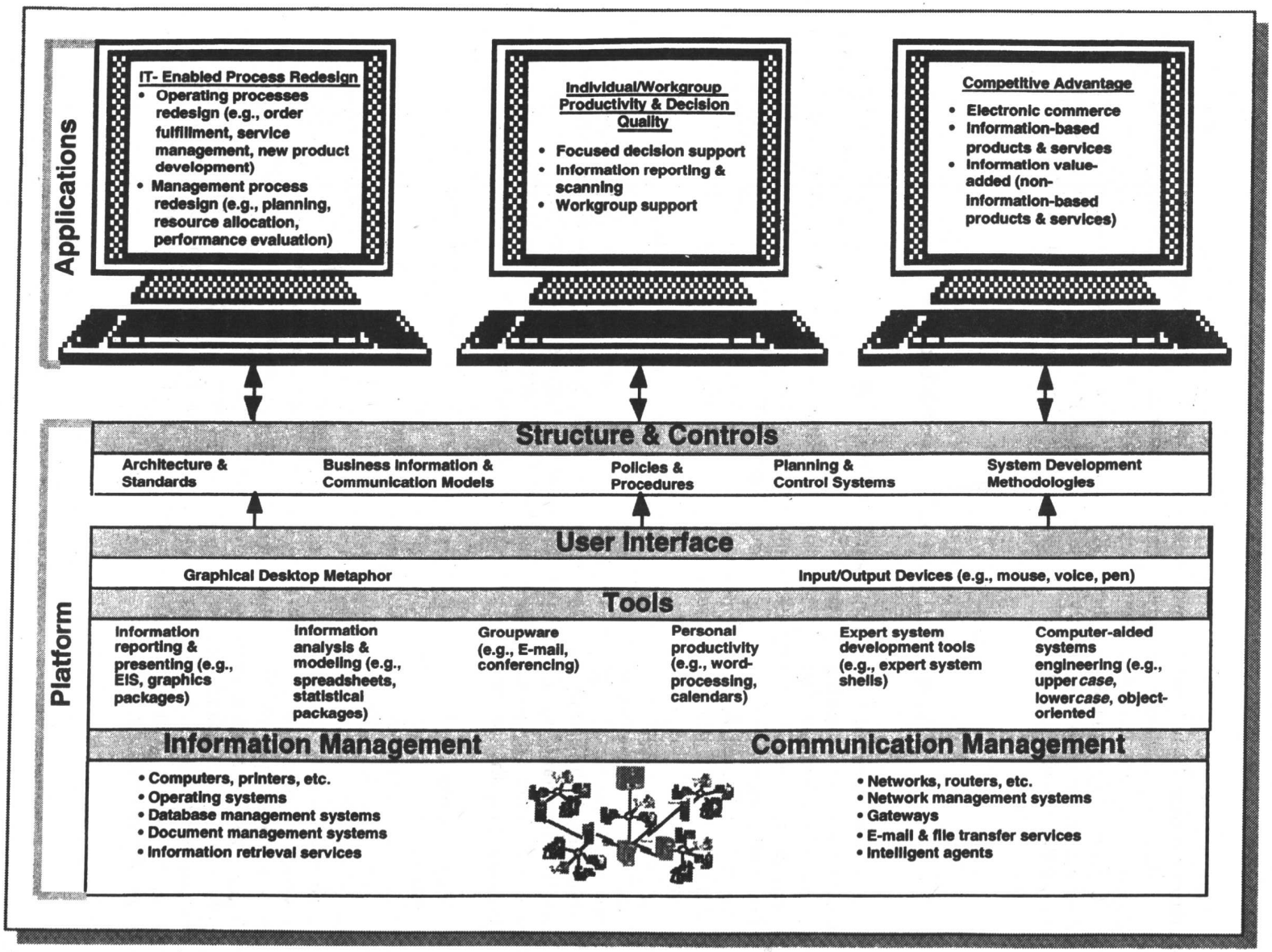

Figure 2: IT Architecture

Table 1: Evolution of IT Architecture

	IT Paradigm			
	Mainframe Era (1950s to 1970s)	***Microcomputer Era (1970s to 1980s)***	***Distributed Era (late 1980s to present)***	***Ubiquitous Era***
Dominant Technology	Mainframe/minicomputer Centralized Intelligence	Microcomputer Decentralized Intelligence	Client-server network Distributed Intelligence	Unstructured network/ personal portable technology Ubiquitous intelligence
Organization Metaphor	Hierarchy	Entrepreneurial	Transitional hybrids	Information age
Primary IT Role	Automate existing processes	Increase individual/group effectiveness	Industry/organization transformation	Value-creation
Typical User	Computer specialists	Computer-literate business analysts	Information-literate managers and line employees	Everyone
Location of Use	Computer room	Desktop	Expanded locations	Everywhere
Justification	ROI	Increased productivity & decision quality	Competitive position	Value creation
	Information Management			
Information Level	Data	Analytics	Information	Knowledge
Information Model	Application specific	Data-driven	Business-driven	Knowledge-driven
Information Storage	Application specific data files	Hierarchical database management systems; early relational	Relational database & document management systems	Hypertext & object-oriented knowledge management systems
Integration Level (Data, Voice, Video, Graphics, Text)	Computer support for data only	Beginning computer support for all information classes but limited integration	Beginning integration of voice, video, data, text, graphics	Sophisticated, integrated support for all information classes
	Communication Management			
Connection Media	Thickwire coaxial cable Air (microwave and satellite)	Twisted pair wire Thin wire coaxial cable	Cable, optical fiber, cellular, satellite Continued channel separation	Channel integration
Transmission Protocols	Proprietary wide area network(WAN): packet switching, circuit switching	Proprietary local area network (LAN); ethernet, token ring	Routers manage WAN & LAN integration; open standards. frame relay	Merging of LAN/WAN technology; ATM
Maximum Transmission Rates	56 Kbps	1 Mbps	3-20 Mbps	10 gbps (or more???)

Table 1 (continued) Evolution of IT Architecture

	Mainframe Era (1950s to 1970s)	*Microcomputer Era (1970s to 1980s)*	*Distributed Era (late 1980s to present)*	*Ubiquitous Era*
Tools				
Information Reporting	Paper reports	Spreadsheets, modeling, word processing, paper reports	Beginning integration	Ad hoc, integrated, associative, browsing, & linking
Information Analysis	Batch transaction processing	Structured decision modeling & document creation	Relational information model and beginning object orientation	Unstructured, real time business modeling & knowledge creation
Communication	Mainframe, E-Mail	LAN, E-mail	Independent groupware products	Any time/any place/any form
System Development	Programming languages	End-user tools	Computer-aided software development environments	Object-oriented development environments
User Interfaces				
Input/Output Devices	Keyboard & monitor	Keyboard, mouse, & monitor	Keyboard, pen, mouse, & remote personal digital assistants	Natural interface on remote PDAs
Application Interface	Command-driven text	Menu-driven	Icon-driven, windows, voice & image	3-D graphical and virtual reality
Structure and Controls				
Information Management Organization Structure	Centralized	Islands of automation; decentralized	Beginning distribution	Collaborative partnerships (includes outside vendors and industry participants)
Information Management Planning & Control Processes	Centralized control, timed to planning & budgetary cycle	Islands of control; ad hoc	Transition	Distributed/interactive management processes Timed to business and information cycle
Information Management Operating Processes	Single, structured model (e.g., system development lifecycle)	Multiple models (e.g., system development lifecycle, JAD, prototyping, end-user development)	Rapid prototyping; multi-generational	Interactive; process integration; quality management; continuous improvement
IT Professionals	Technical specialists	Technical and end-user specialists	Hybrids • Process consultants • Information specialists	Domain specialists; business/IT generalists

Era I—The Mainframe (1950s to 1970s)

By the middle of this century, mechanical technologies had automated factories, creating dramatic increases in production efficiency; automobiles, roads, and railroads enabled distribution efficiency to distant markets; and radio and publishing had stimulated demand for low-cost, mass-produced products. Those able to harness these new technologies grew quickly, linking their dispersed organizations through rapidly improving telephone and telegraph communication systems.

But along with this explosion of growth came dramatic increases in complexity, handled by manual, paper-based information systems. While the hierarchy helped reduce the complexity through structure and systems, scores of middle managers and office clerks were required to process the information needed to do business. Supervisors either walked the floors to monitor operations directly or sat in glass-enclosed offices with a full view of clerical or factory operations. Clerks collected information through paper memos, reports, and word of mouth, all of which was painstakingly recorded by hand, duplicated using mimeograph machines and carbon paper, stored in paper files and records within file cabinets, and distributed through internal and public mail services. Product designs were drawn by hand, and slide rules performed complex computations. In information-intensive industries (e.g., insurance and banking), punch card machines and mechanical calculators helped row after row of clerks filling massive rooms to process and analyze information. Middle-management time was consumed in checking the accuracy of the data and creating reports for upper management to use in making decisions. The introduction of the digital computer in the early 1950s served as the catalyst for radical change in organizational information processing. The pioneers defining the dominant IT architecture of the mainframe era were most often found in information-intensive firms (e.g., insurance, banking, airlines), and the technology was often targeted toward improving the efficiency of information-intensive clerical tasks (e.g., accounting and personnel management).

By and large the work itself was not "transformed;" instead, each computer application was developed to replicate the tasks, thereby increasing overall efficiency and frequently replacing manual clerical work with computer data processing. Because existing processes were clerical and operational in nature, management found little need to become involved in designing or managing the technology. Furthermore, the IT architecture of the day—centralized mainframe computer systems and networks—were most appropriately managed and operated by the corporate management information systems (MIS) function; a single mainframe computer represented a sizable capital expense, required special facilities (e.g., climate control, special wiring, raised floors), and specialized expertise for system development, maintenance, and operation.

Machine intelligence was centralized within the mainframe computer; users "interacted" with it through a variety of data input/output terminals controlled by the mainframe. Because these terminals were essentially "dumb," users were attached to the mainframe directly to "interact" with the data. Given the communications technology available in the 1960s and 1970s, extended work on the mainframe was essentially limited to those residing in the same building that housed the computer; those in remote sites were limited to very brief sessions in which the user would access a single record or piece of data. All other data were "batched together" to be shipped at one time, frequently during evening hours.

Given its local information processing and the limited direct interaction between data and users, the mainframe era characteristically focused on "*data*" processing. And although decision support systems (designed to convert raw data into useful information) and expert systems and other artificial intelligence applications (designed to convert data and information into knowledge)

actually began during the mainframe era, the limitations of the technology hampered widespread use until the introduction of the microcomputer ushered in an era of rapidly increasing local information processing capacity and lower IT cost.

Era 2—The Microcomputer (late 1970s and 1980s)

Several factors combined to usher in the microcomputer era. When the microprocessor was introduced in the late 1960s, technology became smaller and less expensive. Minicomputers, and later microcomputers, required less-specialized facilities, and the expertise required to develop, maintain, and operate local IT systems grew more prevalent. Finally, business managers began to recognize that the data generated by IT applications was becoming crucial to effective decision making and work at the local level, and they wanted to interact more directly with the data to create information. The ability to place computers within users' hands gave managers the power to *regain* control over information.

Early data processing applications tightly coupled organizational data to the computer programs that processed them. As a result, the organization tended to lock itself into its current way of doing business. If a manager or local decision maker wanted to view information differently or change the way it was processed to reflect changes in the business, costly and time-consuming revisions by systems development professionals were required. Forward-looking companies began to realize that centralized information processing and control no longer fit with the decentralized use of business information.

With the introduction of small-scale computer systems—initially minicomputers and desktop computers, and then laptops and personal digital assistants (PDAs)—users gradually took back control of their information. New uses for these locally managed technologies grew rapidly. Personal computers and spreadsheets automated planning, budgeting, and information reporting; personal/portable technologies (e.g., notebook computers, PDAs, fax machines, cellular telephones) and associated software to support collaborative work collapsed the geographic and time barriers that defined "workspace" and "worktime"; point-of-sale and automatic credit card scanners automated the sales process; and digital machine control and CAD/CAM (computer-aided design and manufacturing) automated production systems. "Islands of automation" sprang up within factories, work groups, and on the desks (and in the briefcases) of individuals throughout the organization. The decentralization of computing diffused awareness of IT throughout the organization and began to erode the dominance of the central mainframe computer (and the central IT function that managed it). This all happened very quickly.

With the arrival of local information-processing technologies and user-friendly application development packages, business users gained control of an ever-increasing portion of organizational information processing and management—but not all of it. Microcomputers did not replace mainframe systems. Instead, they were *added to* the existing centralized computing environment, and tradeoffs concerning which technologies and applications would be managed centrally by the IT organization and which would be managed locally by the end users became a constant source of friction. The problems reached a peak as the strategic value of information for many firms increased in the mid to late 1980s.

Era 3—Distributed Information Systems (late 1980s to present)

Fueled by the increased understanding that stemmed from "hands-on" experience in IT use at the local level, improved networks for sharing information inside and outside the firm, increased complexity and rate of change within the business environment, and the actions of a few

visionary managers within information-intensive industries, business managers in a number of industries began to identify strategic opportunities for using IT to shift the balance of power and competitive position of their firms. Senior management took notice—and what they saw concerned them. While the strategic benefits of IT were clearly evident, the *cost* of IT had skyrocketed during the mid to late 1980s.[5] The need to share information locked within decentralized IT systems had similarly increased rapidly, and pressures such as gaining access to local information and controlling locally managed IT resource spending coincided with (and spurred the continued development of) improved network capacity, performance, and management systems.

Thus by the 1990s, we entered the world of distributed information systems and *client/server computing*—a world in which users could access and communicate information through a wide variety of powerful workstations and portable technologies (*clients*) linked to shared information and communication services (*servers*) through high performance local and global networks. (See *Doing Business in a Distributed IT Environment: Clients, Servers and the Stuff in Between*, HBS No. 195-211, for a more in-depth discussion of client-server technologies.)

In this IT era, the centralized mainframe (often called the "enterprise computer") takes its place alongside a wide variety of desktop workstations and minicomputers as merely one more "server" on the network—albeit a powerful one. The servers are the specialists, assuming control of a wide variety of information management and communication functions. For example, a company may create a customer database server that integrates, maintains, and controls access to corporatewide customer information; another server may be created to integrate, manage, and control manufacturing production and performance data; while still other servers manage and control communication and information sharing inside and outside the firm. The clients are the generalists, providing access to a broad range of tools—for example, information reporting, spreadsheets, e-mail, and video conferencing—to help people inside and outside the firm get access to the information they need and communicate with the people they need to reach.

The ideal client/server computing architecture provides an "open system" view of the world. This means that, in the ideal, a wide variety of hardware and operating system software—all of which must conform to open system standards—could be hooked in, enabling tremendous flexibility in technology choices today and in the future. (It is important to note that, while many companies strive to achieve this type of flexibility in the *design* of their architecture, most voluntarily limit the actual choice of hardware and software in its *implementation* to decrease cost and complexity.)

Client/server computing fundamentally changes how people interact with each other and with the technology itself. The magnitude of the shift is comparable to the change in the nature of long distance travel by rail or by car.[6] Consider a trip from Boston to Denver.

A journey by train takes place in a controlled and scheduled environment. You board the train at a specific station in Boston and anticipate arriving at a specific station in Denver at a specific time. You find a seat and relax as the train rolls down the tracks, making predictable stops along the way. If you get bored with the scenery on the trip, you can sleep, but are limited to the accommodations provided for you in the sleeping car. If you get hungry, you can eat, but again are limited to the food provided for you in the dining car. If you change your mind and wish to explore an interesting city en route, you must abandon your previous plan and get off the train. When the

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[5] In *Waves of Change*, pg. 25, McKenney reports that between 1982 and 1986 the use of personal computers quadrupled the total information processing power within organizations.

[6] This analogy was originally developed by Geoffrey Bock. See Bock, G. and Applegate, L., *Doing Business in a Distributed World: Clients, Servers, and the Stuff in Between* (HBS No. 195-211).