EVERY MANAGER'S GUIDE TO INFORMATION TECHNOLOGY

A GLOSSARY OF KEY TERMS & CONCEPTS FOR TODAY'S BUSINESS LEADER

PETER G. W. KEEN

EVERY MANAGER'S GUIDE TO INFORMATION TECHNOLOGY

New Edition Featuring 40 New Terms!

Every business leader must become computer literate.

"Every business leader must become computer literate. The atmosphere of the office in which they work will change drastically in the future. The "new" atmosphere will be shaped by the world of computing. To be effective, managers must understand the new language of information technology, and how it affects business operations. This book provides an overview of the current state of information technology and helps managers grasp the concepts behind it. It is an essential guide for anyone in a management position.

The book is divided into four main sections:

1. Introduction
   - Importance of Information Technology
   - Overview of Key Terms

2. Understanding Technology
   - Computer Hardware
   - Computer Software
   - Networking

3. Managing Technology
   - Project Management
   - Budgeting
   - Change Management

4. Conclusion
   - Future of Information Technology
   - Relevance to Business

This book is highly recommended for anyone in a management position who wants to stay informed about the latest developments in information technology and how they impact business operations.


PETER G. W. KEEN

The current state of information technology is rapidly changing, and managers must keep up with the latest developments to stay competitive in today's business environment. This book is a valuable resource for anyone in a management position who wants to understand the impact of information technology on business operations. It provides a comprehensive overview of the key terms, concepts, and trends in information technology, making it an essential guide for managers in today's business world.
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SECOND EDITION

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For my daughter, Lucy,

"A violet by a mossy stone, half
hidden from the view"

I miss you, kiddo, so much
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Preface

I described the first edition of this book, which appeared in late 1991, as a guide for managers in a strange city or country, which is what information technology (IT) still is for many. Every Manager’s Guide is a road map of the key terms and concepts of information technology. This core language is directly relevant to business managers so they can use IT effectively as a business resource and make informed choices about investing in it. That language is as essential to their management skills as the language of accounting and finance. Information technology is now a major force in business integration and restructuring—an integral element of service, coordination, organization, and the drive to reposition U.S. businesses to meet the challenges of what may be termed the “Cruel Economy”: an era of eroding margins, global competition, quality and service as the entry fees to the competitive arena, and of overcapacity in increasingly more industries, and information technology as frequent subverters of the status quo.

Twenty years ago, the issue for companies was to manage the technology. This meant that the technical professional spoke the language of IT. As a result, the IT field began to proliferate acronyms and jargon. Here the language of IT was purely technical, owned by the technicians who—some managers might say—
sometimes used it to maintain control. This was the era of the IT specialist as "High Priest," managing rites of development and operations that rested on incantations about JCL, threaded lists, ABENDs, and hex.

Some ten years ago, the new issue for companies was managing the use of the technology. Office technology, personal computers, executive information systems, and the like began an organizational glasnost, where more and more people directly used computers on their desktops and in point-of-sale registers, as well as for making airline reservations, using automated teller machines, and effecting electronic funds transfers. These functions moved IT from the periphery of the organization and industry competition to its center. At that time, the language of IT primarily focused on a small subset of technical terms, such as DOS, e-mail, LANs, spreadsheets, and Windows.

Today the issue involves managing the technology, managing the use of the technology, and managing with technology. It is this last task that is the focus of Every Manager's Guide, Second Edition. IT is now a basic part of the fabric of everyday business and thus part of everyday business language. The challenge is to narrow a seemingly infinite set of terms to a manageable subset. In the first edition, that amounted to a little more than 150 terms.

This new edition updates and adds nearly 40 new terms, providing new examples and figures on costs, trends, and impacts. In both refreshing the original Glossary and adding new terms, I have addressed the competitive as well as the technical changes in IT. These changes have been astonishing, and business managers need to understand their key aspects because they open up major new opportunities and pose major new risks and pitfalls. In many instances, a business's choice of strategy in key areas of managing with technology rests at least as much on assessing competition, trends, and innovation among suppliers as on assessing technology.

In the area of technology, this new edition puts more emphasis on wireless communications. In the first edition I state, "There
can be no doubt that wireless communications will be an explosive growth area sometime in the 1990s. . . . This is a little like Hollywood in the 1920s; someone will get very rich, but who?"

The "explosive growth" is at hand. At the end of 1993, when I bought my AT&T EO machine (which includes a cellular phone, e-mail, digital fax, handwriting scanner, sound annotation, and a calendar manager), I was in awe. I saw that we are already as well into the wireless era as the Apple II took us into the PC decade. The "someone" who will get very rich remains unclear as yet, but there are many players, few of whom existed in 1991: the combination of AT&T and McCaw, the latter being a company with no profits ever that AT&T bought for $12.6 billion; the powerful global player created by BT's acquisition of 25 percent of MCI; and Bell Atlantic, one of the notoriously slothlike local telephone bureaucracies, that unsuccessfully attempted to acquire TCI, the infamously aggressive nationwide cable-TV provider. In the field of computers, the old oligopolists—IBM, Digital Equipment, Wang, and others—are all facing trouble if not disaster. The new competitive battles involve such relatively new names as Microsoft, Lotus, and Novell; these are mostly start-ups of the 1980s.

For managers to understand IT or take part in planning for its business deployment, they must understand this new competitive context, and Every Manager's Guide to Information Technology would be incomplete without including it. Any reliable guidebook must be updated periodically to capture such trends. The field of IT now has the same stability, predictability, and sometimes illogicality as the U.S. federal tax code, with its annual umpteen pages of updates. This new edition of the IT guidebook synthesizes trends and changes in mind-sized chunks rather than technical overkill.

My goals in this extensively rewritten and revised new edition are as I stated them in the Preface to the 1991 edition:

Rather than merely give definitions, I provide business examples, business interpretations, and assessments of the business
implications of technical terms. I have aimed at being simple, but not simplistic; selective, but not misrepresented; and rigorous, but not pedantic or overdetailed. I have also tried to make the Glossary interesting and readable: a frequent blockage to business managers' understanding of IT is the way in which an exciting and fascinating field is made to appear boring, obscure, and intimidating.

These remain my goals.
Introduction

Information technology—the combination of computers, telecommunications, and information resources—is fundamentally about businesses making change an ally rather than a threat. The technology itself is constantly changing with significant developments emerging literally every month. The main challenge for organizations once was managing the technology; that was when technology was almost a separate fiefdom within the company, focused on large-scale hardware and transaction processing systems. More recently, the challenge has been to manage the use of technology, with personal computers and telecommunications opening access to IT-based services to more and more communities inside and outside the firm.

The newest challenge is the one this book aims at helping nontechnical people meet; managing with technology, comfortably handling it as part of everyday business and as an integral business resource similar to human resources or accounting. It is close to impossible now to find any area of an organization—customer service, distribution, finance, marketing, or production—where strategy, planning, and operations do not depend heavily on some aspect of IT, as either a competitive necessity or an opportunity. In that context, business choices have technology
consequences and technical choices equally have business impacts.

We need managers and IT people who can work together, and they need a shared language. Technical specialists can easily find ways to absorb the well-established languages of business—the main blockage to their doing so is generally one of attitude and choosing to stay stuck in the old mindsets of data processing as a high priesthood and programming as its main rite. It is far harder for business managers to identify and understand the key terms and concepts of the IT field and to recognize their implications for business planning and decision making.

The story of information technology is a story of nonstop change. The rate of change, in business and organizations as well as in the technology itself, is obvious. The on-line society—in the form of automated teller machines, computerized reservation systems, computer-integrated manufacturing, and point-of-sale transaction processing—is emerging rapidly; the "networked" organization is moving from cliché to possibility to practicality, with telecommunications playing an increasing role in coordinating geographically dispersed operations. Today there is little we might predict about IT that would seem implausible.

Internationally, as well, information technology is a force for change—social, political, and economic. The world bore witness, via telecommunications, to major events as they happened: first in Tiananmen Square, then in Wenceslas Square, and, more recently, in the Persian Gulf. A new international economy is rising on the shoulders of information technology; daily, more than $1 trillion is moved by electronic funds transfers and more than $300 billion by foreign exchange transactions. By contrast, the total world trade in physical goods is about $4 trillion a year—less than a week's worth of international funds transfers.

IT is a business force now. It amounts to one-half of U.S. firms' annual capital expenditures and increasingly affects how firms organize, do business, and compete. Business managers who choose not to reckon with it do so at their and their firms' peril.
The Vocabulary of Change

IT, like many other disciplines, has spawned a bewildering array of terms and concepts. This book presents these from the perspective not of how much, but of how little business managers need to know about the technology to manage IT as effectively as they manage money, people, and materials. Because delegating most aspects of IT planning to technical specialists and consultants was the norm in almost all companies for nearly 40 years, information technology has not been as natural a part of business managers' everyday language as financial terms and concepts.

Often, business managers must sign off on IT recommendations that they cannot fully assess. They are told that "electronic data interchange" is a growing competitive necessity, but that there are many different "standards," that the firm needs an "architecture," and that "local area networks" are a core requirement for a particular department, but there are problems of "incompatibility" between the departmental "LAN" and the corporate "data-base management systems." How can they sift through the necessary jargon and zero in on the key business implications and options?

Telling business managers, as many have, that they must become "computer literate" is a little like telling them that they must become automobile literate in order to operate a car. One does not need to comprehend the mechanics of the transmission system, engine, and catalytic converter to drive well or do transportation planning effectively. A core vocabulary of terms and an insight into the relationships and trade-offs among a few of them will suffice. Literacy focuses on what, fluency on why. This book aims at helping the IT manager become fluent in IT. Thus it answers not only the question "What is a local area network?" but also "Why is the choice of a local area network important to our business strategy and performance?" and "What issues do we as business managers need to know about to make sure that the planning and decision making for local area networks meet business, economic, and organizational as well as technical needs?"
Responsibility for answering such questions has traditionally been delegated to people well equipped to reply to the first, but with little knowledge to bring to bear on the second or third questions. Delegation is not a strategy. Too often it amounts to abdication—of opportunity, control, and responsibility. Delegation is a reasonably safe approach as long as IT remains peripheral to business and organizational growth and health. The management logic is to let the “experts” decide. Today IT affects virtually every area of business. Hence virtually every manager must be an expert, or at least know how to draw on experts’ judgment.

Change can be a threat or an opportunity. It can be anticipated or reacted to. IT and change are now synonymous. In many industries, taking charge of change is impossible without taking charge of IT. A shared language is the starting point for doing so. In accounting and finance, for example, business managers must be familiar with a few fundamental terms, such as overhead, depreciation, and marginal costing. Lack of awareness of, say, the difference between marginal cost, average cost, and allocated cost can easily lead to incorrect business judgments. But business managers need only understand what depreciation is, not the detailed formulas for calculating it.

We take this knowledge of the basics of accounting for granted in business managers. In its absence, planning and decision making are almost sure to miss their targets. This often occurs in Central Europe and Russia, where highly placed managers and government officials are unfamiliar with these basics. U.S. executives, consultants, and educators doing business there are continuously frustrated with obstacles to dialogue, misallocation of resources, and breakdowns in planning that the lack of business basics creates.

Examples abound of how blindness to the basics of IT can impede dialogue, resource allocation, and planning. Consider the concept of “integration,” which is fundamental to the effective
deployment of IT. Today Information Services managers are wrest-
ling with immense operational problems created by “incompati-
bility” and trying to develop coherent “architectures.” Integration
refers to the linking of individual IT components and services for
the purpose of sharing software, communications, and data re-
sources. Incompatibility is diametrically opposed to integration;
architecture is the blueprint for achieving it.

Many business managers, seeing such terms as excuses for
creating a new IT bureaucracy, are likely to make decisions about
individual components and applications—for instance, review their
department’s needs for personal computers—on the basis of cost
and features. This is common sense. Only later, when the depart-
mental system does not link directly to the firm’s major process-
ing systems and data resources, do these managers discover the
hidden costs of incompatibility and inattention to architecture.
So they add more software and equipment to enable the personal
computers to access the corporate information resources, only to
find that cross-links between business services and transactions
are blocked because each has a separate technology base. Remov-
ing the blockages often involves redesigning and rebuilding all of
the systems.

This manager’s guide illustrates how and why these problems
occur, as well as identifying the major components of the IT
resource. It highlights the issues business managers face in making
trade-offs between meeting immediate needs through individual
applications and anticipating future needs that can be met
only with an integrated architecture.

It is as easy for today’s U.S. and European business managers
to view terms such as architecture, integration, and compatibility
as technical abstractions as it is for Russian managers to see
depreciation and marginal costs in the same light. Therefore
many firms spend enormous sums to rationalize a muddle of
multitechnology, multivendor systems that cannot share informa-
tion and communications. A whole new industry of "systems inte-
grators" has developed in the past few years to address the frequency of system incompatibility, which results in cost and blockages to business progress.

It is not unusual for a large firm to have as many as 100 incompatible major systems and 40 incompatible communications networks. When business functions and departments were largely independent of one another, this was not a major problem; a firm's financial system did not need to cross-link to distribution and manufacturing, for example, nor did its European purchasing system need to share information with its U.S. production system. Once a firm establishes these connections—and if the technology is there, some firm is bound to do so—its competitors are at a disadvantage for as long as they fail to follow; and the longer they wait, the more difficult it becomes to follow, because each year sees even more incompatibilities created.

It is not unusual for business managers unfamiliar with the exigencies of integration to be told that particular standards, vendors, software, and more recently, "client/server" computing can end their problems immediately and forever, only to discover that the tidy consultants' or vendors' presentations contain more theory than reality and obscure many important practicalities. It is here that the jargon of IT can be overwhelming. The need to cross-link business services often gets sidetracked from business issues to discussions of UNIX, OSI, X.25, SNA, C++, X.400, NetWare, SQL, and other bits of the IT alphabet soup. Each term has a precise and important meaning; each is necessary to technical planners and implementers. Indeed, it is as unfair to criticize IT professionals for indulging in technospeak as it would be to fault bankers for moving from simple business discussions about investing spare funds in short-term, interest-yielding instruments to esoterica about Fannie Maes, Ginnie Maes, T-bonds, CDs, hedge funds, derivatives, and so forth.

IT professionals, like any specialists, need a specialized language for hammering out details and communicating with each
other. Many such jargon-filled encounters leave business managers perplexed because the discussions are not dialogues. The manager has no context for the technical terms, and, alas, too many IT experts are ignorant of business issues and language, particularly about costs and organizational factors that affect the outcome and value of IT investments. Often they are very assertive about issues that in practice are controversial and uncertain. For example, what does “client/server and downsizing are essential in replacing our mainframes and legacy systems” mean to a business manager? It’s assertive, confident, and unfortunately opaque. As a result, business managers may feel that a technical recommendation or prediction is the truth, that implementation is easy and automatic, and that the proposed investment is the only way to go. They are listening to a monologue instead of participating in a dialogue.

No one today can be thoroughly familiar with IT terminology; the field has become so broad that even experts are often unfamiliar with terms outside their area of specialization. The worlds of computers and telecommunications, in particular, have evolved along separate technical and organizational paths. As a result, few specialists in either area are conversant in both.

Effective dialogue—between business managers and technical specialists, as well as between technical specialists in different areas—rests on a shared understanding of a relatively small number of key concepts and terms, as was pointed out earlier in the examples of accounting and finance. Without this rapport, advisers and clients, managers and IT experts, can work together only on a “trust me—take it or leave it” basis. The stakes have become too great and the pace of change too fast for such delegation to be a viable choice for managers for whom IT has become a part of their core business.

Hence I have prepared this management guide—a deliberately selective glossary of a small fraction of IT terms and concepts. This guide not only provides definitions, but it helps man-
agers understand which of the terms are essential to computer fluency and how they relate to major IT choices and options from a *business* perspective.

The problem with a comprehensive glossary of IT terms is that it does not help managers sort out which terms are key to their activities and which terms they can ignore. Here is an example: one published glossary of more than 5,000 terms assigns equal importance to “V.21” and “X.400.” From a technical perspective, V.21 (which refers to how computer equipment links to a telephone network) is more important than X.400 in many companies’ IT planning. But from a business perspective, X.400 is a major development that opens up many business and organizational opportunities. (Please look it up in the Glossary.) A basic aim in evolving this Glossary is to highlight the terms that, when understood, assist managers in recognizing business opportunities, making sound decisions, and establishing effective dialogues with IT planners and managers.

That makes this a book about business, not about technology.

**Evolution of the IT Management Process**

An underlying theme in the Glossary is the management process of IT in organizations. Understanding this helps explain some of the problems that business managers see in how, for example, IT costs are handled, how new information systems are developed, how changes are made to existing systems, and how new technologies are introduced.

Many of the planning and accounting procedures, attitudes, and relationships in place today in organizations reflect a 40-year tradition of delegating information systems management and of handling IT costs and planning as budgeted overhead. The management process has not kept pace with technology—its uses and pervasive impact and the policy decisions needed to make it effective. As a result, professionals and business managers face one another across a gulf of unfamiliar language and culture and frequently experience mutual frustration trying to bridge it. A
shared language helps, but more important it is a shared understanding of the issues that underlie the decisions. To merely define integration and architecture, for example, gives little insight into what these elements mean for the planning process or business managers' contributions to it.

In retrospect, we can identify four fairly distinct eras in the evolution of IT in organizations:

- Data processing (DP) (1960s)
- Management information systems (MIS) (1970s)
- Information innovation and support (IIS) (1980s)
- Business integration and restructuring (BIR) (1990s)

Many of today's IS management practices were created in the MIS era and are now being adapted to meet the stresses and challenges of the IIS era. A relatively small number of firms are well positioned to use IT as a business resource that can help them rethink and restructure their organizations and business operations. (I estimate that perhaps 10 percent of the Fortune 1000 are at or almost at that stage, with a slightly higher percentage of smaller firms less constrained by old management practices of managing IT. These smaller companies began their deployment of IT as a business resource with the personal computer, not with large, centralized corporate data processing units.)

**The Data Processing Era**

Computers first became economically attractive for large and medium-sized companies in the 1960s. They were very expensive, very limited in application, and incompatible with every other computer until well into the 1970s. The word "incompatible" was assumed and therefore rarely used.

Developments in computer use were hardware driven, relying on improvements in equipment costs, capacity, and speeds; applications were built from scratch, as the third-party supplier of packaged software was not yet in existence. Telecommunications was confined almost entirely to telephones until the 1970s, when
"voice" phone lines began providing access to computers from remote terminals. The transmission techniques for early data communications were slow and expensive. Because telecommunications was entirely regulated and choices of technology restricted, companies had no need to develop in-house technologies beyond operational telecommunications skills. Telecommunications was an operational backwater; the action was in data processing.

The economics of computer use during this era pushed firms toward automating large-scale clerical activities—hence the label "data processing." (Staff at a number of U.S. government agencies still routinely speak of ADP—automated data processing.) Payroll and accounting applications were natural targets of opportunity. If a computer that cost, say, $5 million could be justified only by the large numbers of fairly low-level administrative or clerical staff it displaced, then the natural starting points for data processing were clerical activities that involved repetitive, high-volume transactions based on applying automatic rules, calculations, and procedures.

Automating these functions was much harder than anticipated. Computer programmers with little if any business experience, interest, and aptitude had to wrestle with a new and complex technology, developing methods as they went along. The field was young, as were the people in it. Their value to the business—their analytic skills and infatuation with the technology—also became their limitation. They tended to be intellectually and attitudinally unable to put themselves in the shoes of "users," who were frequently afraid of losing their jobs or influence because of computers and of looking foolish because they did not understand them, or were annoyed at the condescension of programmers. The research literature in the IT field in the early 1970s frequently identified "resistance to change" as a major explanation for the frequent organizational failure of systems that worked technically. There is plenty of evidence that much of this resistance was to computer people, not to computers.

DP developed as a specialized staff function isolated from the
business. The isolation was both psychological and physical. Many companies placed their DP units in new buildings designed to house large computers; those were frequently many miles away from any of the business operations; DP people rarely saw their users.

Even when they did, their main concerns were with the day’s DP problems. Taming the technology, developing systematic project management methods, absorbing a flood of new programming languages, and managing operations consumed DP’s resources and attention. The head of DP was almost invariably someone who had come up through the ranks in the programming field. He—there were very few she’s at the top in DP, even though this was the first major business field in which skilled women were welcomed because of the often desperate shortage of capable staff—operated a factory dominated by systems development, central operations, and increasing investments in “maintenance,” a somewhat misleading term for the work needed to keep existing systems functioning effectively and efficiently. When the tax law changed, the payroll system had to be modified; the firm could not say, “But we like the old tax laws; we’ll keep them.” Few if any experts in DP ever anticipated that maintaining old systems would consume more effort and resources than building new ones. In the 1990s, those old systems are a concrete block on the feet of Information Services desperately trying to meet the business demand for new ones.

Except when a major systems development project affected their sphere of authority and responsibility, business managers had little interaction with DP. Generally, the people who worked with DP in specifying systems were lower-level supervisors. Frequently, busy business units were reluctant to release their best staff to work with DP, and the people assigned were those who were expendable. This hardly improved the quality of design.

Because fully half of application development projects badly overran their budgets, failed to perform satisfactorily relative to expectations and needs, or were abandoned before completion,
business executives tended to view DP as a problem rather than as an opportunity. Furthermore, because it was both a new field and peripheral to the mainstream of business, it was not an attractive career option for most business managers. It had been neither part of their college and management education nor part of their personal development.

It was a frustrating situation for the best data processing professionals, who very often had outstanding analytic skills and were ferociously hardworking, self-motivated, and honestly committed to delivering first-rate systems. Their explanations of the frequent software development foul-ups highlighted users' inability to determine their needs and to decide on specifications, and their unwillingness to commit their time, knowledge, and prestige to the project. It was in this period that computer people began to be seen as "different" from businesspeople.

They also were seen as expensive. Business managers came to view DP as an escalating cost, to be carefully controlled. This control was achieved principally by allocating costs on a formula basis to the departments that used the DP organization's services. Allocations were generally charged out so that DP expenses were fully recovered. Some firms ignored allocations, instead absorbing the costs centrally, with systems development projects paid for by the targeted business unit.

For many business units, "chargeouts" were frustrating; unit managers could not control IT costs, did not see much value in IT, and felt that IT professionals were not only too highly paid, but also far too ready to move on to the next lucrative job in the programmers' boom market of the 1960s through the mid-1980s. IT allocations were like a corporate property tax on business units.

The technology of the 1960s and 1970s was characterized by large economies of scale. A reliable rule of thumb was that a computer twice the cost of the one in place would provide four times the power. This naturally led to an emphasis on centralization and to planning based on hardware-driven decisions. Be-
cause it was expensive, hardware was treated as a capital item; the
less-expensive staff resource became an annual expense.

Because development was not viewed as a capital item, few
firms, even today, have any idea how much has been spent to
create the software systems they use. The accounting system ex-
pensed salaries for development and maintenance staff as well as
operators. As a result, firms did not track the relationships be-
tween these cost elements over the life cycle of a major system.
Today, firms are discovering that most of the costs of IT are
hidden. For instance, the costs of support and training to use a
personal computer are far higher than the purchase price, and
the cost of developing a system is often a fraction of the cost of
operations and maintenance.

In the DP tradition, spending on computers is largely deter-
mined by an annual budgeting process. Next year’s budget is set
by aggregating business units’ requests for new systems, compar-
ing the firm’s own expenditures as a percentage of sales with that
of comparable companies, and capping the budget increase at X
percentage. In a good year, X goes up; in a tough year, it is held
constant or cut. The systems development and operations plan is
fine-tuned within these parameters.

The heritage of the DP era remains a strong force in many
firms. The following are among its remnants.

Naive chargeout mechanisms that block investment in longer-term
infrastructures. If costs must be fully recovered and there is no
central funding, the initial users must bear the total investment.
Today, users can often find less-expensive alternatives in increas-
ingly cost-effective personal computers, departmental communi-
cations, and off-the-shelf software. Cost allocations and recovery
schemes are two of the major impediments to integration and
architecture, because they discourage long-term investments in
infrastructures that must be paid for by the early users.

A broad gulf between senior business managers and IT managers.
Typical 40- or 50-year-old executives—for whom computers were
not part of their education, not part of their move up the management ladder, and, in their new-found senior status, not a necessary personal tool—are ill prepared to play an active role in major IT policy-making and planning. "I am proud to say that I have worked in every single area of the company except computers and that will be true when I retire," the CEO of one Fortune 100 company boasted publicly. More common is the manager who says, "I am too old to learn about computers."

A firm grounding in computing. At one time, computing provided the main body of experience, expertise, and authority for information technology; telecommunications played almost no role. But this scheme has shifted rapidly. Yesterday's add-on is today's infrastructure. Telecommunications today is the highway system over which the traffic of an increasingly distributed resource travels.

A continuing bottleneck in software development and the burden of old systems. DP lost much credibility because it so rarely delivered on its promises. One leading authority, Frederick Brooks, who led the development of one of the largest civilian software development efforts ever when he worked at IBM, coined the term "the mythical man-month" to describe programmers' estimates of how long a project would take; typically, the figure was well over 100 percent too optimistic. Successes in systems development were overshadowed by delays, cost overruns, and bugs for most of the 1960s and 1970s. Large-scale software engineering is a difficult craft even today; the experiences of those years persist, but not for lack of effort, skill, or commitment on the part of development staff. The process is inherently complex and software productivity continues to lag behind other areas of information technology. It is growing in complexity, too. The new style of design called client/server computing combines every IT element—old and new, proven and unproven alike—to create an integrated, cost-efficient service and information base. This is the challenge for the 1990s.
The Management Information Systems Era

With most basic clerical and accounting processes automated by the mid-1970s, the focus of attention in Information Systems shifted to designing and building reporting systems to meet managers' information needs. These efforts were largely flawed for two reasons: limitations in the technology and the mistaken equating of "information" with "data." The technology of this period was still that of the data processing era—large, expensive, inflexible computers that generated enormous volumes of typically historical, highly detailed, accounting-based data. The rationale of MIS was to organize and present this data to managers, assuming almost by definition that the more data they had the better.

In practice, the data met few managers' needs; for example, because reports generally lagged events by several months, they were of little value for competitive analysis or for spotting trends and problems early enough to react constructively. Moreover, accounting data yielded only limited information for management decision making. Its primary value was for planning and administration. Changes in the technology gradually opened up new opportunities for turning data into information and tailoring systems to meet managers' real needs.

One important new tool for doing this was the computer terminal, which for the first time permitted flexible, occasional, and ad hoc access to central information stores and to "time-shared" processing on large computers. Time-sharing was an innovation that allowed a large computer to process many tasks (or jobs) simultaneously by giving each a small slice of time and going from one to the other very quickly. The result was that many people doing different work at the same time could be "logged on" to the computer. Given the economies of scale of computing, this encouraged the growth of time-sharing "bureaus" that could offer services individual firms could not afford. Time-sharing is still the base for today's airline reservation systems and automated teller machines, though more and more of the processing is
shared between "client" software and hardware that requests services from "servers." With time-sharing, the central computer handled all processing. Now, a personal computer (client) can input your travel reservation information, check for errors and completeness, and send the information to the central time-shared computer, which stores data on seat availability. This distribution of tasks from mainframe to local devices and sharing of resources between clients and servers is the basic driver of every trend in the use of IT in organizations today—and will remain so for the next decade.

Another useful tool that emerged in the 1970s to help speed up the development of systems was packaged software—sets of programs written by third-party developers. Most of these packages addressed needs that did not require company-specific software development, such as report generation, financial modeling, and general ledger accounting. The combination of time-sharing and flexible packages and modeling languages stimulated rapid innovation in what would be termed "decision support systems" and "end-user computing," a process that personal computers accelerated principally because the operating costs of time-sharing were high and those of personal computers low.

Nearly all of this innovation occurred outside the central MIS units, mostly in the finance or marketing departments where small teams of business-oriented planners picked up the new tools and applied them imaginatively. Management Information Systems groups, like the mainstream technology they controlled, remained monolithic. The problem of balancing control and innovation led to continued crisis for MIS throughout the mid-1970s. When computers first came into companies, few if any control groups managed them, and the most effective units were those that encouraged experimentation. But to the extent that they managed to "sell" the wonders of the new technology, they created a demand that they could not reliably meet. Experimentation too easily became chaos. Costs escalated. Planning proce-
dures were informal, at best. Software development was an ad hoc process, with undocumented, untested, and unmaintainable “spaghetti” code a frequent result. Testing and maintenance were neglected as the overcommitted DP group tried to catch up with a systems development backlog that averaged from three to five years of resources.

The MIS era saw efforts to introduce discipline and professionalism and to control MIS costs and resources more sensibly. Too often, control created bureaucracy. With MIS wrestling with major changes in technology, continued and growing problems in software development and project management, and senior executives interested in getting costs under control, the Information Systems function found itself increasingly on the defensive. MIS staff rarely understood the business, and few business executives understood MIS.

Most stereotypes of computers and computer people date from this period. Remember “Do not fold, spindle, or mutilate”? Were you among those who received bills for $00.00 and subsequent notice that legal proceedings would be initiated if payment were not forthcoming? Maybe you were one of the managers who received massive computer printouts of monthly reports that went straight into the trash. At the very least, you were probably informed in response to an inquiry that “the computer made a mistake.”

Given that during this era most innovation occurred outside the MIS area, it is not surprising that MIS professionals became frequent resisters of change. The widespread early opposition of most, though by no means all, central MIS staff to the introduction of personal computers in the early 1980s was a case in point. MIS staff wrote off the new “micros” as machines for amateurs, viewing themselves as the “experts” on matters relating to computers; they worried, justifiably, about problems of testing, documentation, and security.

If this summary of the MIS era sounds negative, it is because
little of a positive nature occurred during the period. The field of MIS ossified at a time when office technology, end-user computing, and decision support systems began to flourish. MIS became stuck in an organizational, technical, and attitudinal rut; it failed to build a constituency (few business units viewed the traditional MIS group as more than a necessary part of operations overhead); it had no strong management sponsor.

Although the problems MIS faced were sufficiently complex to persist today—notably large-scale software development and maintenance of old systems—MIS was not without substantive achievements. Its principal technical development was the shift from transaction processing to data base management. In the DP era, the main challenge was computer programming, which relied on quirky minds to develop immensely detailed and precise instructions to carry out even simple transactions or generate reports. Data files—weekly payroll records, customer history files, or purchase orders—were organized for processing efficiency, and data were frequently duplicated. A bank, for example, would store customer names and addresses in each pertinent master file for such business applications as checking accounts, mortgages, and savings accounts. Changes of address had to be entered in each file.

Inconsistency, redundancy, and duplication of data became commonplace and contributed to the bureaucratization of the MIS function, adding considerably to the data administration burden of user departments and customers.

The MIS era saw the creation of the concept of data-base management systems (DBMS), an innovation that has evolved slowly but consistently over the past fifteen years. With a DBMS, data are organized in much the same way as books are in a library. Information, such as a name and address, is stored in only one place, on a computer tape or disk. The DBMS software includes the equivalent of the library's index of authors and subjects. A transaction processing or report program requests the customer record, which the DBMS retrieves, just as a borrower uses the
library's card catalogue to locate the shelf and unique reference number for a book. Any number of programs thus access the same data items, instead of storing them many times over in separate files. When information such as a customer's address is changed, the DBMS locates the relevant item and updates it. The DBMS will also check for errors and handle such aspects of security as providing access to information only to authorized users.

A library catalogues books by title and subject, but not by chapter. The evolution of DBMS has been toward the most detailed level of indexing—the equivalent of indexing a book by phrase or word. Initially, data were organized in records; a customer master record might contain many data items, including last name, first name, middle initial, social security number, home phone number, and so on. Early DBMS accessed information at the record level. "Relational data-base management systems" now access it at the item level and allow very complex searches through data bases in order to answer such questions as, "Show me all the customers in ZIP code 20007 with outstanding balances of more than $500 who own their own homes."

Data-base management software incurred substantial processing overhead and, for most of the MIS era, was too expensive for many applications and completely impractical for major transaction processing systems. But in shifting the focus from programming to data and data management, the genesis of data-base management systems marked a turning point in the role of Information Systems organizations. More and more, IS has become a cornerstone in the balanced coordination of key, shared, corporate infrastructures, and decentralized use of IT. With this shift, the old centralized data centers housing mainframe computers have been turned into information libraries. The computerless office has equally turned into a data center, with PCs, telecommunications, software packages, DBMS, printers, and disks. This "distributed" resource works cooperatively with the central libraries. The technical, organizational, and economic challenges to
manage this resource ironically depend on many of the old skills of the DP professional.

The Information Innovation and Support (IIS) Era
The history of IT in large organizations has been a pendulum, swinging between extremes of innovation and discipline and thus of emphasis on decentralization and centralization. As the pendulum swung back from the freewheeling days of early DP, it met the discipline of MIS.

Indeed, the MIS era marked the extreme of centralization in computing. And there the pendulum hung, through the ossification of traditional MIS, before swinging back toward innovation and a deliberate lack of overrestrictive discipline, first in the early use of personal computers and then in the transformation of both the technology and its uses that subsequently made innovation the norm. We call this position of the pendulum the era of Information Innovation and Support (IIS).

The swing away from overdiscipline, which began in the early 1980s, was fueled primarily by changes in the technology, most obviously office technology and personal computers. These created an entirely new market for IT. The term “information technology” replaced “computers,” “information systems,” and “data processing,” as telecommunications became the access vehicle for computing services, data-base management systems were opened to proliferating personal computers, and low-cost, do-it-yourself software flooded the market.

Office technology was the first step in the organizational perestroika of IT. Business units purchased word processors from a wide range of vendors; personal computers appeared on the desks of many professionals and some executives; and minicomputers and microcomputers introduced an alternative for departmental computers beyond what came to be called “mainframes.” Not a real option in the 1970s at a price of $5 million, departmental machines were practical at $100,000 in the 1980s and $25,000 or even less in the early 1990s. Time-sharing on mainframes was
expensive in the 1970s and early 1980s, costing anywhere from $20 to $200 an hour.

The microprocessor-based personal computer, as much an economic as technical innovation, boasted an operating cost of pennies per hour. With this technology, the analyst who wanted to run what if? analyses of budgets for ten hours a week no longer had to justify more than $20,000 annually for time-sharing. Initially, MIS units mostly ignored, blocked, or tried to control such innovations. The skill base of MIS rested on traditional programming languages, transaction processing systems, and formal project management methods, all of which remained important and will remain important in the future. Inertia in MIS actually stimulated the shift toward business unit autonomy, reinforced and even hastened by the personal computer. Business managers now had choices outside the old MIS monopoly, and they exercised those choices.

They also looked at computers through a new lens. Just about every major application in the DP and MIS era looked inward, at the company’s own operations. The IIS era looked outward and searched for sources of competitive advantage from IT. Indeed, IT-and-competitive-advantage almost became one word in the early 1980s. Consultants and academics chased after examples of firms that had gained—or that seemed to have gained—a sustained edge over their competitors by using IT.

Some of these examples were overhyped; the advantage turned out to be transitory, or where it was real, the firm got in trouble because of something totally unrelated to IT, thus showing that IT could never substitute for business vision, organization, and management. That said, the new focus on competition, business, service, and customers helped transform the mindset of IS and its vocabulary.

Part of sweeping away the cobwebs came from telecommunications. By the mid-1980s, the technology of telecommunications had begun a transformation that continues to be even more radical and spectacular than that of computers. The telephone
lines of the 1970s, designed to carry voice traffic, were slow, unreliable, and very expensive for moving computer data. Local area networks, fiber optics, satellite technology, and a wide range of new equipment that exploited microprocessors increased the speeds and reduced the costs of telecommunications by factors of hundreds in the 1980s, a pace that looks slow compared with what is happening in the 1990s.

Deregulation of long-distance services in the United States stimulated fierce competition, imaginative new products, technological innovation, and new sources of supply. Large firms were no longer confined to POTS—plain old telephone systems—but could design their own telecommunications infrastructures that could deliver a wide range of electronic services. In addition, local area networks, which inexpensively linked personal computers across short distances within a building, provided a base for explosive growth in departmental computing and data management facilities. The resulting IT resources were more powerful, yet far more cost-effective and easy to manage, than the DP shops of the 1970s.

Together, telecommunications and personal computers liberated the use of IT in organizations. Without efficient and low-cost data communications, decentralized departmental computers could not share information among themselves. To share information across business units and functions, computers had to be centralized. The growing availability of telecommunications led to what is termed "distributed" systems, a combination of workstations linked to midsized departmental computers or central mainframes or both. Computers could now be located anywhere and linked among companies as well as departments.

The combination of frustration with the rigidities of traditional centralized MIS, the ready availability of personal computers and packaged software, and local and wide area telecommunications that enabled them to connect with one another and with larger computers, shifted the focus of IT from automation to innovation. This search for innovation has been explicit and
encompasses all areas of IT. The role of MIS shifted to trying to position IT as a new source of competitive opportunity and advantage, in part by supporting the now-institutionalized, distributed, and effectively autonomous users of personal computers.

Individuals exploited electronic spreadsheets, laptop computers, word processing, and desktop publishing; groups and departments exploited electronic mail, local area networks, and shared data resources; and business units transformed customer service. Companies embraced IT as a way to just-in-time everything: online ordering, computer-integrated manufacturing, JIT inventory; the list grows.

The mentality of the new Information Services units that grew out of MIS shifted from control to coordination and support. The Information Services' view of distributed systems built from the mainframe outward, first linking personal computers to central services and information stores, and then redesigning transaction processing, communications, and data-base management systems to exploit the strengths of each element. The implementation of these strategies is variously termed the "client/server model" and "cooperative processing."

The old MIS career path of programmer to project leader to manager was complemented, and in many instances supplanted, by a career path emphasizing a level of business understanding that was virtually nonexistent before. Growth of knowledge and bridging the attitude gaps between business and IS professionals became priorities. Management "awareness" education programs for senior executives, "help desks" for personal computer users, and IS steering committees were typical initiatives. IS and business units encouraged the development of a new form of hybrid staff, skilled in business and knowledgeable about IT or vice versa. Leading IS managers, increasingly called chief information officers or CIOs, opened the MIS fortress and emphasized business support as the priority for IS. (The renaming of DP to MIS and MIS to IS was not a gimmick but a real effort to signal shifts in the role of the IT unit.)
Today innovation is everywhere, much of it uncoordinated. Many “islands” of IT have been created, partly because business units were able to go their own way rather than depend on MIS, but mostly because the entire technology base, large scale and small scale, has for so long been dominated by “incompatibility.” Every major vendor’s equipment—hardware, software, telecommunications, and data management—has been “proprietary.” IBM and Apple Macintosh personal computers, Ethernet and Token Ring local area networks, Digital Equipment Corporation’s VMS and IBM’s MVS operating systems, and most telecommunications networks were incompatible with one another. There are technical, marketing, and political explanations for this, but the reasons matter far less than the impact.

The most farsighted IS managers viewed with growing concern the fragmentation and incompatibilities among systems across the firm. As long as units remained self-contained islands, lack of integration was not a problem and could even be an advantage in that it enabled them to choose technology solely on the basis of what best suited their needs. But more and more elements of business were becoming interdependent: departments needed to share information with other locations and functional areas, and business units increasingly needed to combine data to create new products and services. Meanwhile, the cost of supporting multiple networks and software escalated. The absurdities of incompatibility meant that personal computers within a department could not even read files that had been word processed on another personal computer, use the same printer, or share a local area network, and efforts to link major transaction processes and rationalize telecommunications turned these simple local systems into organization-wide messes.

Whereas business units naturally placed priority on autonomy, quick installation, and low-cost operation, IS focused on the need for integration, immediately or later. “Architecture” became a key term in IS but not in most users’ vocabularies. The dismal track record of old-line MIS led many users to view “architecture,”
"integration," and "standards" as rearguard efforts to reestablish control. The major barrier to central coordination was the very same tool that provided the most cost-effective IT base for user departments—the local area network. This area of IT innovation was easily the one most beset by incompatibility. The calculus of the 1980s favored innovation at the risk of loss of discipline. But local innovation turned out to have its own costs and limitations, and the pendulum began to swing back again near the end of the 1980s.

The Business Integration and Restructuring (BIR) Era

Today the pendulum is swinging toward an innovative discipline that balances central coordination of key IT infrastructures and the use of IT within these infrastructures with decentralized autonomy in decisions about applications. As the costs of incompatibility became clearer to IT users and providers, the telecommunications community mounted a major effort to create "open systems." Committees defined "standards" that would connect equipment manufactured by different vendors in order to provide various types of services. The user community played an increasingly active role in the standard-setting process, creating a number of de facto standards by its choices of vendors and systems. The IBM personal computer is a ready example of how a "proprietary" system, by virtue of gaining substantial market share, became an effectively "open" one. The success of the IBM PC led other vendors to create "IBM-compatible" products. Legally, they could not fully replicate IBM's hardware, so they built products that ran under the IBM PC's software operating system, called MS.DOS. Today, DOS machines are everywhere; users created this situation through their own purchasing decisions.

Standards, integration, and open systems moved to the top of the IS management agenda in the early 1990s. A new industry of "systems integrators" had emerged that grew at a rate of 20 percent a year, largely because there was so much systems disintegra-
tion to repair. Standard-setting committees focused on ending the Tower of Babel of incompatibility. For the first time, vendors anticipated the need to make sure their systems were compatible instead of trying to lock customers in through proprietary systems in the way that IBM and Apple had.

There are many ongoing efforts by vendors, government agencies, standard-setting committees, and business users of IT to agree on open standards or to ensure that proprietary ones can work with each other and with open standards. For instance, the Open Software Foundation defined a comprehensive Distributed Computing Environment that is a step toward the equivalent of the open systems used in construction—a components approach to designing a house that requires builders to use specific standard materials.

It is highly uncertain whether the many efforts to make IT components this open will succeed, because defining standards takes many years, and implementing standards in real products can take longer—if, in fact, the standard can be defined in the first place, the implementations can be made complete and consistent, the innovations in the technology do not make the standard obsolete, and if the vendors do not add their own special "nonstandard" features. That said, open systems are now the enthusiastic or reluctant target of every major vendor and user.

The question today is how to achieve these open systems. Because the standard-setting process cannot keep pace with the change in technology, there are many gaps in standards and controversies about the implementation potential of many that have been defined.

But the major policy issues in IT, from a business perspective, concern investments in infrastructures. The Information Innovation and Support era largely emphasized applications—new purchasing systems, local area networks, workstations for computer-aided design and manufacturing, funds transfer networks, and so forth. Formal policies on standards, because they were viewed as bureaucratic, tended to be avoided.
Today, with business integration driving technology integration, standards are seen as essential. Insurance firms increasingly rely on shared cross-product customer data resources for cross selling and targeted marketing; more and more customers and suppliers are linking their IT bases through electronic data interchange to eliminate such paper documents as purchase orders and invoices; transnational firms are connecting previously separate international systems in order to coordinate operations across twenty-four time zones.

Leading IT thinkers and practitioners have recently begun to question the ethos of automation that underlies the origins of IT. Terms such as "business process reengineering" and "informate instead of automate" have become the new watchwords of the IT profession in what is becoming part of a general rethinking of principles of organizational design in large enterprises; "teams," "communication," the "networked organization," and "collaboration" are replacing the traditional emphasis on planning, hierarchy, decision making, and control. The restructuring of organizational processes and structures is emerging as a business priority, with IT as a powerful potential contributor, especially through telecommunications, which removes barriers of location and time on coordination, service, and collaboration.

The view of IT as a major enabler of new forms of organization includes new interorganizational relationships and processes, and a mechanism for streamlining and eliminating work rather than automating it. Electronic data interchange (EDI) is but one of many contemporary examples. As more and more large firms insist that suppliers link to them electronically or lose their supplier relationship, EDI becomes less an option and more an imperative.

In the retailing industry, EDI and "quick response" systems have enabled a few firms to reduce to a few days their logistics cycle for ordering and stocking; the gap between the leaders and the laggards is so pronounced that most experts expect that fully half of today's retailers will be out of business by 2001. The "very
quick" response firms in the fabric industry take 10 days from getting an order from a store to delivering the goods, while the "average" response firms take 125 days. The same patterns and impacts are apparent in the logistical systems of insurance firms in terms of lead times to issue a policy and manufacturers in "time to market." IT is now about how firms carry out their business and how they relate to suppliers and customers. We have come a long way from the DP era.

The most distinctive aspect of IT's Business Integration and Restructuring (BIR) era is that, relatively suddenly, change has accelerated in just about every area of both business and technology. Business is dominated by radical not incremental shifts; downsizing and reengineering are examples of deliberate efforts to transform basics. Most large companies are working actively to transform organizational forms and principles to free themselves and their employees from the constraints, waste, and inflexibility of the hierarchical structures that have dominated business and that are seen as a major element in the decline of long-successful industry leaders, such as IBM, General Motors, and Sears.

The technology of every element of IT is in a new state of flux, mainly because the old distinctions between computers and communications have been eroded. PC operating systems, for instance, are being designed to manage enterprise-wide telecommunications, making them far more complex than before. Similarly, software for PCs is designed to share information and coordinate work across locations.

The new force of radical change in the BIR era is IT industry change, especially in telecommunications. In the Data Processing era, IBM dominated computers and AT&T dominated telephones, with almost no commercial data communications available. In the MIS phase, the pattern continued, with limited data communications provided through AT&T, still the national monopoly. A number of new entrants became successful, mainly in providing minicomputer alternatives to IBM's machines; Digital Equipment
rose to number two in the industry (but plummeted in the 1990s). The Information Innovation and Support era saw competition accelerate in personal computers, PC software, local area network communications, and long-distance communications. This era saw the rise of Microsoft, Lotus, Novell, Cisco, SynOptics, Oracle, Sybase, Dell, Compaq, and many others whose sales reached more than a billion dollars a year. It also was the era of the deregulation of long-distance telecommunications, with MCI becoming an increasingly effective competitor to AT&T.

During this period, long-distance telecommunications technology remained stable, with continued improvements in price and performance. That has changed dramatically in the mid-1990s. Cable television firms, cellular providers, long-distance companies, and the local phone company monopolies are suddenly all in competition, allying with one another, or converging on each others' markets. In both local and wide area telecommunications, breakthroughs in technology are moving faster than the microchip revolution of the 1980s, which put the personal computer on the desktop and in the briefcase. Cellular wireless communications have, after years of fragmented growth, entered a phase of rapid expansion and competition. "Information" technology now means any type of information and "technology" means any type of delivery base. This is creating a turmoil of new changes, leaving managers with no previous experience to draw on.

In the computer industry, too, turmoil is the norm. The computer manufacturers that dominated and in many ways controlled the entire pace of change during the first three eras are almost all either in trouble or peripheral to the new mainstream drivers of change. IBM, Digital Equipment, Wang, Data General, and Unisys are examples. Microsoft dominates the use of computers and the main directions of key parts of the PC hardware, software, and local communications markets, much like IBM dominated the IT industry during the 1970s and much of the 1980s. A series of fierce contentions are underway, many
involving the well-armed Microsoft, to dominate as the supplier of desktop and network hardware and software products and services to large companies.

Business has changed radically in the mid-1990s, both domestically and internationally. The 1970s and 1980s pictured the United States, Japan, and West Germany as dominating global business. These days we see a limping Japan, a battered Germany, and a United States where no business can be sure of long-term survival.

Organizational forms and technology are changing radically. The IT industry has changed into an entirely new set of businesses and markets. The firms that balance and mesh their responses to these combinations of radical forces will not only be successful but will shape the new rules of change in the coming decade. It is unlikely that any firm that focuses on only some of these changes will succeed. Most firms will find it easier to address business and organizational change, and perhaps IT change in traditional areas. IT is the likeliest to be neglected or overlooked because this has been true for decades now, and very few managers are comfortable with and skilled in managing the technology.

In this context, business managers can still delegate the technical work, but not the planning that drives it. Because defining, funding, and implementing infrastructures, architecture, and integration involve long lead times and the crossing of functional boundaries, they demand top-level attention to policy and careful definition of business and organizational priorities to guide the choice of standards and pace and degree of integration.

This is the context in which we ask the question, "How little do managers need to know about IT to play an effective role in planning its use?" The answer is, "Enough to help move the firm forward to the era of business integration and restructuring."

**The Glossary**

How much of the vocabulary of IT do business managers need to restructure and integrate their firms? Earlier I referred to the
vocabulary of change—the terms and concepts with which a manager must be familiar to understand and meaningfully discuss change.

I have made the case that, to a great extent, change in IT has become change in business. It is this circumstance that has occasioned the call for “hybrid” managers: IT managers fluent in the vocabulary of change for business, and business managers fluent in the vocabulary of change for IT, the latter being the audience for this book.

A guiding principle in the drafting of Every Manager’s Guide to Information Technology has been the recognition that a business manager is, after all, a business manager; hence the Glossary presents a highly selected vocabulary, a supplement to the manager’s primary vocabulary. Furthermore, its terms and concepts are less defined than discussed. There are other sources to which the business manager can turn for precise technical definitions of any of the thousands of IT terms.

The Glossary emphasizes the technical context and the business relevance of the terms and concepts it presents. Thus the many permutations of networks—local area, wide area, value-added—are discussed in one place in terms of their individual characteristics, relationships to one another, and business relevance, both individually and in the aggregate. The business manager who has read the Glossary entry under “networks” has the advantage of a general understanding when consulting reference sources for more comprehensive definitions of particular types of networks.

The Glossary carries the emphasis on context further by providing for each entry a list of other entries that are relevant to a broader basis for understanding the term or concept. Hence the Glossary entry for “networks” includes cross-references to terms that relate to the technical basis of networks (e.g., “bandwidth,” “mobile communications,” “protocol,” “satellites,” and “transmission”), terms that relate to the context of providers (e.g., Regional Bell Operating Companies), and terms that relate to the business
relevance of or functional responsibility for networks (e.g., “architecture” and “chief information officer”).

Business managers are busy people. The author knows this firsthand, having consulted with many of them. Hence the design and organization of the Glossary: It is slim enough to fit into a briefcase without displacing a manager’s “work” and large enough to occupy a place on the shelf among other “computer” books without getting lost. It can be browsed through on a plane or a train, or while waiting for either. But most usefully, it is a convenient dispenser of context at a moment’s notice. “Oh, by the way, there’ll be some people from corporate IS at the meeting this afternoon to talk about a way our field people can get into our network through them.” “Hmm, not through ‘them,’” you think, nodding to your colleague and reaching for your Glossary. “They must have a scheme for using mobile communications. I seem to recall that there’s a security issue associated with that.”

The cross-referencing in the Glossary is so extensive that if you were to look up all the related terms for each entry you consulted, and the related terms for each of those terms, you would soon have finished the book. But, of course, you needn’t. A quick glance at most terms, in some cases even at the associated marginalia, is sufficient to determine whether to read further. The entry on “networks” and enough related terms to provide a context for attending the meeting mentioned above could probably be read in five minutes. The purpose, after all, is to prepare for meaningful discussion, not to go head to head with IS people on technical issues.

On the shop floor today, there is a call for “renaissance engineers”; at the level of running the business, we must have “renaissance managers.” Every Manager’s Guide to Information Technology is offered as one of the textbooks in “Renaissance Management 101.”
**Glossary**

**Acronyms**  See Jargon and Acronyms

**Adapter Cards**  The modern personal computer does far more than compute. It uses a telecommunications network to communicate with other devices, run videos, create sounds, send and receive faxes, and handle a growing range of other operations. These specialized capabilities require extra software and hardware; they would overload the central processing unit's capacity if they were all included in the main memory of the machine.

Historically, the functions provided by a PC depended on its operating system and the specific software applications (word processing, spreadsheets, etc.) that it ran. Today, adapter cards provide more and more features, especially wireless communications, the wide variety of telecommunications protocols now in use (protocols are just that: the mating dance of birds that enables them to get together. Making a phone call requires Bird 1 [your phone] to get attention, send signals, synchronize timing and the like with Bird 2.), and the range of computers they must be able to work with. These cards, which are slotted into the PC, are the size of credit cards and contain specialized computer chips. Vendors have standardized the card interface, which is called PCMCIA (Personal Computer Memory Card International Association in-

**Sochet Communications Inc.**'s GPS adapter card lets your personal computer locate your exact position within 30 yards anywhere in the world. **Global Positioning System** is a $12 billion satellite-based system developed by the U.S. Department of Defense. It is widely used in boats, planes, and cars and provides information on weather and velocity. The adapter card includes software, a GPS receiver chip, and antenna. The adapter card fits into a slot on the PC.
These adapter cards have fax or cellular modem capabilities; some provide extra storage, and others quickly connect portable computers to local area networks. Their compact size and weight, low power consumption, relatively low cost (currently about $100 to $300 and dropping), and speed make them a major force in mobile computing. In addition, they do not take up valuable disk space and computer memory. They play an increasingly important role in business use of portable devices. PCMCIA has provided a great service to PC users and shows the importance of defining standards early enough to avoid the typical muddle of incompatible, competing products. Intel’s ads call PCMCIA cards “the ultimate business cards.” Perhaps they’re more the “next way of doing business” cards.

**AI** See Artificial Intelligence

**American National Standards Institute (ANSI)** Founded in 1918, ANSI is a central organization for the development of standards for both information technology and for American industry in general. The 1,300-member organization also represents the United States in international standard-setting activities.

The standard-setting process relies on organizations such as ANSI to provide a forum for vendors and users to reach agreement on standards for telecommunications, programming languages, equipment interfaces, and new technologies. An ANSI standard carries weight in the marketplace, though like all IT standards, it has no legal status.

ANSI is also a brokering forum. Its committees argue, horse trade, and compromise. Increasingly, they choose among competing proposals or even products that have already implemented a technology, but that users, suppliers, and vendors want standardized to facilitate design, allow high-volume production of parts, and ensure consistency of implementation. Because standards are about details, some ANSI standards take hundreds of pages to define. One member of an ANSI committee that addressed a
standard for fiber optics recalls that at one meeting a few people argued about the design of a “ferrule module with a concentric hole in the middle” for eight hours straight.

See also: Standards

**American Standard Code for Information Interchange (ASCII)** ASCII (pronounced “as-key”) is one of the earliest and simplest standards for representing computer data. It is a code for representing numbers and alphabetic characters in digital form—that is, as ones and zeros. IBM rejected ASCII and had already created its own coding scheme, EBCDIC, as the basis for its computers. ASCII, extended ASCII, and EBCDIC are the coding schemes most widely used to represent data.

An “ASCII file” is a data file that any program should be able to read. In practice, many packages have unique conventions for representing information, particularly details of formatting. Data stored in a way that facilitates computation, compact storage, and rapid retrieval (accounting and marketing data, for example) typically does not employ ASCII coding.

See also: Standards

**Analog** See Digital

**ANSI** See American National Standards Institute

**App(s)** Personal computer industry jargon that crept into the IT language in 1993, app is simply short for application. It is used differently from “application development.” Historically, an application was software that a firm developed. An app is software it buys off the shelf. The industry appears to have created the term to reflect the new competitive battleground that parallels that in operating systems, where Microsoft’s Windows and NT, Apple’s System 7 and IBM’s OS/2 battle each other. The apps battle is just as aggressive and it includes Microsoft’s Word versus WordPerfect in word processing, Lotus Notes versus Microsoft’s Workgroup for
People who use both Windows and the Mac prefer the Mac by a factor of two to one. The five-year cost of a Mac-based system, including training and support, is estimated by the Gartner Group at $25,000 per user. That of a Windows machine is $29,500, and for a DOS machine, it is $40,100. The consensus among experts is that while few "love" Windows and many love their Mac, Windows is good enough and getting much, much better.

Windows in groupware, and Lotus 1-2-3 versus Excel in spreadsheets. Every firm, in the new cliché, wants to create a "killer app."

This new focus is the result of the many companies that now see apps as software packages that are first-rate, low-cost commodities; it makes little difference if they choose Word, AmiPro (Lotus), or WordPerfect. It makes a huge difference to companies like Microsoft and Lotus because the firm that buys 10,000 copies of Word will probably buy 10,000 copies of Microsoft's spreadsheet package, Excel, rather than 1-2-3. Similarly, the company that standardizes on Lotus Notes rather than Workgroup for Windows is likely to do the same with Lotus's graphics presentation, word processing, and spreadsheet products. The commodity nature of apps encourages firms to use one provider's full suite of software; this simplifies purchasing and support and also offers very substantial volume discounts. Increasingly, leading vendors are interlinking the applications in their suite, so that, for instance, a spreadsheet can import a word processing document or extract part of a graphics presentation. The battle between Microsoft, Lotus, WordPerfect, and Borland centers on suites, and its weapons are aggressive marketing and pricing. The main reason for picking Microsoft's Office is the universality of its operating system; the main reason for choosing Lotus Smart Suite is Lotus Notes, the most widely used groupware package for coordinating work and collaboration. In each case, the alternative apps are largely indistinguishable and very good products.

Computer users want apps that are cheap, effective, easy to learn and use, and technically worry free. Information services managers who aim to meet these demands focus on standardizing on a suite of apps.

Apple Computer The word "Apple," to most people, means the Macintosh. It also means "No—we will not use this" for many information systems managers. For 10 years, the Macintosh has been the PC's main rival. Both are personal computers, but the Mac was originally positioned specifically in opposition to IBM's
PC as "the computer for the rest of us." The term PC began to be used for any IBM or IBM "clone"—a cheaper but fully compatible alternative to an IBM. The Mac was different from a PC and was thus contrasted to it. The PC's original operating system, DOS, used typing to enter instructions. The Mac used a simple graphical user interface (GUI) that allowed people to point to the file or application they wanted to use.

There can be no question that the Mac has always been easier to use than a PC. Information systems managers nonetheless said no to it because the PC could be easily linked to the firm's communications networks and host computers, while the Mac's differences included differences in the communications capabilities and requirements, making it drastically incompatible with the IBM- or Digital Equipment-based infrastructures of most large organizations. As a result, the Mac became a niche product: very popular in schools, with people who could use its superb "look and feel" graphics for designing presentations and publications (desktop publishing), and with people who did not need to link into a corporate network.

Just as Apple was improving its IBM compatibility in the late 1980s, Microsoft introduced its Windows product, which is a GUI that features many of the Mac's special advantages. Windows now dominates the PC field and the fierce competition among PC vendors has cut prices of Windows systems, leaving Apple unable to charge the premium it could when it was the only GUI on the desktop.

In the early 1990s, Apple introduced the Powerbook, a portable laptop Mac with superb multimedia capabilities; this machine is a triumph of engineering and industrial design whose sales passed the billion-dollar mark in its first 18 months. Apple continues to introduce new versions of the Powerbook as well as a new generation of Mac-based machines, often every few months.

Apple has been unable to ward off the Microsoft juggernaut, however; its sales growth slowed in the 1990s, despite the Powerbook and other innovations. It introduced its Newton Personal
Digital Assistant in 1993, which had such a buildup that perhaps it was almost inevitable that this product—the first of a new generation of tiny wireless devices with powerful computer capabilities—would be a disappointment, which it was. Apple’s chairman, John Sculley, resigned in 1993, with most commentators agreeing that he failed to position Apple for a difficult future.

Apple is betting its fortunes on a venture with an unlikely ally—IBM. Both companies must find ways to end Microsoft’s stranglehold on the direction of the personal computer industry. (The FCC has been investigating Microsoft for restraint of trade and unfair competition, which Microsoft’s admirers see as business brilliance and innovation.) The third major member of the PowerPC alliance is Motorola, which has to find ways of ending Intel’s stranglehold over the PC microchip market. IBM PCs and hence its clones have used Intel’s series of chips, whose versions have been numbered 8088, 80286, 80386, and 80486. Intel’s latest chip, Pentium, marks a step up in performance over the 486, which is found in most of today’s lower cost PCs.

Apple’s machines have always used Motorola chips (thus making its software incompatible with Intel-based machines). The PowerPC consortium decided to develop a new generation of chips and crash the Pentium party. In early 1994, both Apple and IBM broke with their tradition and introduced their new machines, which run Windows and DOS as well as the Mac’s operating system. Apple is licensing its previously proprietary System 7 operating system, accepting in effect that its efforts to exploit its proprietary features and strengths make no sense in a world where key users demand open systems—ones that are not supplier specific. This means that Apple is now in the mainstream of business computing.

The managerial implications of the PowerPC, Pentium, Microsoft, and related competitive battles (between Novell and Microsoft, Lotus and Microsoft, and IBM and Microsoft, among many others) may seem remote and the issues those of technology. Some of them are just that, but others directly affect decisions
firms have to make in defining the basics of their IT strategy and infrastructures. IS planners and managers may seem at times unreasonable in their demand that a specific vendor or chip or operating system become a standard. After all, why should so many of them require people to use PCs when Macs are by far the easiest machine to use? There is no recorded instance of a Mac user voluntarily switching to Windows, but a survey of those who write about PCs found that almost all use Macs and Powerbooks to extol some new Windows development.

The answer is that the IS planners are responsible for a business resource that relies on “seamless” communication across the organization, not on just meeting individuals’ personal preferences. (This author’s personal preference is the Powerbook 180c, a dream machine on which Every Manager’s Guide was written. He does, however, use a 486 PC for all computing and communications that involve working with other companies.)

Apple’s future is unclear. Will the company with the best track record for fundamental innovation and the highest level of individual customer loyalty in the IT business make it? At the start of 1994, Apple was the leader in market share in personal computers (12.3 percent), just ahead of IBM (11.8 percent), with Compaq at 9.5 percent. Apple’s stock price dropped by half in 1993, however.

See also: Newton, Personal Digital Assistants.

Application Software and Application Development An application refers to the way a business or an organization uses a computer. Application development is the design and implementation of the software facilities to support such use and is the core activity of Information Systems units. Payroll, invoicing, and salary administration are applications. Each may involve the development of many individual software programs.

Application software is distinguished from systems software, which supports the effective and efficient operation of application programs and is usually provided by the manufacturer of the
In 1993, Bell Atlantic announced that it would spend $2.1 billion redesigning its core customer service applications. Some of the components are 25 years old and use a mix of programming languages that are no longer at the cutting edge. Some of those components will need to be maintained; so, too, will the relevant skills in the programming languages and software environments. New components will use newer languages and tools.

computer hardware on which the applications run. Operating systems, for example, control the processing steps of an application program, handle errors, and manage links to printers, data base files, and switching among the many programs that constitute the application.

On a mainframe computer, the operating system may have to manage literally hundreds of application programs simultaneously. The operating system may access stored libraries of routines, support dozens of different programming languages, and act as a traffic cop when several programs try to access the same data base. Communications control programs handle the flow of messages to and from the applications. File utility, security, and data-base management software similarly manage the access and updating of data bases, ensure error checking and security, and perform other “housekeeping” functions.

Traditionally, systems analysts and application programmers develop applications. They translate the target business requirements into a technical system design and then write, test, and install the needed programs using programming languages such as COBOL (for business applications) and FORTRAN or C/C++ (for more technical and scientific applications). An invoicing system, for example, may entail the development of programs to sort and validate input data, update master records, create invoices, and generate management reports.

Increasingly, new and old applications must coexist and link with each other. This prevents users from exploiting many new development tools. A new term has crept into the IT professional’s vocabulary: legacy systems. These are older systems that must be maintained for some time before gradually being rebuilt and replaced. Most of these are mainframe based and most new development is based on workstations (clients) and their access to information, communications, and transaction services from a variety of “servers.” The business person who sees just the client end of this—a personal computer running a software package—needs to recognize that client/server application development is
extraordinarily difficult for the very reason that it aims to make everything look simple. The workstation software automatically links to the network, locates remote data, interacts with the mainframe, etc. In the old days of mainframes and dumb terminals, the user did all the work: logging off this system, dialing another to download data, logging off and reentering the original system, copying files, and so on.

Developing and running a system on a single large machine is much simpler than coordinating many subsystems across many devices. The payoff from client/server computing should be huge in terms of its simplicity, flexibility, and responsiveness to users and its efficient and cost-effective exploitation of technology, resources, and integration of business services. But after an early enthusiastic response to client/server computing, IS (information systems) professionals are much more cautious. They have come to recognize that large-scale, enterprisewide application development is exponentially more difficult, especially in terms of building or finding skilled people.

Application development dominates the planning of IS departments and the relationships users have with the systems that are developed. IS departments' business plans are built largely around their application portfolios, with each major development project involving a business unit client that is generally desperately concerned with cost, delay, and quality, especially when the new system is a key element in marketing, product innovation, or customer service. Major development projects usually take at least two years to complete. An experienced application programmer can typically produce about thirty lines of computer program code per day. A new billing system for a large firm can easily amount to a million lines of program code—20,000 pages of computer printout requiring about 140 person years to complete.

Successful application development relies on (1) the ability to establish relationships and dialogue with business units, (2) systems development and project management skills, and (3) client support, especially education. IS units are trying to broaden the
skill base of their development staffs, a base that has traditionally been focused on technical rather than business and organizational skills. For many years, IS units built application systems in isolation from the people who understood the context of the work, information, and procedures. The difficulties of just making the technology work drove out organizational considerations and dialogue with users. As IS groups have come to recognize that such dialogue is essential, the profile of the application development professional has broadened beyond traditional programming skills.

For four decades, the IS field has been preoccupied with speeding up application development and improving the quality of application software. Although some progress has been made, application development causes the same problems and bottlenecks it did in the 1970s and 1980s. Capers Jones, one of the leading authorities on application development, estimates that more than 60 percent of large systems projects have "significant cost and schedule overruns" and 75 percent of completed systems exhibit operational difficulties, high maintenance costs, and inadequate performance.

The problem is not lack of effort or competence. Application software development is inherently slow and complex. The process of designing, coding, testing, installing, and operating a system involves many meticulous steps. Shortcuts are routes to disaster. Once in place, a system must be updated constantly to meet new business needs and changes in regulation, accounting, or reporting. The costs of this maintenance may be one to three times the original development cost.

One of the biggest disasters in application software development—more than $300 million in write-offs and out-of-court settlements—occurred in 1992 at a firm legendary for its successes in large-scale development. American Airlines announced six weeks before its CONFIRM reservation system, built for a consortium that included Hilton and Marriott, was scheduled to go "live" that
the system contained errors that would take at least 18 months to fix. The consequent battle of blame and shame identified the usual development pitfalls: poor communication with partners, constant design changes, weak project management, and inadequate test.

Backlogs of approved development projects are frequently so large that it would take two or three years to catch up if no new requests for applications were approved during that time. In 1990, the IS department of one major bank developed an entirely new application every three weeks and made at least one major enhancement to existing applications each day. “The business can’t get these systems from us fast enough,” observed the head of IS. “I wish we could get them out faster, but there are no quick fixes, especially in testing.”

Today, a growing share of application development is being handled outside the IS function and without the involvement of specialized programmers. Development tools such as application generators—software systems that create application programs from a description of a business problem—are enabling business units to do more and more of their own application development, although mainly for smaller systems.

A general-purpose application package from which a firm chooses among optional routines is an attractive alternative to custom-developed applications. It is particularly effective for generic applications that are common to many companies. A payroll package, for example, can provide a range of prewritten state tax calculations. The user specifies which one applies and which of the available reports are to be produced. Needs not accommodated by a package may be provided by modifying the package or developing additional customized application software. Information systems professionals often refer to the 80–20 rule with respect to packages: users get 80 percent of what they need for 20 percent of the time and effort that would be required to custom develop it. How important is it to get 100 percent?
Tools such as packages and application generators are appealing, given the cost, time, skill base, and complexity associated with application development. But much development must still be done in terms of defining business requirements, creating a customized software system design, and programming, testing, and installing the system. General-purpose packages and application generators incur substantial overhead to translate user specifications into detailed processing steps. These tools tend to be best suited to relatively small applications that have generic, firm-independent characteristics (e.g., report generation and small-business general ledger accounting) or to larger well-understood and stable applications common to a business function that requires little, if any, adaptation to company-specific procedures.

Improving software productivity is a major priority for IS units. The pace and quality of application development increasingly affects key aspects of business innovation. Demand for new systems continues to outstrip the ability of IS units to respond. Typically, only 10–20 percent of the programming resource in an IS department is available for developing new systems; 20–40 percent is usually committed to enhancing existing systems to meet additional business needs and 50–70 percent to maintaining old systems (for example, adapting them to changes in tax laws, organization, processing needs, and so forth).

Many IS units are investing in productivity tools such as CASE (Computer-Aided Software Engineering) to speed up design and implementation. These are personal computer-based software aids that provide a structure to the development process that ensures greater accuracy and consistency. Some companies report significant productivity gains from CASE, but there is as yet no evidence that it solves the ongoing problems of delivering large-scale applications on time, within budget, and without errors.

A new source of stress in IS organizations is that old legacy systems must still be maintained and linked to new systems that are built on different hardware and that use newer programming
tools. This has created a major cultural divide. Old-timers are stereotyped as “mainframe dinosaurs” and expensive retraining is needed for experienced application developers to learn new programming languages and development methodologies. One organization launched a crash project to rebuild its main business applications using object-oriented techniques—the emerging new mainstream of systems development; 75 percent of the IS staff were unable to make the transition to a new style of thinking and were fired. Although the old tools are unproductive and have never been able to meet business demand for applications, the new productive tools demand far more skilled and knowledgeable people than are available. We can therefore expect the historical problems of application delivery to continue through this decade.

There is no quick fix to the application software bottleneck. Managers should not look for a panacea, nor should they listen to those who say, “But it’s easy . . . here’s our magic tool.” There are no magic solutions to application development problems, and the success of one tool can be highly circumstance specific.

See also: Bug, Computer-Aided Software Engineering, Package, Programming, Prototyping, Maintenance, Systems Life Cycle

**Architecture** One of the central concepts in the organizational evolution of IT, architecture refers to a technical blueprint for evolving a corporate infrastructure resource that can be shared by many users and services. The three main elements of an architecture are themselves often referred to individually as architectures.

- The processing systems architecture defines the technical standards for the hardware, operating systems environment, and applications software needed to handle the full spectrum of a firm’s information-processing requirements. Standards are formats, procedures, and interfaces that ensure the equipment and software from a range of vendors will work together.
Because British Airways had the same technical architecture as British Caledonian, British Airways could fully merge British Caledonian's systems, when it acquired the airline, over just a weekend. Conversely, Northwest and Republican took many years to rationalize and merge their disparate systems.

- The telecommunications (or network) architecture defines the linkages among a firm's communications facilities over which information moves within the organization and to and from other organizations. It, too, depends on standards.

- The data architecture, by far the most complex of the three architectures and the most difficult to implement, defines the organization of data for purposes of cross-referencing and retrieval, and the creation of an information resource that can be accessed by a wide range of business applications.

The three subarchitectures fit together to provide the corporate master architecture, the blueprint by which a firm's separate IT resources can be integrated. The alternative to developing an architecture is to choose the technology base best suited to a specific application, using such criteria as cost, efficiency, speed, and ease of use. This is a sensible strategy only if business applications need not fit together in order to share data or telecommunications resources. As soon as they do, an architecture becomes essential.

Given the enormous variety of services and equipment that must be integrated, the technical details involved in defining and implementing an architecture are extraordinarily complex. Most firm's information technology facilities cover a wide range of incompatible systems that have been built up over many years. Standards are a very recent development in the IT field, and most hardware, operating systems, and telecommunications services are still unique to single vendors. Many companies are choosing to wait until the needed standards are fully implemented before defining a blueprint for integration. They are ill-advised to do so. However difficult the task of rationalizing a multivendor mess and moving toward integration is today, it will be even more so tomorrow.

The need for an architecture is driven by widespread "incom-
compatibility" among existing computer and telecommunications and data formats and by the lack of an accepted set of complete, proven, and stable IT standards. Many standards have been defined but few are fully implemented and their interpretation and implementation in products vary widely, effectively rendering them nonstandard standards.

An effective architecture must satisfy three, often conflicting, requirements: (1) that it provide as much vendor-independence as practical (firms are increasingly hesitant to adopt "proprietary" systems that only one vendor can provide); (2) that it be capable of rationalizing the frequent multivendor, multitechnology chaos of incompatible elements (a given company may have built its financial applications on IBM systems, its engineering applications on hardware and operating systems unique to Digital Equipment Corporation, Hewlett-Packard, Prime, or Sun, its office technology applications on Wang or Data General products, and its data-base management software, local area networks, and data communications facilities on a wide variety of vendors' facilities; it is not unusual for a firm to have from 10 to 40 incompatible networks and from 5 to 50 incompatible processing systems); and (3) that it incorporate the standards being adopted or likely to be adopted by leading vendors and electronic trading partners.

The need for a comprehensive set of vendor-independent standards is increasingly being recognized by vendor and user communities alike. What is needed is the equivalent of what has evolved in the electrical utilities industry: standardized interfaces such as the three-pin plug into the wall socket, standardized voltages, specifications for light bulb fittings, and so on. The Open Systems Interconnection model, or OSI, is the internationally accepted framework for evolving a complete and open set of such standards.

Although there has been a tendency to advance OSI as the long-term solution to integration, defining and implementing an architecture can take years, possibly even a decade.

The OSI model helped create many important open stand-
ards, but it did not achieve its enthusiasts' promise of a comprehensive and stable base for open systems in every area of IT. New technologies generate new needs for standards. Older technologies still in use are built on widely varying open and proprietary standards. Both of these must be taken into account in defining the IT architecture. For example, wireless data communications were nonexistent at the time OSI was first defined. The explosion of wireless technology has led to providers like Motorola developing a product outside the OSI model and then proposing it as an industry standard. Motorola's CDPD (Cellular Digital Packet Data) leapfrogged the OSI process by the very fact it was available in a working product, and not just a proposal. IS planners must be very selective in balancing the combination of standards that preserve existing investments with those that increase openness.

The technology moves far faster than the standards-setting process. Thus, for example, wireless local area networks appeared on the market in early 1990, but products based on an industry standard weren't widely available until 1995. The new core technologies of data communications, termed "fast packet-switching" (asynchronous transfer mode, SMDS, and frame relay), will require most companies to significantly redesign their architecture. That redesign can be phased in, and vendors increasingly recognize the importance of ensuring their products can be linked into the existing technology platform. Nonetheless, ensuring that the architecture neither blocks implementation of a high payoff business opportunity nor blocks adoption of a key technology is a constant challenge.

Conceptually, architectures and open standards are deceptively simple. Managers need to be aware that the tidy diagrams hide a morass of technical details, uncertainties, and, above all, existing incompatibilities. Nevertheless, developments in standards, particularly the convergence of IBM and many of its most effective competitors on compatibility with both key IBM architectures and key vendor-independent standards (notably OSI and UNIX), are easing the architect's task.
One common approach to defining and implementing an architecture is to standardize the "desktop." In other words, select a common set of tools for personal computers, including the operating system and "suite" of applications, such as Microsoft Office or Lotus's competing SmartSuite equivalent. (Suites bundle together word processing, spreadsheet, graphics, and electronic mail.) By doing this, architects can more easily exploit the many standards and devices that link PCs to telecommunications networks, remote transaction processing systems, and information resources. They can rely on a small set of standards that address most needs instead of trying to meet every need, although even meeting basic needs is hard. One trade publication described "The Network from Hell," a relatively simple exercise in integrating four desktop computer systems with a local area network and minicomputer. This task required forty-eight separate products. By contrast, the same article described how the Associated Press integrated 2,000 workstations with an almost identical minicomputer. AP's architecture-centered planning made this work like "an IS manager's dream" versus "the network from hell."

The firm without an IT architecture has no real IT strategy. The architecture is the strategy; it determines the practical range of applications the firm can develop, which in turn determines the practical range of business and product strategies the firm may choose among. Business planners and many business managers are also well advised to know their key customers' and competitors' architectures.

See also: Compatibility, Integration, Open Systems Interconnection, Platform, Standards

Artificial Intelligence (AI) Artificial Intelligence, or AI, studies ways to emulate human intelligence so that computer hardware and software systems can be developed to act as decision makers. This is one of the most promising, if overhyped, longer-term efforts for exploiting computers.
The evolution of AI has followed two distinct tracks. The first has been to create computer systems that mimic human thought processes in order to solve general problems. Chess playing programs have been the main measure of progress here, with proponents of AI arguing that as soon as an AI program beats the human world champion, we will at last have computers that "think." Among philosophers and computer scientists, there is both strong support for and opposition to that claim.

The second approach combines the best thinking of experts in a piece of software designed to solve specific problems. Such so-called expert systems have been most successfully applied to aspects of decision making that principally involve recognizing and responding to recurring patterns. The expert’s knowledge is coded as "rules," which typically take the form of "if... then... else" statements (for example: if condition A applies, then make inference B, else move on to C). Expert systems have been developed in such diverse areas as robotics in manufacturing, financial planning, medical diagnosis, credit risk assessment, chemical analysis, and oil and mineral exploration.

The fledgling AI industry that grew up in the 1980s, although it greatly underestimated the difficulty of "knowledge representation" and "knowledge engineering," has nevertheless turned out many practical, if highly specialized and expensive, tools for software development. Notable among these tools are expert system "shells," which provide an organizing framework for developing software targeted at a specific decision task, such as troubleshooting a steam turbine generator or a diesel locomotive engine.

The greatest obstacle to progress in AI has been the inability to "teach" a computer to recognize and adapt to context and to use what we call common sense, something computers entirely lack. How can a computer recognize the difference between a hole in the ground and a dark shadow? How can it infer the difference between the following sentences: "Time flies like an arrow" and "Fruit flies like a banana"?
The excessive claims of the AI movement in the 1970s and early 1980s generated a backlash, while its most successful practitioners tried to avoid the label. They used the software tools of AI, particularly shells, plus increasingly powerful workstations to build what they simply called systems. These include those systems that credit card companies use to spot fraud, those that manufacturers use to schedule production and configure complex systems, and those that diagnose machinery failure. The "intelligence" in such systems is more speed of applying rules than cleverness. Northrop's expert system for planning the manufacture of a jet fighter, for instance, cut planning time by a factor of 12–18. The process requires 20,000 plans, each taking hours to create and even longer to coordinate and revise.

One of the most promising lines of development in AI is neural networks. Here, instead of "teaching" a computer through rules that are programmed into it, the software literally learns from experience. Neural networks imitate the neurons of the human brain, forming connections and reinforcing successful patterns. The system is "trained" on case data and can then make its own predictions and judgments.

For example, a system used in several hospitals in California can predict the length of a patient's hospital stay, the likely type of "discharge" (where death is one type), and also spot abnormal "problem" diagnoses. It does this by using just 26 input variables. It was trained using 80,000 cases and 473 diagnoses. Each diagnosis comprised 400 to 1,000 examples, and the system evolved its own intelligence.

Progress in AI will, in the aggregate, be driven by developments in psychology, linguistics, computer science, and hardware technology. Expert systems development will be paced by the sensible choice of decision tasks and realistic expectations of what can be accomplished.

See also: Decision Support System, Expert Systems
Asynchronous Transfer Mode (ATM) ATM is a type of fast packet-switching transmission that will be the basis for most network communications by 1997. It is by far the most important development in telecommunications since fiber optics, and, like fiber optics, it offers greatly increased speeds and lower costs. Unfortunately this term, which is widely seen as the major technical innovation in the telecommunications industry, is the same as the acronym used for an automated teller machine. Generally, the context makes it clear which term is being used, although we may see a headline within the next few years about “First National Megabank chooses ATM for ATM network.”

Packet-switching is a method for sending information that divides a long message into small units (packets), which it handles like a set of mailed letters, with each one containing a numbered sheet. The packets move through the network on something like a conveyor belt, mixed in with packets from other senders’ messages. These packets are then routed to their destination and the full message reassembled when they all have arrived. Packet-switching allows a very large number of users to share a very high speed transmission link. The older alternative, circuit-switching, "dedicates" a link to a communications session; your phone is circuit-switched.

Packet-switched networks have historically been slow. The public data networks that use the X.25 standard for public switching allow users to operate typically at speeds of 9.6 kbps (9,600 bits per second, roughly 250 printed characters per second). The standard leased line that large companies use for their high-speed data communications operates at 56 kbps. ATM can pulse bits through the network at speeds up to 622 Mbps (millions), with much faster speeds on the horizon. Ignore the specific rates, which mean little to managers; instead, examine the scale of increase: 56 kbps is close to six times faster than 9.6 kbps and 45 Mbps—a low ATM rate— is more than 800 times that.

ATM is "scaleable"; companies can use lower capacity transmission and move up to higher speeds with minimal changes.
They can also reduce their costs substantially. Initial 1994 prices for ATM equivalent to the standard private leased line were around 40 percent cheaper.

Think of ATM as a strobe light. It pulses information at fixed intervals and in fixed sizes of packet. The faster it pulses, the more packets are sent. Speed up the strobe, keeping the packet size constant, and you send more packets per second over the same transmission link.

There is a strong caveat here: ATM is the wave of the future and elements of ATM services are only sporadically being implemented now. New types of switches, fast enough to catch and transmit the strobe’s pulse, are needed to handle the traffic and to connect ATM services with local and wide area networks and with another major type of fast packet-switching capability—frame relay. The telecommunications carriers (AT&T, Sprint, MCI, Bell-operated companies, and rivals) are in the early stages of rolling out ATM, which they all see as the key technology for the public data networks of the 1990s and beyond. In many instances, they solve problems as they go and the articles in the trade press during 1994 that announced a new ATM product each week were full of such qualifiers as “will theoretically . . .,” “is expected to . . .,” and “initial release.”

Fast packet-switching is literally the new wave of telecommunications, with ATM the key for local area networks and the public network, and frame relay a choice for large companies’ backbone wide area networks (see glossary entry). The main advantage of frame relay is that while slower than ATM, it meshes easily and reliably into existing packet-switching technology and services.

The main implication of ATM for business managers is that it marks a major technical and economic shift in telecommunications that will require both complex planning—with business input and assumptions about types, volumes, and locations of information to be transmitted across the enterprise network being vital—and complex design and implementation. Stated bluntly, the network designs of 1995 are as out of date as the personal com-
puters of 1985. Businesses will need to upgrade their networks to remain effective in an era where information now includes television, videoconferencing, document images, software programs, and any other forms of multimedia.

See also: Fast Packet-Switching, Multimedia, Packet-Switching

ATM ATM stands for automated teller machine but also for asynchronous transfer mode, the hottest innovation in telecommunications transmission (see previous entry). Both acronyms are ubiquitous. It’s almost impossible to read either a banking trade publication or a telecoms publication without finding the acronym “ATM.” For this reason, it’s well worth a manager’s time to read up on both.

AT&T American Telephone and Telegraph is the world’s largest telecommunications provider, with $70 billion in revenues. In the 1990s, AT&T’s growth in market share slowed and its profit margins eroded as a result of fierce competition. To step up new market growth, AT&T is rapidly moving away from its traditional position as the dominant U.S. supplier of domestic long-distance communications to business and consumers. AT&T’s three main thrusts have been (1) to again gain a foothold in the computer business by acquiring NCR; AT&T lost billions of dollars in the 1980s trying to build in-house capabilities and alliances with such firms as Olivetti, (2) to increase its international presence, mainly through alliances with national Poste Télégraphique et Téléphoniques (PTTs), their predivestiture monopoly equivalents, and (3) to spend $12.6 billion to acquire a firm that has never made a profit, McCaw Cellular Communications.

Most analysts saw this last move as throwing down a gauntlet for the duel of the late 1990s: to attain preeminence in the nationwide digital cellular market. Cellular communications have grown rapidly in the last five to seven years, but the Federal Commerce Commission’s policies on licensing providers have
made this a regional business. McCaw has made its losses very productive; it bought up licenses at a very low cost, attempting to create the strongest nationwide base at a very low entry cost. Most commentators see AT&T's purchase of McCaw as a good one and some have argued that AT&T is positioned to dominate the cellular market as it was predivestiture in long-distance telephone services.

Until 1982, AT&T had a monopoly in the United States, not just of phone calls but even of the devices attached to a phone line. Its intransigence in preventing even small-scale and localized competition led to an antitrust suit that resulted in AT&T's chairman agreeing to break up the entire Bell system (Alexander Bell, the inventor of the telephone, founded AT&T). The divestiture of AT&T, which took effect in 1984, had two main elements: opening up competition in the long-distance market and creating seven "Baby Bells," the Regional Bell Operating Companies that were given a monopoly of local services that has been immensely profitable and has allowed them to also be immensely unresponsive to customers until recently.

AT&T had to learn the new basics of competition. It faced two main competitors postdivestiture: US Sprint (now called Sprint) and MCI, the company that was the driver of the antitrust suit brought against AT&T. AT&T initially held the advantage of size and technology, and the two other firms struggled for much of the 1980s to achieve volume and reliability of service. By the late 1980s, MCI had achieved the 12 to 15 percent market share most commentators saw as essential for it to survive. During this period, AT&T had invested heavily in new facilities and in marketing, but its culture remained the same—bureaucratic, traditional, and introverted. The company continued to be inflexible and out of touch with its customers. AT&T drifted but remained the dominant force in the industry through the late 1980s.

A new chairman, new strategy, and powerful competition awoke AT&T. Its near-100 percent market share of 1984 in the consumer
market dropped to about 70 percent, as a result of MCI's aggressive discount program, Friends and Family, which AT&T's own technology base could not match. AT&T's position in the business data communications market remained strong, holding a 90 percent share of the "private" leased lines—the main choice of large firms' "backbone" networks (the main connections between their primary business centers). It dominated the toll-free 800-number market, too, partly because companies were unwilling to switch to MCI or Sprint if that meant losing a distinctive number like British Airways' 1-800-AIRWAYS or reprinting all their brochures and marketing material that had the old number.

AT&T's early advantage had been quality, and MCI's and Sprint's, price. As MCI improved the quality of its previously unreliable network and AT&T cut its prices, the differences among the main providers narrowed. Customers benefited, and AT&T executives publicly admitted that the company profited from the competitive environment that they had ferociously fought to prevent for 20 years. The average cost of a long-distance phone call dropped by more than 40 percent in real terms in the first decade of competition. AT&T's average predivestiture revenue was 40 cents a call minute (the basic industry measure of traffic). In 1993, it was 15 cents, but the huge growth in volume stimulated by competition more than made up the difference. From being a high-margin department store, AT&T and its competitors created low-margin, high-turnover discount stores.

MCI, the original irritant to AT&T, is now a large thorn in its side, and in many ways MCI has driven long-distance innovation. In 1993, it made two major moves: it sold 20 percent of the company to Britain's British Telecom, creating a powerful international combine and providing MCI with more than $4 billion in new capital. Its second move exploited its new strong financial base. At the end of 1993, MCI announced it will spend $2 billion on local phone networks as part of a $20 billion expansion plan. That may seem a small issue, but it will save MCI around 45 cents
on every dollar of revenue. MCI, AT&T, and Sprint pay the Baby Bells this fraction of a long-distance phone call as a "local access charge." AT&T pays $4.5 billion a year for this. If MCI succeeds in bypassing the Baby Bells, its cost base will greatly improve.

An additional challenge to AT&T came in early 1992 when the FCC allowed large companies to take a "Fresh Look" at their long-term contracts with AT&T that provided these companies with large volume discounts. The FCC also permitted the transfer of 800 numbers to other providers. British Airways could thus keep 1-800-AIRWAYS and negotiate for the best deal. These 800 numbers have very high margins and at peak business periods amount to half AT&T's network traffic on main transmission routes. Losing even 1 percent of market share could amount to $160 million of revenue. AT&T's strength as well as its weakness is its size. For MCI to add $1 billion to its roughly $14 billion sales base is a significant gain. For AT&T to lose $1 billion is less immediately significant. AT&T's competitors often focus on specific niche areas. Just about any telecommunications services provider is a competitor of AT&T. This includes providers of VSAT (very small aperture terminal) satellite services like Hughes Spacecraft, local phone companies focusing on regional services, cellular providers, international communications companies, long-distance firms, and many others.

For businesses, competition has translated into continuing technical innovation and price competition. It is very tempting for telecommunications managers to focus purely on price and play providers against each other. Some of them argue that transmission is now just a commodity. That can be a self-confirming prediction; treat it as a commodity and it becomes just that, as does the telecommunications manager. Now that telecommunications is becoming fundamental to almost all aspects of business operations, leading firms, while still price shopping, also emphasize long-term relationships, technical support, network management, and collaborative planning. Texas Instruments, for instance,
meets with all its leading providers monthly and gives them feedback on every problem found. TI's network monitoring and statistical reports are often better than the telecom firms'.

See also: Cellular Communication, 800-Number Portability, International Telecommunications, MCI

Automated Teller Machine Automated teller machines, or ATMs, have become a basic access point for banking services. An ATM system comprises (1) specialized card-accessed workstations (the ATMs); (2) remote computers that store and update customer records and authorize and execute transactions; and (3) the telecommunications links between the ATMs and the remote computers. The range of technical and competitive options within and across these elements is broad.

A bank may decide to build its own ATM network or to share development and operational costs with a consortium of banks. It may design its systems to link to such other services as credit card providers' or retailers' networks. It may "distribute" functions to the ATM in order to reduce both the workload on the central computer and the amount of telecommunications between the bank and the ATM. For example, the software that displays options and guides the card owner through the procedures can reside in the ATM; only when the transaction involves the need to check whether the customer has enough funds to cover a withdrawal is control passed to the remote computer.

There are several general lessons managers can learn from the history of ATMs that are relevant today to strategies for such major IT-based business initiatives as point of sale, electronic data interchange, computer-integrated manufacturing, and image processing. In the decade in which ATMs changed the basis of customer service, banks have had to address primarily two competitive issues: whether to lead or to follow the leaders and whether to compete by installing an ATM system that accepts only the bank's own cards or by sharing services and facilities with other banks and nonbank service providers.
Many commentators question whether the early leaders in ATMs gained any real competitive advantage; as the laggards caught up, customer demand pressured more and more banks to accept one another's cards and required all banks to find a way of providing what is now the electronic equivalent of the checkbook. These commentators argue that the industry as a whole would have gained more by cooperating rather than competing.

This view, though subject to many valid counterarguments, highlights the managerial importance of continued attention to the two sets of questions that dominate competitive positioning through information technology: (1) When should we lead and when should we follow? Is it important that we quickly move ahead to ensure that we are not preempted by competitors? Or are we better off waiting until the technology and application are proven, thereby reducing our risk? (2) When should we compete and when should we cooperate? Is this an area in which it will pay off to have our own systems? Or should we share costs and resources with other firms within or outside our industry?

There are no easy answers to these questions. Moving too early risks failure; moving too late risks loss of business to competitors. If catching up involves a lead time of two to five years, as it often does, waiting may result in a sustained competitive disadvantage.

One useful way to address the issue of timing in the competitive use of IT is to look ahead five years and ask these questions: (1) Is this business service likely to be a competitive necessity then? If so, when must we begin our move to be there when demand takes off? (2) Is this a competitive opportunity today? If so, what is the likely payoff from getting there ahead of the competition? How long an advantage in years are we likely to obtain? (3) How long can we afford to wait?

The principal technical issues associated with ATMs relate to security, reliability, and efficiency. From the customer’s perspective, efficiency is indicated by response time: how fast the ATM responds when a key is hit. Adding a tenth of a second to each
transaction can create unacceptable delays in a network with 50,000 customers simultaneously trying to make withdrawals and deposits. Reliability and security are obviously essential, but they are also technically complex and costly.

Banks are increasingly looking at ways to get more benefits from their expensive ATM infrastructure. Many are experimenting with multimedia—video, audio, and graphics—rather than the telex-like display of line-by-line characters. The hope here is to make the ATM a marketing machine, not just a transaction processor.

The very term “automated teller machine” focuses one’s mind on banking. When people are asked to suggest additional services that could be added to the ATM’s basic deposits and withdrawals, they naturally think of other types of financial transactions, such as paying bills, buying insurance, or investing in mutual funds. But the ATM is a general-purpose device that can just as easily link to New Jersey’s Department of Motor Vehicles for auto registration renewal, to a college’s system for students to register for courses, and to Maryland’s computers to process welfare payments. By introducing its Independence card for use by welfare recipients, Maryland has transformed a key and expensive element of welfare, reducing its own costs, providing security to recipients, and encouraging thrift in spreading benefits over the month instead of taking and spending them at once. These examples represent just a few of the growing uses of ATMs outside banking.

Managers can learn several general lessons from these examples of ATMs: many of the innovations in IT are coming from using some other industry’s electronic delivery base, as Maryland has, greatly reducing the costs of operation without building a complex infrastructure, or adding services to the firm’s own delivery system services that another industry traditionally provides. For instance, leading airlines added hotel and car rental reservation services to their airline reservation system at a time when most of those other industries had yet to build expensive reservation bases.

See also: Network, Point of Sale, Telecommunications
**Baby Bells**  See Regional Bell Operating Companies

**Backbone Network**  A backbone network is a key managerial and technical concept. The physical locations of information stores and of information needs are often very different in a large organization. To get information from where it is stored to where it is needed, a company relies on networks. A large organization will often use a number of different networks, some of which may not be connected to others.

A backbone network, like the interstate highway system, is not intended to connect two points, but rather to provide a high-speed corridor that is common to many points. Entering the system from a connector route, one can use as little or as much of the length of the corridor as is needed to get to the destination connector route. While on it, one is afforded the advantage of fast travel on a broad surface and efficient routing through complex exchanges. These correspond, in a backbone network, to high bandwidth and advanced switching technology, respectively.

Defining an effective corporate backbone network can be easier conceptually and even technically than politically. To overcome resistance from business units that have extant networks and see no benefits in change, a firm needs a corporate telecommunications planner with the clout to establish policies and standards and to ensure that they are adhered to. The economic and technical advantages that accrue to all business units from the implementation of a corporate backbone network are generally sufficiently compelling to warrant surmounting whatever obstacles emerge.

*See also: Data Communications, International Telecommunications, Network, Telecommunications*

**Backup and Recovery**  Computers and telecommunications systems are susceptible to damage from a variety of sources, including power loss, hardware problems, computer viruses, hackers, and such acts of God as fire and flood. Viruses are software
New York City processes $1.5 trillion of financial transactions a day, yet only 15 percent of the firms involved have any backup capabilities. If their telephone systems or computers go down, all they can do is send people home. When this happens, their business strategy is now suddenly and completely irrelevant.

programs designed to worm their way into the transaction processing bloodstream and crash the system. Hackers are often well-intentioned computer nerds who want to prove to themselves, their peers, or the world that they can break into any system whenever they want.

Even without these deliberate creators of disasters, any complex system—and a large firm’s IT resource is second only to the human brain in complexity—is vulnerable to unanticipated accidents and errors. In general, computer systems operate at a level of reliability that exceeds 99.9 percent. Unfortunately, that is not good enough for companies that depend on on-line transaction processing for key elements of operations and customer service. For such companies, when the system is down, so is the business.

Routine protection against system failures, or “crashes,” can be provided by copying, or “backing up,” data files. How frequently a backup is made depends on how critical it is to avoid losing or reprocessing transactions. The more time-critical the business process, the more frequent the backup. Personal computer users often learn too late the importance of backing up their hard disk files.

A few computer vendors offer “nonstop” on-line transaction processing systems, in which multiple systems process data in parallel. If one fails, the others continue processing and no data is lost. Many airlines, banks, and retailers that rely on point-of-sale processing use such nonstop systems, which are the distinctive market niche of Tandem Computers and Stratus.

Recovery from a system failure can be either quick, involving a “hot” restart that is automatic and so fast that users may not notice loss of service, or lengthy, requiring a “cold” restart in which the entire system is reloaded using the backup data files. Hot restarts can be provided by running two processors in different locations. When one crashes, the other’s operating system immediately takes over. Telecommunications networks accomplish
the equivalent of this approach through automated network management software that continuously monitors transmission flows through the system and reroutes traffic if a line is down or a piece of equipment fails. The network design that ensures that there are alternative paths through the network takes planning and can add expense.

Firms vary widely in the provisions they make to handle disasters. Some make none. They have a single computer center with a single transmission line coming into it. If the line is cut, they hope it will be repaired soon. When the computer is down, they hope the vendor's systems engineers will get it back up quickly. Given the high level of reliability of today's computers and telecommunications systems, this is often an acceptable strategy. But it is a dangerous risk if a company's cash flow, customer service, and business reputation depend greatly on its on-line processing systems.

A number of companies provide disaster recovery services. IBM, for example, has built a $22 million facility that includes a cafeteria, bedrooms, ATMs, and even sports activities. As is standard for such services, customers pay a "declaration" fee amounting to several hundred thousand dollars. The declaration is "Help!!!!" and reserves the data center and network services for the firm to install and run its own software and recover from the disaster.

Banks and airlines are the heaviest users of such services, for obvious reasons. As one executive comments, when computers mainly handled clerical transactions, a 72-hour recovery was acceptable. Today, even a few hours can be critical. One airline lost 5 percent market share, which it did not recover for six months, when its reservation system was down for two four-hour periods in a week.

Every survey of information systems managers shows that the large majority do not believe their IT facilities are adequately secure. They report that it is difficult to justify what is the equivalent of hurricane or flood insurance for homeowners. As with
these, "insuring" against disasters is a trade-off between cost and risk. That makes it a business, not a technical, decision.

See also: Network Management, Security

**Bandwidth** Bandwidth is a measure of the carrying capacity of a telecommunications link. It determines the speed at which information can be transmitted, how much information can share the link, and, consequently, the practical range of the applications it can support.

Although generally expressed in terms of "bits per second" (bps), bandwidth technically refers, as for radio and television, to the usable range of frequencies of the transmission signal (e.g., kilohertz, megahertz, and gigahertz).

Voice-grade analog telephone lines typically transmit information at up to 9,600 bits per second, which is sufficient for applications such as electronic mail. (At 1,200 bits per second, a typed page takes about 12 seconds to transmit, which is acceptable to most casual users; transmitting complex engineering diagrams and large data files would take an unacceptably long time at these speeds.) Clever tricks of data compression can about double this speed; the modems that do this cost just a few hundred dollars.

Microwave (and satellite) transmission speeds range from 1.544 to 45 million bps and local area networks typically run between 2 and 16 Mbps (millions of bits per second). A speed of 100 Mbps is obtainable over short distances. Fiber optics links currently transmit at rates of 100 Mbps to 2.4 Gbps (billions of bits per second). (At 720 Mbps, the entire works of Shakespeare could be transmitted in a quarter of a second!) SONET (synchronous optical network) transmits data at 2.4 Gbps. AT&T is the driving force for SONET, which was first implemented by the Chicago Teleport in early 1991. ATM (asynchronous transfer mode) offers both fast and ultrafast rates on demand and is seen by every expert as the blueprint for the public networks of the mid-1990s and beyond.

In terms of volume, the equivalent of the number of tele-
phone calls that can be handled simultaneously by each of these media range from 4 to 240 for telephone wire, to 5,000 for coaxial cable, to 8,000 to 15,000 for microwave, to more than 100,000 for fiber optic cable.

Bandwidth has historically been expensive and scarce. Today, it is cheap and plentiful. High-speed digital communication offers tremendous economies of advanced technology and scale. It also makes practical entirely new uses of telecommunications in business. The old systems could not transmit high-resolution images of documents, for instance, at an acceptable cost and speed. Fiber-based transmission can send voice, image, video, or data quickly and accurately and increasingly inexpensively.

While bandwidth is not free, it is becoming so cheap that yesterday's impossibility is today's premium item and tomorrow's commodity. In January 1994, MCI, the aggressive number two to AT&T in the long-distance field, announced a $20 billion plan to create a transcontinental network, ending its dependence on the Regional Bell Operating Companies (your local phone company) for handling the "last mile" of a phone call (and their charging MCI 45 cents on every long-distance dollar for doing so). MCI's advertisement boasted that this new highway will "move information 15 times faster than any SONET network available today." SONET is the fastest fiber optics transmission link: it is thousands of times faster than the standard data communications of five years ago. MCI's costs in producing a millionfold increase in transmission capability will be reduced greatly through a 19th century innovation: the telegraph. In 1989, MCI acquired Western Union whose conduit pipes reach into 2,000 buildings in 200 cities, including the 20 largest in the country. By installing fiber optics in these conduits, MCI greatly increased its bandwidth per mile of cable.

Bandwidth of cable grows exponentially every few years. Bandwidth in the air does not. Wireless communications, especially cellular phones, is one of the fastest growing areas of IT, and now that the Federal Communications Commission has opened up
high-frequency wavelengths in the wireless spectrum for use by Personal Communications Systems (PCS), the race is on to create the mobile equivalent of today's wired phones. Wireless devices, however, currently make very inefficient use of the spectrum; it is more difficult to establish a connection, avoid interference and distortion, or send and receive clear signals with wireless devices than with well-shielded wires. Thus, sending a fax from your personal computer via wireless communications takes about four times as long to transmit as sending it via a modem over the standard phone line.

See also: Fiber Optics, Megahertz and Gigahertz, Network, Satellite, Transmission

Bar Code Bar coding is becoming the most effective way to capture sales and inventory information. Bar codes can be read far more quickly by a scanner device than they could be keyed into a computer or even read by the human eye. For this reason, they are turning up in unlikely places. Long common on groceries and magazines, bar codes are now on railroad cars, parts destined for assembly, and all manner of products. In Europe, trucks driving between France and Germany display on their windows bar coded information about licenses, customs clearances, and freight. A customs official can aim a bar code reader at the truck, immediately see if it has the necessary clearances, and wave it through as the driver downshifts to second gear. Portable scanning devices, hand-held computers, and even radio devices can quickly read and input the information from bar codes into computer processing systems for point-of-sale pricing, updating inventory and delivery records, tracking physical movements of goods, invoicing, and so forth.

A bar code is nothing more than an electronic tag; the technique is as applicable to insurance application forms as to supermarket items. Bar coding enables a company to capture information as events happen, move it quickly into central data bases, and feed it back in the form of selective summaries and reports that
Batch Processing  Batch processing is the oldest established way of operating computers. Batch processing takes its name from the “batching” of transactions; orders, payments, and time sheets, for example, are accumulated over a period of time, such as a day, week, or month, and then processed in a single computer run.

Batch processing incurs lower costs and overhead and is more efficient and less expensive than on-line transaction processing. It is far more economical to store large volumes of data off-line on tape than on-line, and because they are typically processed in sequence, data such as employee records can be organized so as to ensure the simplest and fastest updating of master files. Batch processing also generally affords a wide enough time window to accommodate reruns in the event of major system errors. Should the computer “crash,” a service bureau may be able to provide a machine to run the batch system. Security is another strength of batch systems; the data centers are typically off limits, and the only way transactions get into the system is through the user departments. The principal shortcomings of batch processing are the information gaps that result from the time lag between the processing and reporting of transactions, and that put a firm’s internal operational needs ahead of the customers’ service needs.

Although rapidly being replaced by on-line transaction processing, a more expensive and complex but increasingly essential requirement for more and more business activities, batch processing remains the most practical alternative for many traditional business functions. Obviously, an airline reservation system is not a candidate for batch processing. Travel agents would have to wait

One of the largest financial service firms in the United States discovered in May 1990 that it had incorrectly overstated its foreign exchange profit for April by $45 million. It handled the FX trades on-line, but the accounting and payment records were processed monthly, by batch; someone made an error in the paperwork so the trading and accounting records were out of sync. Batch processing is the most efficient and cheapest way to operate. It is not the most effective though.
until the next day for a response to their requests and airline managers and planning staff would be a day behind in operating information. For payroll, the situation is quite different.

Transactions—pertaining, for example, to hours worked, absences, salary increases, overtime, and so forth—do not have to be processed immediately but can be accumulated and then sorted, checked for errors, and processed literally as a batch at the end of the month. Batch processing keeps costs and overhead low. Off-line storage on tape is far cheaper than keeping large volumes of data on-line. Because all the employee records need to be processed in sequence, the transaction data can be organized and records sorted to ensure the simplest and fastest updating of master file records.

Ten years ago, almost all banks processed customer checking account deposits and withdrawals through batch systems, daily for transactions, monthly for statements, and annually for tax records. Automated teller machines have moved more and more transactions on-line, although check processing, monthly statements, and tax accounting continue to be handled in batch mode.

Batch processing will survive through the century, but every system that is part of just-in-time business and customer service is likely to move on-line well before then.

See also: On-Line, On-Line Transaction Processing

**Batteries** Laptop and notebook computers, mobile phones, and similar devices all rely on batteries instead of electrical outlets as their power source. Battery technology is as old as computer technology is new—well over 120 years. Such a mature technology cannot be expected to provide radical shifts in performance. As a result, batteries are perhaps the problem for most users of portable devices. They almost always die out sooner than the vendor’s specifications state and need recharging or replacing.

This is not a major problem for business managers and only an irritant for users, who typically carry spare batteries and heavy recharging devices that look like a ball-and-chain and often weigh
more than the notebook computer. Major changes in battery technology have been rare and slow to make an impact. Even the best batteries now on the market power a cellular phone for only a few hours. The need for better performance in wireless and laptop devices is stimulating innovation. The two main types of batteries now in use are nickel-cadmium and nickel-metal hydride. Nicad batteries have been around since the 1960s. Their biggest problem is their “memory effect.” They have to be almost fully discharged before they are recharged; otherwise, they “re-member” the level at which they were last recharged and shut down when they reach it again. That irritating feature, plus the hazardous nature of cadmium, makes nicad batteries increasingly obsolete.

Nickel-metal hydride batteries cost about twice that of nicads (around $200). They also have twice the storage capacity. They are less reliable and sensitive to extremes of temperature.

Duracell, the U.S. firm, is invading what has previously been a predominantly Japanese-controlled market in an effort to standardize rechargeable batteries and turn them into easily available consumer items instead of manufacturer and computer proprietary ones. There are more than 100 different models for computers and 50 for cellular phones. Duracell hopes to cut this to 4 and 2, respectively.

Standardization can reduce cost but does not remove the limitations of today’s products. The most promising lines of development are lithium-ion, lithium-polymer, and zinc-air. Although these are lighter and can run for longer periods, lithium is unstable and therefore a safety hazard, and zinc-air is bulky.

It’s not possible to predict which battery technology will be most efficient as well as practical. Until batteries can operate a cellular device or computer for 10 to 20 hours, they will remain a source of major irritation to their users.

Bell Atlantic/TCI Bell Atlantic is one of the seven Regional Bell Operating Companies that have held a monopoly on local phone
services. In late 1993, it effectively announced a new era of telecommunications competition when it proposed a merger with TCI, the nation’s largest cable TV company. The alliance would have signaled an end to the old telecommunications industry and would have been the largest ever, with Bell Atlantic offering more than $33 billion for TCI.

The deal fell through as a result of price cuts required by federal regulators that reduced TCI’s value and hence the price Bell Atlantic was willing to pay for it. Several other loudly announced deals between cable and communications companies also fell through at that time. This has led some commentators to conclude that these deals were only hype and that the “Information Superhighway” and multimedia age that they intended to be part of are on hold.

Maybe, but the importance of the Bell Atlantic/TCI venture was simply that it was contemplated. When the chairman of a firm in one of the most conservative and least innovative businesses—the local phone company—makes the largest acquisition in business history and when the chairman of one of the most innovative and aggressive companies in the industry, viewed as the local phone companies’ most threatening competitor, agrees to be the minority partner, then something is in the air. There will be more such deals, driven by the capital-rich Bell companies. In 1993, Southwestern Bell paid $650 million for two Washington, D.C., cable companies. US West spent $2.5 billion to acquire a 25 percent share of Time Warner’s cable TV and entertainment businesses.

The message to business managers here is that the old distinctions between consumer and business telecommunications services are rapidly disappearing, so that, at some point, the many so-far failed efforts of home banking and consumer information services will find their market, probably through the same entertainment channels through which households get their pay-per-view movies and cable TV services.

In addition, and of more immediate interest to telecommunications managers, the weakest link in the business use of telecom-
munications—the local loop—is guaranteed to be broken. As the IT manager for a car rental company commented in late 1993, “The nine miles between our headquarters and our long-distance carrier are the worst part of my data communications problems. . . . I don’t care if this [the Bell Atlantic/TCI] deal is driven by ‘movies on demand’ as long as it means I can get the bandwidth I want without paying a fortune. If it motivates phone companies to develop technology that brings reliable, high-speed channels to the end user, then we are all better off.”

Telecommunications has already changed the basics of many industries—electronic banking, 800-number catalog shopping in retailing, and booking reservations systems in the travel business are just a few instances. This all happened without firms being able to get the bandwidth they want in the local loop. The Bell Atlantic/TCI deal, though canceled, signaled an era that would bring massive bandwidth into the home and across the city plus end the local phone company’s monopoly. It may take 10 years before all this is completed, but every business needs to ask if its existing services can be better delivered through telecommunications (as personal computers were by Dell via phone and UPS versus Computerland’s physical stores) and if some competitor is better positioned to use the new cable/phone delivery channels than it is.

**Bits and Bytes** A bit is the fundamental unit of coding by which information is represented digitally. A bit is either “on” or “off,” signifying the presence or absence of an electrical signal, which is the only thing a computer can store. A 1 is typically used to code an “on” bit, a 0 to code an “off” bit. A set of eight bits, termed a byte, represents one “character,” such as “W,” “j,” “5,” or “#.”

Any form of information—voice, text, graphics, color photographs, and television pictures—can be reduced to combinations of bits and stored in a computer or transmitted over telecommunications lines. The magnificent photographs of Jupiter and Sat-
Computers code all information or instructions as ones and zeroes, which represent on and off electrical signals. A single character, such as “a,” “$,” or “>” is coded as a combination of eight bits, called a byte. A color photograph may require hundreds of thousands of bits of code. The speed of telecommunications transmission is indicated in bits per second, and the size of a computer software program or database in bytes.

...urn and their moons that were relayed to earth by Voyager were in digital form. So is the music on a compact disc.

A computer’s storage capacity is generally measured in bytes and a telecommunications facility’s information-moving capability in bits per second. As a point of interest, approximate sizes in bits of selected types of messages and transactions are given below:

- A credit authorization request: 1,000
- An electronic mail message (1 page): 5,000
- Digital voice (1 second): 56,000
- Digital facsimile (1 page): 100,000
- Full motion video (one second, TV quality): 10,000,000

Bits and bytes are the background for what IT professionals call “voice/data/text/image integration,” or, in the more recent term, “multimedia.” When all these are coded in bits, the telephone system becomes a vehicle for carrying any type of information into the home and office. This is the goal of Integrated Services Digital Network (ISDN), the telephone service providers’ grand plan for the 1990s that will enable a firm’s telecommunications highway to carry voice and data simultaneously, with many opportunities for reducing costs and improving efficiency. Image processing technology will be used to handle documents, checks, photographs, recorded phone calls, handwritten letters, and conventional computer transactions and data as if all were the same medium.

ISDN is already obsolescent and is being overtaken by other forms of transmission, sometimes lumped together under the heading fast packet-switching, Broadband ISDN, or simply the Information Superhighway. These will all pulse digital bits at rates that will exceed 2 billion bits a second on the main highway routes. The network does not distinguish the bits that code a fax, a phone call, or a video. The multimedia age has arrived in terms of transmission capability and of computing power for storing and processing bits.
Humans see photographs as different from telephone messages and handwritten memos as different from memos produced by a word processor. These distinctions are meaningless to computers, which simply manipulate ones and zeros. Computers process bits, digital communications facilities move them. The significance of what bits represent is lost to these electronic contrivances.

*See also: Data, Digital Multimedia*

**Bridges, Routers, and Gateways** These devices link local area networks and have been an area of explosive growth because they link separate networks to create an enterprisewide capability. Bridges, routers and gateways are special-purpose computers designed to receive communications traffic from one local area network and pass it on to another. If networks use the same communications protocols (message formats, mode of transmission, type of medium, etc.), they are linked by a bridge; this is the simplest device, connecting like networks together.

Routers are more complex, and their explanation requires many technical terms because routers are a technical solution to a technical problem. By converting formats and interpreting protocols, routers can connect different types of local area network and connect LANs to wide area networks. In effect, routers are transaction processing systems, where the transactions are telecommunications messages, rather than purchase orders or ATM withdrawals. Multiprotocol converters can link, say, local area networks that each use a different protocol, such as IBM's Token Ring, Novell's IPX, Ethernet, and TCP/IP. Dozens of these protocols are used within most companies, and each requires an intermediate translator and traffic cop—a router—to manage their interconnection. As the term implies, a router also identifies the destination network through directories of addresses and ensures the incoming message is sent correctly through the system on the fastest and/or cheapest route. This process involves significant overhead because routers need specialized software for each net-
Routers are the major building block of enterprise-wide networking. To link its 1,242 stores, regional offices, and head offices, J. C. Penney is installing 1,200 routers that will provide all locations with transmission 18 times the speed possible over long-distance telephone circuits.

work protocol they support. They also use their computing power to add other capabilities, including network management, fault identification and isolation (routing messages to bypass a failed node), and traffic flow management to avoid congestion.

Gateways are an extension of routers. Essentially, bridges and routers take in a flow of messages, determine their destination, make any translations needed, and pump them out again. Gateways are used to handle more complex translations and interpretations. Electronic mail gateways, for instance, examine e-mail messages, convert their formats and address information, and may then pass the data on to a router. Gateways for electronic data interchange applications similarly interpret the data and convert it as needed. The distinction between routers and gateways is that routers process the communications message without knowing anything about its content and its application; they are super traffic cops that move data from one network to another. Gateways move data from one application to another via a network, after identifying the nature of the messages.

Routers are the workhorses of enterprise computing. Originally, local area networks were separate departmental resources that did not communicate with devices on other LANs or remote sites. Wide area networks handled the flow of traffic across the firm's main locations. Each element of this networking capability had its own technology base and protocols. The result was multitechnology chaos. Routers came to the rescue. They protect existing investments, allow decentralized units to choose the type of LAN most suited to their needs, and allow the central corporate telecommunications unit to exploit new types of transmission, vendor services, and high-speed capabilities. Changing one LAN has no impact on the WAN or on other LANs; the complex of routers handles the internetworking. This is not a simple process and bridges, routers, and gateways vary widely in the range of protocols they handle as well as in efficiency and reliability.

The distinction between the devices is blurring as vendors add features. Routers and smart hubs (super routers, bridges, and
gateways combined in one box), are the fastest growing area of telecommunications as companies begin building enterprisewide capabilities out of their many individual network resources. In 1992, the estimated sales of routers was just under 40,000 units. In 1995, sales are expected to top 100,000; this should double by 1998 (forecasts in the IT field are notoriously unreliable, but this one seems safely conservative). Costs are dropping rapidly. The average cost of a router in 1992 was about $7,000. Today, the average is closer to $4,000 with far more functionality and features. The challenge to router manufacturers is to ensure that their devices can handle well-established LAN and WAN protocols now in use as well as the new ultra highspeed services, especially the asynchronous transfer mode that is consensually viewed as the blueprint for the networks of the late 1990s and beyond. Today's high-performance router will need continuous upgrading as the technology of telecommunications continues its accelerating pace of innovation.

See also: Asynchronous Transfer Mode, Protocol, Switch, Telecommunications

**BT** BT is the new name for British Telecom, the first national long-distance and local telecommunications services government-sponsored or government-run monopoly outside the United States to become privatized. BT has been more aggressive and innovative internationally than in its domestic market. In fact, it is now an important player in the United States. It built its presence there through acquiring a leading provider of data communications services in the 1980s and made the move to consolidate its position when it bought 20 percent of MCI, the number two U.S. long-distance carrier. If BT and MCI can mesh their very different business and national cultures—a huge "if"—they will have a chance to dominate the busiest telecommunications market in the world: transmission between New York and London. At peak times, communication between Lower Manhattan, where banks and Wall Street make around $1.5 trillion a day of electronic transactions, and the City of London, which handles at least half
of Europe's transactions, amounts to almost half of U.S. total network traffic.

The BT/MCI link is the forerunner of many ongoing and upcoming international joint ventures. In response, AT&T (the largest international carrier) has initiated its own joint venture with the second- and third-largest carriers: Germany's Deutsche Telekom and France Telecom. If they can merge their cultures, who knows what can happen; that is an immense "if."

**Bug** A bug is an error. Because large-scale software systems are extraordinarily complex, it is practically impossible to anticipate every potential combination of circumstances that will arise in their use. Consequently, they can never be proven to be bug free or guaranteed to produce perfect results all the time, however rigorously they might be tested.

Most business computer systems are compilations of relatively simple processing rules that involve little mathematics. But the rules must be complete, consistent, and precisely sequenced. Tiny differences or oversights can wreck a process and have expensive business consequences. For example, a small and overlooked miscalculation in American Airlines' yield management system, the best in the industry, led to discount fares being cut off too early. This bug, which went undetected for several months, cost the airline $50 million. The programs appeared to work correctly; the error was subtle. In another instance, the sequence in which a spreadsheet program added numbers yielded an analysis that indicated that the firm should acquire a company, which it did. Later suspicions that the numbers were faulty led to the discovery that switching the sequence in which the calculations were made clearly indicated that the acquisition would be a disaster. That bug cost $12 million.

Managers may be interested in a bug that is patiently waiting until January 1, 2000, to reveal itself. Dates in computer records are stored in as compact a form as possible to save space and speed up retrieval and processing. There is no need, for example,
to store year of birth in a payroll or benefits system as "1945", "45" is sufficient. But what will happen in the year 2000? The dutiful software will calculate pension and pay for an employee who has turned minus 55 years old (the age calculation is the current year minus birthdate; 2000 minus 1945 will be represented by the software as 00 minus 45). At a conference on the year 2000 "date-dependency" problem held in New York in early 1991, attendees offered such comments as "the impact of the problem hasn't hit top management yet" and "we may not really understand the scope of the date problem." What makes programming such a complex craft is that it requires a quirky way of thinking that can anticipate such vagaries.

Bugs are a reality of IT life. They explain why testing costs more than programming in the systems development life cycle. They also demonstrate the degree to which technology risk is now business risk. When IT was confined mainly to back office operations, the impacts of bugs could generally be hidden from customers. Today, with more of the basics of customer service, quality, and logistics on-line, situations like the following are becoming all too common.

Thousands of Sovran Bank customers looking for pocket money from the bank's automated teller machines yesterday started the weekend on the wrong foot. The ATMs ate their magnetized cards . . . "We changed a program, we tested it fully, but something showed up that didn't appear in the tests," . . . Technicians corrected the program by early afternoon and branch staffers began mailing the 2,100 captured cards back to their owners, who will have to rely on credit cards and checks for the duration of the weekend. (Washington Post, May 13, 1990)

Large software systems involve masses of detailed definitions of procedures, calculations, and data. The Air Force calculates that 5,000 pages of documentation are needed to specify the "requirements" for a program of 100,000 lines of code. The logistics system for the F-15 fighter contains more than 3 million lines

The three most expensive, known software errors cost the firms involved $1.6 billion, $900 million, and $245 million. Each was the result of changing just one line of code in an existing program. No large software program can be proven bug free.
of code for more than 4,000 discrete processes in nearly 70 programs. Many Fortune 1000 firms’ existing processing systems for manufacturing, distribution, ordering, and customer service are comparable in scale and often contain very old, generally undocumented elements that become harder and harder to maintain.

The best remedy for bugs is to improve the quality of the software development discipline through the use of such emerging tools and techniques as computer-aided software engineering (CASE), structured methods, database management systems, and object-oriented programming systems (OOPS). IS units must also avoid caving in to business unit pressures to cut corners in systems development because of budget and time pressures. In addition, IS units must encourage sustained, meaningful involvement by people who understand the application being worked on and can anticipate and know how to handle exceptions and special cases.

Using CASE tools, the Air Force cut error rates in a major operational system from eight to four errors per 1,000 lines of code. For a business that has one million lines of program code in use, that improvement translates to 4,000 instead of 8,000 potential disasters in customer service and the reliability of business operations per year. A 1991 MIT study concluded that the typical domestic program experiences 4.4 technical failures per 1,000 lines of source code in the first 12 months of use. The corresponding figure for Japanese-developed programs is estimated at less than two.

When bugs occur in a company’s systems, they do not affect other firms’ operations. However, more and more IT is being used to link systems and services across organizations: electronic data interchange, payment systems, and telecommunications networks. In 1992, dozens of major "crashes" occurred on the phone network because of tiny bugs in the software that handles advanced digital communications: this breaks new ground and thus is vulnerable to new errors. On one occasion, JFK, La Guardia, and Washington National airports came to a complete standstill for
seven hours because of a one-line error in this software (called SS7, or Signalling System 7). One bank, most respected for the quality of its systems, “released”—made fully operational—a new international funds transfer system in early 1993. The system ran for three months with no problems and then suddenly crashed. Computer data files were “corrupted” (i.e., full of garbage) and international customers’ multimillion-dollar transactions were either misprocessed or lost. The bank’s chairman and CEO cancelled all their appointments and for three days they phoned clients to explain and apologize. An audit of the project showed that the development team had followed required procedures for testing but the head of marketing had insisted the system go “live” on January 1, 1993. The head of information services commented, “So, they cut a few corners. What else could they do?”

There is an ever-present tension in application development between the business need for fast delivery and the technical need for reliable operations. This is a tough trade-off, and business managers rightly feel frustrated by the notorious and continued cost and schedule overruns of large-scale software projects. These managers can help avoid a bug becoming a business disaster if they keep in mind four precepts: (1) all programmers are optimists; they honestly want to deliver fast and meet your timetable, (2) you may be creating the disaster if you impose an arbitrary deadline; as one of the most insightful analysts of the “tarpit” of software engineering commented, it takes roughly nine months to have a baby and using nine obstetricians does not reduce this to one month, and throwing programmers at a project doesn’t either, (3) bugs are inevitable; there is no such thing as an error-free large system, and (4) you can never test a program too much; an error-free test run does not mean that bugs are not lurking, waiting for their time to appear—how about January 1, 2000?

See also: Application Software and Application Development, Computer-Aided Software Engineering, Maintenance
**Business Process Reengineering** Reengineering is either the wave of the future, a new fad, or an old idea in new clothing, depending on your viewpoint. Reengineering amounts to "starting again." It argues that existing business processes are built around a division of labor that has created "stovepipe" functional departments that make simple work complex. By taking a fresh look at the processes that most affect customer satisfaction and service, firms can use senior management's commitment to radically and fundamentally transform the organization and mobilize the company's culture and information technology. For example, workstations and telecommunications can be used to hub work to a "case manager" who provides a single point of contact to customers and can complete their requests, instead of having customers phone dozens of 800 numbers or having their transactions moving through dozens of steps and departments, with paper dominating the workflows.

Typical success stories of reengineering reduce time, staff, and errors in workflows of 40 percent or more. Unfortunately, an estimated 50 to 70 percent of reengineering projects fail and even the successes often do not reduce business unit costs or increase profits overall. The most powerful contribution of the reengineering movement has been its insistence that firms must take a fresh look at business processes from a cross-functional, customer-centered perspective if they want to go beyond cautious incremental change. Its main limitation is its overfocus on workflows that have well-defined steps, ignoring many other key business processes, including cultural, leadership, decision-making, and communication processes. The very term "reengineering," which comes out of electronics manufacturing, signals its roots in industrial engineering.

The emphasis on radical transformation of organizational processes in reengineering contrasts with that of continuous improvement espoused by advocates of total quality management. Advocates of business process reengineering and such variants as business process redesign and innovation vary widely in their
definitions of process and in their radicalism. The most extreme enthusiasts tend to underplay the relevance or importance of the human element in the radical change they insist is essential for almost every firm in today’s business environment. When asked about how firms can co-opt people, one leading authority replied, “On this journey, we shoot the dissenters.” He advocated taking a machine gun and ax to the organization and believed the manager of a reengineering project must be a “legbreaker” because plenty of people need “clouting.”

While reengineering is not directly related to or dependent on IT, it emerged from the IT consulting and research field and most of its techniques rely heavily on IT. The most commonly used IT tools are image processing, which attacks the organizational tyranny of paper; powerful workstations that access information and manage transactions to and from remote systems; and groupware, tools for helping people collaborate across locations and time zones.

**Business Television** Business television is an alternative to memos and the corporate communications department’s glossies for supporting management-staff communication and getting word out to the broader organization. It can be surprisingly inexpensive to provide, being just another type of traffic on the corporate communications network. A firm that has installed small satellite dishes at its stores and principal dealer locations to handle, say, on-line transaction processing already has the basis for providing business television. Kmart, for instance, calculates that the full cost for its business television via satellite is 50 cents an hour per store.

Business television differs from videoconferencing in being a one-way video medium, although generally a two-way audio link is provided to support questions and discussion. This makes the medium valuable for management presentations, training, and news updates.

With “communication,” “partnership,” and “teamwork” widely

*The chairman of Kmart regularly uses the firm’s television network to talk to staff across 2,200 stores simultaneously and answer their questions. “The satellite is fantastic,” he said. “I would never believe it. You walk into a store and it’s like they’ve known you for 15 years.”*
espoused organizational priorities for the 1990s, business television is a tool for organizational advantage. Its adoption is most often impeded because it does not fit the typical information systems organization's responsibilities and capabilities. Thus it must often rely on "championing" by an influential business manager.

A number of leading companies have set examples in the effective use of business television. Fedex's founder and chairman, Fred Smith, is a strong believer in its value in keeping employees in touch with what is happening in the company and ensuring that they never hear important news about the company from the press before they hear it from management. Digital Equipment Corporation's founder, Ken Olsen, argues that the ability to bring teams together electronically will be a major source of organizational advantage in a world of just-in-time everything. The head of Domino's Pizza believes that business television helps both to keep people informed and well-trained and to keep the corporate headquarters staff small, flexible, and responsive to the field.

See also: Videoconferencing

Bytes  See Bits and Bytes

Cables, Plugs, and Sockets  Lack of standardization in the IT field is perhaps most clearly illustrated by the plethora of cables, plugs, and sockets needed to tie IT devices together. Imagine if connecting a VCR to a television set required choosing between 22 types of cable, depending on the make of the VCR and TV. That is precisely the number of cable sockets that appeared in a recent advertisement for a telecommunications provider. They were identified as "standard."

Few senior managers ever visit their organization's data centers and fewer still ever view the tangled black and gray spaghetti beneath the floor panels that interconnect the quiet cabinets and consoles that comprise the corporate computer system. The schematics that vendors and consultants draw to illustrate integration
and interconnection are one thing; the cables, plugs, and sockets required to achieve them are quite another.

There is an apocryphal, but plausible, story of a company that had so many undocumented cables running through its walls and under its floors to connect personal computers, word processors, telephones, and computers that it finally sold the building, with the cables intact, and moved into new quarters to start over. Simply moving a person's telephone to another desk took weeks, and installing and upgrading local area networks became major logistical projects. The company knew neither where all the cables were nor how many it had; it could manage its computers but not the cables that interconnected them.

One implication of the myriad of connectors involved in even a fairly simple IT facility is that buildings now need to be explicitly designed for computer and telecommunications use. Such "intelligent" buildings include central shafts and underfloor space for cables, backup power supplies, and, in some cases, built-in fiber-optic links.

This may sound simple, but in practice, designing and implementing the cabling of a building is an art because so much can go wrong, and when it does, your most powerful PC or network link can't solve the problem. The people most frustrated by all the cables, plugs, and sockets are PC users. If they want to add, say, a CD-ROM, an optical scanner, or a new printer, they often have to wrestle with a problem that can take days to solve. As a result, business costs of PCs and departmental local area networks relate more to support than to purchase price. Managers always need to keep this in mind; they should ask what is the five-year cost of purchase, support, education, and maintenance. Typically, these are at least four times the price of the device.

See also: Compatibility, Connectivity, Network

Cable TV The technology of cable TV is very different from that of the telephone. Sending full-motion television programs over a coaxial cable—the same thick black cable that links a TV

"My best friends are rats, asbestos, and bureaucrats" (said a supplier of wireless local area networks). "Rats gnaw through cable, asbestos-filled walls may not be drilled through, and bureaucrats protect historical buildings from being cabled."
to a VCR—requires large bandwidth. Bandwidth is the telecommunications equivalent of horsepower, a basic measure of how much information can be carried over a transmission link. Standard telephone lines have very limited bandwidth. For this reason, the leading cable TV companies have been eyeing telephone services CAD/CAM as an easy addition to their networks; it requires no additional bandwidth and the cables are already in place. They also see many new opportunities for information, publishing, education, and shopping services, although most previous efforts in these areas have been disasters.

The main blockage to cable operators entering such markets has been regulation. The divestiture of AT&T, which opened up competition in the long-distance telecommunications market, gave the Regional Bell Operating Companies a monopoly over basic local phone services but blocked them from entering entertainment, publishing, and information markets. There have been many legal challenges to both the monopoly and the market restrictions, with joint ventures and alliances bypassing some regulatory constraints.

Now, the status quo no longer holds. The technologies of cable and both long-distance and local communications are converging rapidly. So, too, are the individual companies. In late 1993, five of the largest cable firms created an alliance to offer advanced telecommunications services—i.e., high margin ones—in competition with local phone service providers. Four of them own a share of Teleport Communications Group, which offers access facilities between local and long-distance services. The irony here is that several members of the alliance also have ties to the very same local exchange carriers they are targeting for attack. The alliance may be just an announcement and not a serious venture (many ventures have been proposed among cable providers that have come to nothing). In any case, it shows that the telecommunications industry is now any business that moves any type of information to any place.

See also: Bandwidth, Information Superhighway, Multimedia
Cellular Communication Cellular communication is a form of mobile communication involving the use of a wireless, radio-frequency telephone that allows calls to be made from a car or while walking along a sidewalk as long as the caller is within what is termed a statistical metropolitan area, or SMA. Located within each SMA are radio base stations that are capable of sending and receiving telephone calls over short distances. The broadcasting range around this base constitutes a cell. Calls are passed from one cell to another as the sender or receiver moves (for example, driving from New York into New Jersey). Calls made to recipients in a noncontiguous SMA or outside of any SMA are connected to local and long-distance telephone systems.

A new generation of digital cellular systems that will replace existing analog systems will increase capacity by a factor of three while reducing operating costs. The cellular communications industry is roughly in the stage the cable television industry was in during the early 1980s and exhibits many of the same trends, problems, and issues—it has yet to make money and lacks the critical mass of subscribers needed to recoup the necessary investments in infrastructure. Absent fully defined standards, many facilities are incompatible. State and federal regulators are still defining policy. Given that the Federal Communications Commission (FCC) is dividing the country into 300 metropolitan and 420 rural units, it should not be surprising that the industry is highly

The launch of McCaw Communications’ CDPD (Cellular Digital Packet Data) Service at the end of 1993 marked a step up in cellular communications. It is national in reach, digital, and while still slower than wired transmission, several times faster than existing wireless facilities. It also has security features, which are entirely absent from today’s analog cellular phone systems.
fragmented geographically. Current FCC strategy for awarding cellular franchises, reminiscent of cable television, is to encourage duopolies consisting of a local consortium or company and an established “non-wireline” telecommunications provider.

The year 1993 saw major changes in the industry and in the technological and regulatory environment. The FCC opened up the 1.8 to 2.2 gigahertz frequency range for personal communications systems and allocated a frequency band for emerging technologies. AT&T bought McCaw, the leading acquirer of cellular licenses in the United States over the past seven years, which had also launched the first nationwide digital cellular service for business use. Motorola raised the funds needed to implement its Iridium system, which uses low earth orbit satellites sixty miles above the earth to create a worldwide cellular phone system. The wireless-equipment industry adopted a Cellular Digital Packet Data standard (CDPD) as the base for a modem that any personal computer can use to access the many cellular networks being implemented in the 1994 to 1996 time period.

The regulatory barriers to innovation and competition are estimated to have cost the United States close to $90 billion in lost cellular revenues between 1980 and 1991. The FCC’s policies created an acute spectrum shortage, with only limited frequency ranges open to cellular communications.

Progress in cellular communication has been more rapid in Europe. Scandinavia leads the world in mobile communications, with approximately 5 percent of telephone subscribers also having cellular service, and Germany has taken the lead in promoting a pan-European capability, which should be in place by the mid-1990s. Mobile communication—cellular plus satellite-based systems—will certainly be a key element in Eastern Europe’s entry into the world of modern telecommunications, because countries such as Poland and Hungary simply cannot afford the time and costs associated with developing a fixed-network infrastructure.

In 1993, the World Administrative Radio Conference agreed to assign the 1.7 to 2.6 gigahertz frequency spectrum to mobile
communications systems across Europe, the United States, and Japan.

For business, this means that the mobile work force will have access to mobile data and voice communications via cellular phones, laptops, personal digital assistants, and the like by the late 1990s. Companies need to think ahead to exploit this opportunity. In 1995, almost every office worker has a phone on his or her desk. Most blue collar workers do not have access to anything other than pay phones. A 1993 study concluded that less than 5 percent of people who work out in the field—sales reps, repair crews, etc.—carry cellular phones. Why not? The only answer is “tradition.” Phones used to be expensive. Cellular phone services still are, but not for much longer.

*See also: Mobile Communication, Network, Satellite, Telecommunications, Transmission*

**Central Processing Unit (CPU)** The central processing unit, or CPU, is the chip or set of chips that contains the circuits that process instructions and data stored in a computer’s memory. The basic dimensions of power of a CPU are its “clock speed,” measured in megahertz (the range of usable electromagnetic frequencies used to move information) and the number of bits of data it can input, store, and process simultaneously. The original Apple II CPU was built on an 8-bit chip. The IBM personal computer used a 16-bit chip. Today, the standard chip is 32 bits, with 64-bit chips in wide and growing use.

The number of bits also determines the amount of memory that can be directly “addressed,” which, in turn, determines the size of the software programs that can be run. The rate of progress in the development of chips is illustrated in the table on page 88. The period from the introduction of the first chip to the last was just over ten years.

This table will be out of date the day this book appears, but readers can reliably extrapolate from it; progress in chip technol-
ogy will be at least as fast in the 1990s as it was in the 1970s and 1980s.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Chip</th>
<th>Bits</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel</td>
<td>8088</td>
<td>16</td>
<td>The chip used in the original IBM PC</td>
</tr>
<tr>
<td>Intel</td>
<td>80386</td>
<td>32</td>
<td>The first power chip; about 30 times faster than the 8088; the key element in the PCs of the late 1980s by providing the speed and power needed to go beyond simple software applications</td>
</tr>
<tr>
<td>Intel</td>
<td>80486</td>
<td>32</td>
<td>The workhorse of PCs in the 1992-95 period</td>
</tr>
<tr>
<td>Motorola</td>
<td>68000</td>
<td>32</td>
<td>Used in the Apple Macintosh</td>
</tr>
<tr>
<td>Intel</td>
<td>Pentium</td>
<td>64</td>
<td>2 to 4 times faster than the 486</td>
</tr>
<tr>
<td>Motorola and others</td>
<td>PowerPC</td>
<td>64</td>
<td>At least as fast as the Pentium</td>
</tr>
</tbody>
</table>

Classes of computers are increasingly referred to in terms of the generation of chips they use. Managers today are likely to hear about a “386,” “486,” or PowerPC machine. The chip is often more meaningful than the brand in indicating the capabilities of the computer.

In addition, because different manufacturers’ CPU chips are mutually incompatible in terms of the software that can run on machines that use them, the chip basically determines the market niche of the computer. Thus, Motorola’s chips are the base for the Apple series: Macintosh, Powerbook, Quadra, and others. Intel’s line of 286, 386, and 486 chips have been the core of the PC industry, including machines from Compaq, Dell, IBM, Tandy, and hundreds of other IBM PC clones.

A Macintosh that uses a Motorola 68000 series chip and that runs a software package such as Microsoft Word is not at all equivalent to, say, a Sharp PC that uses an Intel 486 chip and also runs Word. The Word commands may look exactly the same to
the user but they are entirely different implementations. Add to the Motorola and Intel line Hewlett Packard’s RISC chips, Digital Equipment’s Alpha, IBM’s RISC processor and others, and it is easy to understand how incompatibility became the norm in IT.

It’s also easy to understand the logic of the two major initiatives that hit the market between 1993 and 1994 and that will strongly influence the success of Intel, IBM, Apple, and perhaps Motorola. Intel launched its Pentium chip and the PowerPC consortium followed a little later with its own superchip. The goal of both is to control the mainstream market for PCs. In Intel’s case, the aim is maintaining control. “Intel inside” is the firm’s logo that appears on ads for many PCs. The last issue of PC Week magazine in 1993 had 13 of these ads. Intel wants to stay inside these 13 manufacturer’s products, including IBM’s.

IBM wants to regain control of the PC market it once owned and lost. Apple wants to regain its position as the provider of premium personal computers and also gain entry into mainstream corporate America. Motorola wants to displace Intel as the dominant market leader in chip manufacturing.

Intel’s Pentium chip and the IBM/Apple consortium’s PowerPC define, for now, the new limits of personal computer power and speed. Most users may remain content with 486-based machines and do not need the extra capability, but that seems unlikely. Software makers have continuously added new features to their products to exploit innovations in chip technology, and once manufacturers build up production capacity, prices will drop rapidly even though the CPU chip amounts to just 10 to 20 percent of the cost of a typical PC. Intel increased the number of plants producing Pentium chips from one to five in 1994. The PowerPC group licensed a number of Asian manufacturers; these, too, want to dethrone Intel.

In January 1994, the price of a Pentium 66 MHz (megahertz) chip was $900; it dropped to $750 by midyear. The corresponding figures for a 66 MHz 486 chip were $460 and $360. The price of a Pentium-based PC fell from an average of $3,500 to less than

Currently, the United States dominates the CPU chip market. The major next contenders are likely to come from Taiwan (an island of 21 million people), which sold $10 billion of computer hardware in 1993. The PC produced by its Acer company is the leading brand in Asia and number 10 in the United States. UMC, a spin-off from a Taiwanese government lab, is the first Asian firm to manufacture a competitor to Intel’s 80846 chip.
$3,000. Clones of 386 and 486 chips undercut Intel, which is retaliating by continuing its aggressive investment in R&D, which has doubled the performance of its chips every 18 months since 1982.

What does all this mean for businesses? The most obvious answer is that the exponential improvement in speed and computing power will move PC use from applications that handle mainly words and numbers to ones that process and provide video, voice, and photographs. This "multimedia" will be the mainstream well within the next five years.

See also: Bits and Bytes, Chip, Mainframe and Minicomputer, Megahertz and Gigahertz, Millions of Instructions per Second, Multimedia

**Chargeout and Allocation** Chargeout refers to the allocation of corporate Information Systems’ costs to users. It is based on two business principles, one outmoded and ill-guided, the other sensible and vital. The ill-guided notion—that because IT is an overhead expense, all central IT costs should be charged out to users—put a leading U.S. university’s computing center out of business. The accounting system that required the center to allocate its costs so as to be fully “recovered” on an annual basis employed a simple formula based on connect time (the period of time a user is connected to the service). Because the computer facility was underutilized (subscribers consumed only about 40 percent of its resources), its full cost was spread over a narrow base of users. The resulting chargeout rate was extraordinarily high, as if a restaurant charged $750 for a hamburger because it had only 12 customers. The high chargeout rate drove away more customers, which drove the rate higher and discouraged still more customers until the center was forced to close.

At another university, the computer center took a different approach to chargeout; it developed elaborate formulas to calculate how much of the computer’s resources each user was consuming. The typical hourly cost for this university’s system was between $30 and $75. Nevertheless, one day a student used the computer
for two hours and received a bill for $7,800. The day was Christmas Day; the student was a Moslem and the only user on that day. Because costs were automatically fully allocated, he was charged the entire cost per hour of the system for that period. Welcome to People's Distress Airline of Transylvania; you are the only passenger on our scheduled Flight 9099 to Slovarik—that's $12,680, please.

The alternative to allocation—not to charge out computer use at all, but instead absorb it as a central cost—might have been acceptable when IT was a tiny fraction of expenditures, but not when it is a major and growing percentage of capital investment. IT is not a free good. There must be some basis for pricing so that it is sensibly used. If there were no charge for electricity, who would bother to turn off the lights?

The critical need in allocating IT costs is to establish a realistic usage fee that (1) facilitates investment in longer-term infrastructures (naïve chargeout systems often discourage such investment by making early users pay for the entire resource when usage is still small), (2) establishes a price that spreads the cost over the long term, providing users both a fair deal (in that no user group is charged a disproportionately low price at the expense of other users) and a good deal (in that the internal user is charged a price at least as low, and offered a quality of service at least as high, as could be obtained from an external supplier), and (3) encourages a sensible balance between the development and operation of central, shared services and decentralized decision making (striking this balance is the central issue in managing Information Systems as it shifts from highly centralized, corporate data processing to service-driven support for effective business uses of IT).

Although many firms have established policies that transform the central IS unit into a competitive supplier of IT services that must vie with outside suppliers and hence offer competitive prices and services, there remain areas in which efficient exploitation of technology demands a central, shared processing base and
technical support that must be charged out or absorbed centrally. Security, network management, operation of corporate data centers, and many areas of telecommunications—though they may look like overhead to business units that face heavy chargeouts and have little control over them—can provide considerable economies of scale, technology, or expertise.

Many firm's allocation, chargeout, and pricing policies for internal systems impede effective economic decisions about IT investment and use, as evidenced by the preceding examples. Too many financial controllers and accountants are locked into the old paradigm of IT as an overhead expense. Those times are gone, and the mindset must go, too. Developing an effective strategy in this area is a key management-policy need.

See also: Cost of IT

Chief Information Officer (CIO) Chief information officer, or CIO, is the fashionable term for the manager of the corporate Information Systems function. On the positive side, it signals recognition of IT as a major business resource that requires a new type of executive. On the negative side, the title has often been introduced into organizations without the changes needed in the management process to make the role meaningful, the job practical, and the individual effective.

The CIO's role is to coordinate the firm's corporate IT strategy and to ensure that IT is viewed as a competitive as well as an operational resource. Coordination is not the same as control. Traditional data processing departments were notorious for their perceived (and often real) efforts to maintain a monopoly on IT decision making, viewing themselves as both guardian of the technical resource and the only qualified source of expertise and opinion. This has changed, as first the personal computers and then the local area networks facilitated decentralization of hardware, software, local communications, and even many aspects of development. Business units that recognize the business importance of IT, and that have felt poorly served by unresponsive

The CIO position is a relationship, not a job. If the CIO–top management team relationship is effective, the title doesn't matter. If it is ineffective, the title doesn't matter.
central data processing groups, increasingly want to bring IT resources into their own sphere of operation and decision making.

The CIO’s job is to encourage such decentralization while ensuring that infrastructure facilities and services remain centrally planned and coordinated and that the process does not lead to systems disintegration. His or her primary responsibility is to guarantee the integrity of the corporate architecture, promote economies of expertise, and identify critical corporate standards that will ensure that disparate and decentralized development is consistent with the overall needs of the firm. Network management, R&D, vendor strategy and relationships, data and telecommunications architectures and standards, security, the piloting of new technologies, data center consolidation, and strategic application development are all within the purview of the CIO.

In many ways, the CIO is a relationship rather than a job. The relationship is with the business leadership of the firm. For IT to be used effectively as a business resource, there must be real dialogue and joint planning. Yet in many firms, the CIO is isolated from business discussions but still expected to work competitive wonders, with little if any meaningful direction from the top. It is for this reason that Business Week in 1990 said that CIO stands for “Career Is Over”; many CIOs have been unable to balance all the needs and constraints of centralized versus decentralized development and operations, funding of infrastructures, cost allocations, systems development, and getting demonstrable competitive payoff from IT. They are being fired, according to Business Week, at twice the rate of other corporate executives.

In many instances, the company that fired the CIO had conducted an executive search for that person just two to four years ago. Chances are, that CIO, “who resigned to pursue other interests,” is well known and respected in the industry. It’s an insider joke that being chosen CIO of the year and appearing on the cover of a leading trade publication is a message to update your resume—you’ll be gone within a year.

When top companies spend a lot of money to hire a known
star but soon get rid of that person, the issue is not personality but some deep-rooted problem about balancing central coordination and decentralizing autonomy and developing effective relationships. Common causes of the problem seem to be (1) top management overdelegates to the CIO the responsibility for handling these complex political and organizational issues without defining clear business priorities, policies, and authority; delegation is not a strategy and the CIO generates either political stress by pushing too hard or disappointment and confusion by trying to flow with the tide; (2) the CIO works himself or herself out of a job by downsizing and outsourcing and by encouraging business units to handle more and more of their own IT planning and operation; at the end of this process, there’s not much to be CIO of; or (3) the CIO’s skills address either business relationships or technology planning, but not both.

The last of these three factors is very common. Up to the 1980s, the priority of what was then a job with no glamorous title was to ensure effective planning of IT hardware investments and efficient operations and to make sure major application development projects were delivered reasonably on time and close to budget. The IT professionals who were good at this had risen through the ranks of programmers and in most instances either lacked business and organizational savvy or were just too busy firefighting runaway projects and negotiating with vendors to spend time on building relationships. They also found it hard to let go of control of the technology, budgets, decisions, and even development projects. Even today, many of the best of this old guard who have successfully made the transition to CIO (and kept their jobs) admit it’s still hard for them not to interfere with a software project and start questioning the details of design.

This old guard coined the term CIO in the early 1980s. It caught on because it signalled that IT (then mainly computers, not telecommunications) was a new force in competitive positioning and needed a new style of management. The CIO was thus analogous to the chief financial officer: a business executive with
oversight of a key business resource. If the old guard placed technical issues above business ones, the new generation of CIOs often went too far in the other direction. Many of them had limited technical experience, and it became almost fashionable for them to boast of this. One acerbic commentator claimed that when two CIOs met and tried to establish their relative pecking order, one would say, "I know more about business than you do," which would then be countered by the other saying, "I know so much about business that I don't know anything about technology."

Today, the CIO has to know a lot about business and also have excellent judgment about technology. Companies quite literally are betting their business futures on the choice of architecture, key vendors, and specific emerging technologies. Although the CIO no longer has a large fiefdom of data centers, programmers, and projects, this position is highly specialized and critical for any firm that depends on IT for service, reputation, efficiency, and business innovation.

One of the roles of the CIO is to facilitate the immense shifts in the IT planning and management process that have been underway for about five years now. This balancing act creates a form of coordinated devolution—coordination of infrastructures and enterprise integration and devolution of every aspect of business use of IT.

"I wear two hats," explained one top CIO. "Under my customer service hat, I encourage every move toward making business units autonomous and putting them in charge of their own destiny; under my corporate hat, I make sure that autonomy doesn't put the company at risk. I am sometimes the good guy and sometimes the bad guy. If I were always the good guy, I am sure the company would end up in technical chaos. If I were always the bad guy, I'd get fired because I'd be blocking the businesses from getting the technology they must have to compete effectively."

Just as IT is no longer overhead but often the largest single
element in a firm’s capital investment, the manager of the IT function is no longer a staff administrator and planner but a new style of line executive. IT is today part of the direct responsibility of top management; it is not something to be delegated and largely ignored.

See also: Architecture, Platform, Security, Standards

Chip Chips—or more properly, microchips—are made of thin wafers of silicon, about 1/16 inch square and 1/30 inch thick. Manufacturing chips consists of etching many layers on electronic circuits 100 times thinner than a human hair and involves as many as 200 discrete steps.

Miniaturization of circuits reduces the distance electricity must travel and thus speeds processing. Packing more circuits onto a chip reduces the cost per unit of computing power. Initial versions of chips are very expensive to design and produce, but as production yields increase with experience (the well-known manufacturing “learning curve”), chips become relatively inexpensive. Today’s advanced chip is tomorrow’s commodity.

There are two main types of chips, logic chips and memory chips. Logic chips are the basis for the central processing units that execute instructions and perform calculations in computers. Memory chips provide the random access memory (RAM) used to store programs and data. Other specialized chip types include ones that preserve the contents of memory when electrical power is switched off or interrupted, notably EPROM (electrically programmable read-only memory) and EEPROM (electrically erasable PROM), and a more recent variety of highly reliable logic chips, called RISC (reduced instruction set computing) chips, that simplify the design of hardware architectures. RISC chips are especially suited to the development of high performance workstations, such as those used in engineering and scientific applications. In 1994, Apple adopted RISC chips for its personal computer line. Flash memory chips are another rapidly growing part of the market. These retain their contents when the machine is
switched off and are a useful feature of portable computers; you can put them to sleep and restart exactly where you left off.

A decade ago, the United States dominated the memory chip industry, and the typical chip stored 16,000, or 16K, bits of data. (The “K” stands for “kilo,” which literally means thousands. In computer storage 1K = 1,024 bits. It is not precisely 1,000 because computers code bits in binary powers of 2, and 9 to the power of this number comes close.)

In 1964, the chairman of Intel defined what is now called Moore’s Law, which remains a reliable predictor of improvements in memory chip capacity. Moore’s Law states that a 10 percent per year shrinkage in the size of the lines on memory circuits will lead every three years to a new generation of chips with four times the number of transistors per chip. That means that the 16 megabit chip of 1993 and the 64 megabit chip of 1996 will become a 64 gigabit chip in 2011—all with a mere 10 percent annual shrinkage.

In the CPU market in 1989, Intel held 38 percent, AMD bust...
technology only to see a cheaper, more powerful technology come along months later. Other firms choose to forgo the benefits of a technology upgrade while they wait for the follow-on technology. A firm’s best buffer against the present circumstances is a strong corporate architecture that can provide a framework within which new components can be added and older ones replaced in an evolutionary manner consistent with the pace of technology.

See also: Architecture, Bits and Bytes, Central Processing Unit, Digital, Intel, Random Access Memory

**CIM** See Computer-Integrated Manufacturing

**CIO** See Chief Information Officer

**Client/Server Model** Client/server computing is the emerging mainstream in the combination of computers and telecommunications to create a low-cost, high-performance business capability. The logic is to exploit the “front end” capabilities of workstations (clients) plus devices that provide shared information, coordinate communications, and handle transactions (servers). Before the availability of powerful workstations (a personal computer with communications is effectively a workstation), mainframe computers handled data processing and information management for users who were connected to them by “dumb” terminals, typewriter-like devices that had no processing or storage capability of their own. As use grew and mainframe capacity was taxed, access became bottlenecked and response time was seriously degraded. Use became disproportionately expensive as mainframes spent much of their time handling trivial operations, such as checking the validity of inputs and generating and transmitting an error message.

In the client/server model, a “server” provides data and services to “clients,” most usually workstations. The client device handles as many functions as possible, reducing the time spent mov-
ing information to and from the server. The server, a mainframe, 
minicomputer, or high-end PC, handles functions that are not 
efficiently handled by client machines, such as data base man-
agement, security, and automated network management. To exploit 
the very different comparative advantages of client and server, 
each must logically share the handling of the elements of a 
business task. The client handles “front end” computing, including 
all aspects of organizing data for manipulation and display 
(e.g., generating graphs and reports); the server supplies the data 
needs of the client as well as any computing that requires extra 
machine power or specialized software.

The client/server model, though conceptually simple, is not 
at all simple technically. It requires new operating systems facili-
ties capable of efficiently and effectively managing and synchroniz-
ing the communication flow between clients and servers. Be-
cause servers must manage complex data access procedures and 
often high-speed data communications, client/server increases 
rather than eliminates the need for mainframe equivalent power 
for what firms often term “mission critical” applications. The local 
area networks that support client/server communications add 
another element of complexity.

The major blockade to exploiting client/server computing is 
skill, not technology. When the server is a departmental machine 
accessed by, say, 20 personal computers via a local area network, 
it is relatively simple to design and implement the client systems 
and to define their interfaces to the server system(s). Most re-
ported client/server successes are small scale. Enterprise client/
server systems are exponentially more complex, and as of late 
1994 few successes had been reported, but many projects underway.

Client/server computing exploits increasingly powerful work-
stations as clients and a wide range of machines, from specialized 
personal computers and “superserver” minicomputers to massive 
mainframe computers, as servers. Development on one side of 
the client/server divide fuels development on the other. Power

About 20 million personal computers are now linked to 
telecommunications local area networks. Each is a 
potential “client” for processing, data, and communications services. 
Each has its own increasingly powerful applications, data, and communications 
capabilities. Client/server computing is emerging as 
an approach to getting the most dynamic and effective combination of 
personal computers, networks, and the machines and software that act as “servers.”
clients need power servers to keep up with their data and communication needs; power servers open up new applications for power clients. The client/server model is clearly the mainstream for Information Systems development in the 1990s. It may be ten years before we can lay out reliable principles for applying it.

The definition of client/server, like so many innovative concepts in IT, is imprecise, with vendors and IS professionals battling about its exact meaning. It started as basically, “Get things off the mainframe—we can do it quickly and cheaply on PCs and LANs.” Then, it became “Enterprise client/server—exploit PCs and LANs, work with the mainframe and get as much off as you can (no, it’s not quick and cheap).” Today, the implicit definition is “Enterprise client/server—exploit all these tools in the most cost-efficient and technically effective way you can.”

From management’s perspective, client/server is yet another IT industry buzzword that can’t be defined and therefore can’t be used. Senior managers’ awareness of client/server is about what it should be: zero. To become the mainstream of IT application, client/server must be defined in business terms. That’s easy to do. Client/server is the shift from the constraints of computing by centralized systems and inflexibility to exploiting the power and ease of use of tools for real people to access services and information—mainly PCs, UNIX-based RISC workstations, and GUIs (graphical user interfaces). It also uses a building-block approach to choosing software, hardware, communications, and data-base management systems made practical through the growing availability of open systems—that is, neither vendor nor machine-specific. Finally, and by far the most difficult, client/server makes all these work together flexibly and simply across the enterprise.

Client/server as a philosophy if not a definition is the information equivalent of electricity. Keep in mind that the electrification of America didn’t happen just by saying, “Let There Be Light,” and neither will the client/serving of America. It will take time, money, and skills, all of which senior managers must pro-
vide. It's the job of the IS professional and the IT industry to deliver. That's a big but practical challenge.

See also: Cooperative Processing, Distributed Systems, Mainframes

**COBOL** COBOL (Common Business-Oriented Language) is the computer programming language that has longest served commercial application development. Today, it is viewed as a cumbersome language and used primarily in large transaction processing systems. Often these are sets of older programs that have been patched and updated over the years, usually without adequate documentation, making them painfully and tediously difficult to maintain.

A very wordy language, COBOL's special strength is the richness of its facilities for describing data items (such as the master records that store customer information). It is probably also the language most widely known among application system developers and remains essential to firms that must maintain existing COBOL systems. More than 90 percent of domestic companies still use COBOL; estimates put the amount of COBOL code in use by U.S. business at about 100 billion lines. Thus we can expect COBOL to still be in use in the year 2001, more than 40 years after it first came into commercial use.

See also: Application Software and Application Development, Programming

**Compact Disc-Read Only Memory (CD-ROM)** Compact Disc (CD)-Read Only Memory (ROM) is a form of optical storage. CD-ROM exploits digital coding of information and laser technology to provide fast and flexible searching of large volumes of data. A CD-ROM the size of the compact discs sold in music shops can store more than 100,000 pages of text, and reproduction cost is so low that many firms find it less expensive to provide manuals on CD-ROM than in printed form.

Although CD-ROM products and applications have steadily grown in the past five years, there has been no major surge in

An estimated 100 billion lines of COBOL code are in use today. This cost about $2 trillion to produce. U.S. firms spend $30 billion a year to maintain it. The typical Fortune 1000 company maintains 35 million lines of code.
their use in either business or consumer markets. This is due largely to the early lack of standards, difficulties in developing indexes to stored information, and a general lack of awareness of the medium among IS professionals and a lack of skills and experience among those who are aware of it.

Examples of CD-ROM offerings include the Grolier Encyclopedia for about $100, aerospace manuals (a one-inch stack of CDs replaces literally tons of paper), and many specialized industry and technical data bases that pack masses of abstracts and articles on single discs. Citibank’s Collections division, which once spent hundreds of thousands of dollars on “411” directory assistance phone calls, purchased a CD-ROM that contains a directory of all regional telephone numbers of US West, one of the Bell Operating Companies. The directory is stored on a local area network and accessed by customer service terminals. Hewlett-Packard currently distributes software updates and documentation on CD-ROM (one disc replaces dozens of manuals and can be searched directly from a personal computer). And Disclosure, a Maryland company that has for twenty years published paper and microfiche versions of financial reports filed with the Securities and Exchange Commission, found that many of its customers were willing to pay far more for the CD-ROM version the company now offers because it is less bulky, easier to use, and much faster to access.

A CD-ROM disc reader that attaches to a personal computer costs well under $500 and incurs none of the telecommunications costs associated with accessing on-line information services. CD-ROM is a powerful and proven tool for putting masses of information at the fingertips in a form that is easy to scan and digest. Its variants include CD/I (interactive CD, with music and pictures), CD-WORM (write once, read many times), and optical disks that can be erased and updated.

CD-ROM has been available for almost ten years but has yet to take off. Cost and the supply of useful CD disks has limited growth; consumers have been unwilling to experiment with an
$800 device to attach to their $800 PC, and businesses mostly want customized and regularly updated information, not lists and encyclopedias. There were, however, signs in 1994 that more and more PC users were buying CD-ROM drives, and the rapid growth of multimedia applications—video, audio, graphics, and text—has made CD-ROMs as essential as hard disk drives for storing information. The storage availability of multimedia far exceeds the typical 60 to 100 megabytes of disk space on a PC. For example, a CD-ROM stores about 100 high-resolution photos on a single disk; there would be room for perhaps 10 on the hard disk, taking into account the need to leave room for software and data.

*See also: Digital, Disk Storage, Image Technology*

**Compatibility** Two pieces of hardware (e.g., a personal computer and a printer) are compatible if they can operate together. A software program that runs on a particular operating system is compatible with that operating system. Incompatibility has been the norm in the IT field—computers that don’t talk to other computers, communications facilities that can’t connect to other communications facilities, printers that work with some computers but not others, software that runs only on specific computers, data bases that will exchange data with some programs but not with others, and different sets of cables for (it seems) every pair of devices that have to be interconnected.

Standards, published specifications of procedures, equipment interfaces, and data formats, are the key to reducing and eventually perhaps eliminating incompatibility. Suppliers that ensure that their telecommunications, hardware, and software products comply with a standard can expect those products to be compatible with the products of other suppliers that have adhered to the same standard.

Two types of standards that help to reduce incompatibility are (1) de facto standards created by the marketplace, and (2) stable standards defined by standard-setting groups that are im-
The costs of incompatibility are large and widely recognized. They are being reduced by progress in implementing standards, but unless business managers understand the causes of incompatibility and why integration is such a priority for Information Services planners, incompatibility is likely to remain the norm; managers will then assess personal computers, local area networks, and software packages on the basis of their individual features instead of their compatibility with other elements of the firm’s IT base.

Implemented in the products of a plurality of key suppliers. An example of a de facto standard is MS.DOS, originally a proprietary operating system for the IBM personal computer. When MS.DOS first appeared, there were several competing, and of course incompatible, operating systems on the market; within two years of its debut, the IBM PC dominated the corporate marketplace, which led software suppliers to develop products for the MS.DOS market and hardware manufacturers to ensure that their products were “IBM-compatible.” The dragon, incompatibility, was not slain, however. Apple Computer announced its own operating systems for its Macintosh and enthusiasm continued to build for the Bell Laboratories-developed UNIX operating system. Both were incompatible with MS.DOS. Even IBM, when it announced a new generation of personal computers, introduced a new operating system that was initially incompatible with MS.DOS. Nevertheless, MS.DOS remains the best-established de facto standard in business use and thus the base for the widest range of compatible hardware and software. DOS is more than ten years old, but the newest operating systems still run DOS programs; these systems include IBM’s OS/2, Microsoft’s NT and Cairo, and—at last—Apple’s PowerPC models.

Examples of committee-defined standards implemented in real products include the vendor-independent Ethernet (for local area networks), X.25 (for international telecommunications), and SNMP (Simple Network Management Protocol) in telecommunications. Computer vendors, recognizing the importance of compatibility, increasingly work together to ensure equipment can interface with other equipment. Thus, for instance, when the market for low-cost optical scanners took off in 1993, each manufacturer was using a proprietary connector to a PC. The leaders subsequently agreed on the charmingly named TWAIN standard: Technology Without An Important Name. The PC industry’s earliest standardization of adapter cards, called PCMCIA—a mouthful of a name—created a whole new market of plug-in modems and credit card sized adapters, fax cards, extra disk storage, local
area network connectors, and memory cards. This industry exists only because of compatibility, but it is much easier to ensure compatibility of physical devices than of complex software and data. Thus, even though the SQL standard is the universal interface for database management applications, the Gartner Group estimates that 90 percent of a typical organization's data cannot be accessed by using SQL; they reside in incompatible systems.

It will be decades before incompatibility ceases to be a significant impediment to effective IT use. The primary goal of an IT architecture is to move away from incompatibility toward integration by evolving a business platform for delivering IT services, sharing information and resources, and integrating business functions. As a technical barrier, incompatibility is irksome; when it becomes a business barrier, it can cost an organization dearly. In many instances, the cost of supporting multiple incompatible systems, buying special devices and software to make them compatible, and replacing or redesigning existing ones is more than their purchase price. This, not bureaucracy or an effort to control use of IT, is why compatibility and integration, rather than features, are priorities to IS managers when considering specific PCs, software, and network tools. Users, by contrast, are most interested in features, but they need to balance this with a respect for the growing importance of compatibility.

See also: Architecture, Connectivity, Integration, Open Systems, Platform, Standards, Systems Integration

**Computer** See Mainframe and Minicomputer, Portable Computer, Supercomputer

**Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM)** High-performance computer-aided design (CAD) workstations enable designers to manipulate parts diagrams, simulate operations, infer complete designs from a few specifications, and draw on libraries of designs. In sum, they speed up the design process.
Computer-aided manufacturing (CAM) encompasses an extensive variety of systems designed to facilitate manufacturing, including numerical control, robotics, materials requirement planning, and process control.

CAD/CAM systems can be used to link design and manufacturing. In some firms, CAD designs can be sent directly through telecommunications links to the computer-controlled machines that make the parts.

The extremely fast and powerful workstations responsible for streamlining design and manufacturing look much like personal computers, but they outperform many of today's mid-range host computers in terms of raw speed of computation.

See also: Computer-Integrated Manufacturing, Workstation

Computer-Aided Software Engineering (CASE)  Computer-aided software engineering (CASE) is the use of computer technology to help improve application systems development. CASE consists of a set of workstation-based software tools designed to support application developers: data dictionaries to store and validate definitions of items used in programs and record how and where they are used and calculated; diagnostic tools to check for inconsistencies and redundancy; diagrammatic representations of system designs that can be created quickly and kept up to date and reused in other applications. Developers can design report formats and screen displays at the workstation and when any part of the design is changed, the relevant documents and displays are updated automatically. A few CASE tools generate program code directly from design specifications. Blue Cross/Blue Shield of North Carolina is reported to have built a major system in six months, with CASE tools generating more than 90 percent of the code and programmers custom developing the rest.

CASE tools embody particular development and project management styles or methodologies based on "structured" methods and graphical representations of information and procedures. There are many gaps in existing tools and many competing prod-
ucts, and using them involves learning new ways of operating. Furthermore, implementing CASE is expensive. A leading consultant estimates the five-year cost for introducing CASE tools into an organization with 150 systems professionals at $3.2 million. The initial investment, including hardware, software, and training, is $1.5 million, and annual maintenance costs are $0.35 million. The consultant estimates that to justify such expense, the average productivity gain needs to be 25 percent by the fifth year, because productivity may actually drop in the early years as staff adapt to the new tools.

Business managers need to view CASE as an investment in R&D and organizational development, give proposals a sympathetic hearing, and be skeptical of grandiose promises.

See also: Application Software and Application Development, Programming, Maintenance, Software, Systems Life Cycle, Testing

Computer-Integrated Manufacturing (CIM) Computer-integrated manufacturing involves organization as much as technology. It refers to the use of IT to streamline manufacturing processes from purchasing and accounting to scheduling, production, and distribution. The logic of CIM is that the systems that control these processes should be able to exchange information with one another directly. Thus a purchase order should automatically update the scheduling system and the production processes should trigger reordering of parts.

This integration of technical processes is also an integration of business and work processes. Implementing CIM involves analyzing, rethinking, and planning each manufacturing process. It also entails overcoming the many incompatibilities between financial and accounting and engineering and manufacturing systems, which have evolved on largely separate hardware and software tracks. Leading computer vendors tend to be strong in one area or the other, but rarely both.

Business integration entails rethinking operations designed around separate organizational functions and, in many instances,
asking if they are really needed. Ford Motor Company, for example, examined the use of electronic data interchange links to streamline invoicing. As a result, it would be able to reduce its invoicing staff from 500 to 400 people. Further analysis led Ford to entirely eliminate invoices, because the existing EDI systems contained all the relevant data. They cut the staff from 500 down to 100. This "business process reengineering," to use a current term, adopts the view that the best way to automate something is to stop doing it.

Increasingly, companies are reporting that the implementation of computer-integrated manufacturing is much more difficult organizationally than technically. Because CIM redefines skill needs, reporting relationships, information flows, and management, making it work often demands a substantial commitment to education, the development of new incentives, a much more open management style, and a genuine culture of teamwork.

The technology employed in computer-integrated manufacturing extends over the full range of IT, and systems are more distributed than those in banking or airlines. Whereas the latter tend to develop large central systems organized around a key data resource (the reservation data base in airlines and the customer account data base in banking), manufacturing relies on plant and departmental systems located at the site of operations.

Studies of major CIM projects have revealed that the need to integrate what has been termed "islands of information" is frequently the greatest impediment to progress. Firms that lack an overall architecture must first rationalize existing systems and then adopt technology standards that maximize the ability to pull existing systems together and ensure that new ones are compatible. The process is a long one.

*See also: Computer-Aided Design/Computer-Aided Manufacturing*

**Computerized Reservation Systems (CRS)** Computerized reservation systems, initially developed by just a few major airlines, constitute the first use of IT that radically altered the dynamics of
competition in an entire industry. Prior to airline deregulation, CRS were viewed as an operational tool—an automated approach to tracking and allocating seat availability—with no apparent competitive relevance. Since deregulation, CRS have become the core of sales and distribution strategies and yield management for most airlines. (Yield management is the management of on-line pricing and profit—the fine-tuning of discounts to ensure that when a plane takes off it carries the maximum operating profit, the "yield.")

Ownership of a CRS has strongly influenced relative competitive positioning, mergers and acquisitions, marketing options, and pricing. The acknowledged leader in the industry, American Airlines, turned its CRS, called Sabre, into a multi-use platform that cross-links applications other airlines have built on separate technology bases.

CRS demonstrate the competitive advantage of occupancy for the early leaders and the ability to add new services to an existing electronic delivery base. By getting there first with good enough systems, American (with Sabre) and United (with Apollo) were able to fend off competitors for nearly a decade. They have used these infrastructures as the base for alliances (Apollo with Loews hotels and an international CRS consortium called Galileo, for instance) and for creating integrated business services (by providing, for example, a single point of contact for airline tickets, hotel bookings, rental car reservations, rail tickets, theater bookings, insurance, and more).

Each U.S. and international CRS has a different technical design philosophy, which has had major business impacts. Sabre, the most centralized and integrated system, has allowed American to cross-link its reservation, hubbing, yield management, and frequent-flyer programs while the other airlines were building separate bases for each. This afforded American a major competitive advantage throughout the 1980s.

American is currently trying to relieve Sabre’s heavy dependence on centralized processing (the overloaded central system
Just about every major alliance, acquisition, and antitrust action in the U.S. and international airline business in the late 1980s centered around ownership of or access to a CRS. In mid-1994, three of the “majors,” including United Airlines, saw their best way of countering Southwest Airlines, by far the most successful carrier of the 1990s, was to refuse to allow travel agents to book flights on Southwest through their own CRS.

failed several times during peak travel periods in 1989 and 1990) by distributing functions to workstations. Covia (United Airlines’ IT subsidiary that operates Apollo), driven in part by the Apollo system’s inability to keep up with travel agent demand during the early 1980s, had earlier turned to distributed systems and then to “cooperative processing,” a move that has given the company an advantage of flexibility in development and operations. In mid-1992, American surprised the industry by waging a massive price war. The resulting voluminous sales growth overwhelmed the system. Sabre processed 3 million tickets in just a few weeks, with transaction rates increasing from 2,000 to as much as 3,000 per second. Sabre crashed frequently, leaving travel agents idle for hours. Ironically, at this time American announced its plans for its TravelBase system—one of a new generation of IT building blocks called client/server processing that distributes work among workstations (clients) as well as a variety of small and large computers for processing transactions, managing information queries and updates, and coordinating communication (server).

The most important lesson learned from the evolution of CRS relates to the importance of senior business management involvement in IT planning. Top management at American Airlines and British Airways, the companies that most violently disrupted the industry status quo, viewed IT as much its responsibility as any other key resource. Other well-run and well-known airlines treated IT as operational overhead, to their continuing competitive cost.

Another more recent lesson is a cautionary one: even the most experienced and competent organizations are vulnerable to disaster in large-scale software development. Sabre is a case in point; it was almost 20 years old, robust, and proven one of the most successful business users of IT when Marriott, Hilton, and Budget Rent A Car chose American as their partner to develop CON-FIRM, a reservation system expected to leapfrog competition. Instead, it became, in Business Week’s phrase (January 1994), “American’s Total Disaster,” costing $165 million in write-offs and that
much again in out-of-court settlements to Marriott and the others. CONFIRM seems to have followed the classic pattern of software development fiascos common in the 1960s and still a major problem today. This pattern includes the “95 percent debugged” phenomenon, which means the system is “almost complete—just a few more errors to find and remove.” More accurately, it means “the system doesn’t work.” American’s top managers learned less than two months before CONFIRM’s much-delayed on-line date that the project was really 18 months behind schedule. Design changes, lack of project planning, technical flaws, subcontractors’ poor work, overoptimistic progress reports, and the like, combined to ruin the reputation of American’s $1 billion-a-year IT services business. If this can happen to a company such as American Airlines, what might happen to the average company?

See also: Cooperative Processing, Distributed Systems, Platform

Connectivity It is helpful to think of telecommunications in terms of two questions: “Can we send and receive information between these two locations/devices/business services?” and “Can the transmitted information be interpreted and processed?” The first question relates to connectivity, the second to integration.

Just as telephone companies have made it easy to connect most of the world’s telephone systems through direct dial, telecommunications managers and providers have succeeded in interconnecting many of the transmission facilities that companies have in place. But just as telephone companies do not provide language lessons to subscribers, telecommunications technicians do not, in general, deal with the many difficulties of sharing different types of information in business applications. In effect, they deal with the problem of how to direct dial Frankfurt from New York, not with the problem of conversing if the communicating parties do not speak the same language.

In terms of IT standards and architectures, the link to Frankfurt corresponds to the lower levels of communication effected by physical and electrical connections and interfaces. These are
far easier to define and implement than higher-level standards and architectures for the format and content of business procedures and messages. The 1990s have seen explosive growth in the variety of equipment that provides connectivity across networks, including bridges, routers, gateways, and switches.

Managers must recognize that connectivity is not integration but a necessary precondition for it. Telecommunications specialists typically focus only on the standards and tools needed to ensure connectivity; the standards and tools needed to increase integration generally lie outside their experience base.

See also: Architecture; Bridges, Routers, and Gateways; Cables, Plugs, and Sockets; Compatibility; Integration; Network; Platform; Standards

Consultative Committee for International Telephony and Telegraphy (CCITT) The Consultative Committee for International Telephony and Telegraphy (CCITT), part of the International Telecommunications Union headquartered in Switzerland, has been the most influential standard-setting organization in the area of international telecommunications. Its 150 member countries represent the major national telecommunications providers. CCITT standards often take more than a decade to fully define and implement, but once established carry immense weight in the marketplace. The rapid pace of technical change makes such organizations less central in the standard-setting process, with key users and vendors playing a more active role and many innovative products becoming de facto standards.

See also: International Telecommunications, Standards, Telecommunications

Cooperative Processing Cooperative processing, one of the newest terms in the IT professional’s vocabulary and potentially one of the most important, extends the ideas of distributed systems and the client/server model of computing, to which it is closely related. All three aim at exploiting the relative capabilities
of local distributed devices, software, and data bases, and central
and shared services such as corporate data bases.

In cooperative processing, work is distributed among client
workstations that access servers or other workstations for applications
that work together cooperatively. For example, a workstation
may initiate a transaction for a customer order that requires
software that resides on two different servers and data that reside
on a third. All the necessary linkages are established in the act of
initiating the relevant transaction; the data-base management sys-
tems and the requisite applications work together as needed,
entirely transparent to the user, who sees only the results. The
workstation drives the processing, making it appear to the user as
if all the services needed are in the workstation.

Consider the example of a travel agent making airline, hotel,
and car rental reservations for a client. With on-line processing,
each activity is handled by a separate reservation system, which
can make the process time-consuming, particularly if an availability
problem in one system necessitates reaccessing one of the
other systems. An intelligent reservation workstation that man-
ages the dialing and automatically accesses each system in re-
sponse to the agent's selection speeds the process but does noth-
ing about the individual reservation systems' lack of knowledge
of one another. Distributing functions to workstations eases the
strain on the central reservation mainframe and, by allowing the
workstation to store master data for all three reservation systems,
ensures the travel agent to move among the systems more easily.

With cooperative processing, the individual systems know about
one another and can exchange information automatically. When
a change in a passenger's departure date is noted, the three
systems cooperatively produce a new set of reservations. With
cooperative processing, the agent is no longer handling three
separate reservation systems, but managing travel relationships.

Cooperative processing involves complex telecommunications
networking functions that are the basis for cross-linking separate
transactions, hence for creating new, cross-linked business services such as travel relationship management, cross-product financial services and profiles, and so forth. It thus relies on a high degree of integration of the relevant software and telecommunications components of the IT base.

The evolution of modern business computing moved initially toward greater distribution of functions, later toward exploiting low cost and powerful workstations, and, most recently, toward building intelligence into the software applications themselves. Client/server and cooperative processing demand an integrated architecture. Only senior business managers can ensure that relevant IT infrastructures and standards are seen as a long-term competitive issue, and not sidetracked by short-term priorities and local business unit needs that push away from integration.

It's quite likely that the popularity of the term client/server will win out over cooperative processing. They are only subtly different, after all. The term "cooperative," though, captures more of the essence of distributed systems because they are designed through building blocks that work together.

See also: Architecture, Client/Server Model, Computerized Reservation System, Distributed Systems, Network, Platform

Costs of IT  The costs of information technology are paradoxical. On one hand, the price of hardware drops 20–30 percent per year. On the other, over the past three decades information systems budgets have grown at a rate of 15 percent per year. Business executives frequently see IS expenditures as being out of control. As a result, executives have increasingly looked for ways to cut growth by downsizing facilities such as corporate data centers that house huge mainframe computers and outsourcing services, which are the most visible costs.

This may or may not be the most appropriate target. Companies' accounting systems rarely track the real costs of information technology, most of which are hidden. A useful rule of thumb is that the price tag of any IT investment is only 20–25 percent of
the full cost. A $5,000 stand-alone personal computer, for instance, becomes a capital investment of $25,000 when the costs of telecommunications, remote data storage, and technical support are added. Every dollar spent on systems development typically generates a follow-on annual cost of 40 cents for maintenance of the system and 20 cents for operations. Thus $1 million for systems development ties up $4 million of capital for the next five years.

Education is a major hidden cost in systems development, especially for systems that change the nature of work rather than merely automate an existing activity. Typically, it amounts to 20 percent of a project budget. Though rarely included in the budget, firms typically have to ante up anyway when they discover that effective use of the system demands sufficient training.

One of the worrisome implications of inaccurately accounting for IT costs is that companies may find it is the apparently low-cost personal computer and local area network base that can get out of control. As the CEO of a 50-person, 30-PC company said, “I had no problem budgeting $100,000 last year for PCs, but I was shocked to find I had to spend $150,000 for LAN administration and add-on equipment. If I’d known that, I’d have looked more carefully at standardizing on one machine. Our budgeted pretax profit was $150,000.”

The hidden and follow-on costs of IT are often overlooked by both business and information systems managers largely because accounting systems were designed to treat IT as an overhead expense. But information technology has become a capital investment; indeed, it amounts to half the incremental capital expenditures of many large firms. Any firm that does not know its real IT costs, especially hidden and compounded follow-on costs, has no basis for making rational decisions, because the business justification ignores many life cycle costs, hidden costs, and organizational costs.

See also: Application Software and Application Development; Backup and Recovery; Bandwidth; Bridges, Routers, and Gateways; Bug; Busi-
When the Royal Bank of Canada does a mail promotion for a new product, it typically gets a 40 percent response rate versus 2-4 percent for other banks. This is due to a database that cross-references information about individual customers in terms of demographics, the products they use and don’t use, and their history of transactions. Several credit card providers, by contrast, regularly send junk mail to their own card holders, offering them the same card they already have.

Data Data are numbers, text, graphics, images, and voice stored in a form that can be processed by a computer. Historically, the term has been used by information systems professionals to describe the numeric and alphabetic contents of computer files and data bases that constituted the bulk of business data processing. A major thrust in telecommunications innovations has been to integrate these varied forms of information; today, any information that is coded digitally can be processed as if it were a single medium. Thus telephone calls, photographs, video frames, and electronic transactions have all become “data.” (The term “multimedia” is replacing “data” in IT-speak.)

Many commentators on the effective use of IT distinguish “data” from “information,” the latter being the meaningful interpretation of the former. The world is awash in data (many older management information systems are little more than bureaucratic aggregations of accounting system data). Useful information is much less plentiful. With Information Services professionals today paying more attention to how to provide information with relevance and meaning, traditional reporting systems are being supplanted by management alerting systems. These collect and store data from core on-line business transaction systems in data bases managed by powerful data-base management systems; they make it accessible to decision support and executive information systems and other software tools designed to provide rele-
vant information to those who need it, in the form they need it, when they need it.

As the use of information becomes an ever more important business tool, competitive advantage accrues to the firm with an IT platform that allows information to be captured, combined, organized, moved, and displayed across locations, levels of staff and managers, and functional areas.

*See also: Data-Base Management Systems, Multimedia*

**Data-Base Management Systems (DBMS)** Many different business applications use the same data. For example, the same customer name and address records are used by a bank in its ATM, customer statement, and internal statement and reporting systems. Originally, such records were duplicated and stored in separate files for each application and changes had to be propagated through all the individual systems. Inconsistency was commonplace; redundancy and duplication were enormous.

Data-base management systems (DBMS) function as libraries that make the same information accessible for multiple applications. With a DBMS, a customer's name and address information, for example, need be entered only once and subsequent changes made in only one place. Audit, security, definitions of formats, error checking, and so forth are handled by the data-base management system.

The breakthrough in DBMS has been "relational" data-base management systems (RDBMS), which organize data in a structure that maximizes the variety of ways it can be combined, or "related." This enables an RDBMS to respond to queries such as "Find all employees in the salary range X to Y who have not been promoted in the last five years; indicate their departments and evaluation scores, and identify the evaluators." Because translating such an inquiry and locating the data entail heavy computer overhead, RDBMS technology is only now becoming suitable for very high volume transaction processing.

A further evolution of RDBMS, still in a relatively early stage
The difference in performance between DBMS and packages is substantial, with each being better suited to particular types of querying, searching, and reporting. A 1994 comparison of the four leading products found one able to handle a test in 2 hours while another took 36 hours. Similarly, one took 47 seconds to update a file versus another's 759 seconds.

of development, is the "distributed relational data-base management system" (DRDBMS), which permits information residing in data bases in different locations to be cross-referenced, updated, and accessed from all locations as if it were in a single, centralized data base. There are other emerging and promising developments, with few large-scale proven successes; most firms have yet to take on the risk of being on the "bleeding edge." These new developments include object-oriented data bases (OODBs) and parallel-processing query systems. OODBs are an extension of object-oriented programming that can create intelligent data bases. Instead of an item being stored as a field of data, such as "PART NUMBER," it is defined as a small, self-contained packet called an object that includes information about the item, its use, other objects it shares properties with, and the like.

Object-oriented techniques combine information and procedures. They are so different from the most widely used planning, design, and modeling tools for DBMS development and related applications development that progress in adding them to the DBMS tool kit will be evolutionary. A 1993 Handbook of Data Management, which is more than 800 pages long, aptly summarizes OODBs in the heading of its final section: "Object Orientation and Other Next Steps." Current steps will continue along the relational path, with PC-based data access tools playing a major role in innovation.

Implementing such systems is organizationally complex, involving procedures used to inventory existing data resources, eliminate duplication, and ensure consistent formats and definitions of information. It is also technically complex in terms of designing the data base structures, ensuring that the needed cross-references between items can be reliably made, and fine-tuning the systems to achieve an acceptable level of efficiency and adequate response time.

To be a true corporate business resource, information must be managed with the same degree of discipline as a firm's budg
eting and accounting systems. Indeed, data management may be thought of as a form of information accounting.

Creating a companywide information resource is not the same as creating a universal corporate data base, which is both organizationally and technically impractical. Because just getting agreement on definitions of data items sometimes takes years, efforts to build universal data bases have cost many large companies tens and even hundreds of millions of dollars and have met with little success. A more sensible approach seems to be to evolve sets of key data bases and in the process clean up inaccurate data, generate consistent definitions, install new and reliable procedures, and extend the relevant RDBMS technology across more business functions.

See also: Application Software and Application Development, Data, Object-Oriented Programming Systems, Platform, Relational Data Base

Data Center  Traditionally, the corporate data center, the “computer room” as it was called, was a well-guarded facility that housed a firm’s mainframe computers, banks of disk and tape drives, and a complement of printers. Mainframes were the dominant form of computing because they offered economies of scale; for twice the price, a company could get four or more times the power. Today, with economies of distribution prevailing over scale, data centers are becoming home to physically smaller mainframe/host computers and greater concentrations of telecommunications devices.

A bias toward personal computers, departmental systems, and distributed computing has led many to argue that corporate data centers are obsolete. Cost per unit is far lower for small, departmental machines, and decentralized IT affords each business unit the autonomy, flexibility, and responsiveness it needs to effectively support its business priorities. Yet many firms, finding that personal computers and other components of the decentralized IT resource are generating new demands for high-performance sys-

One extreme view of data centers sees them as outdated Kreminks. The other extreme sees them as the equivalent of the Strategic War Rooms of spy films, coordinating a wide range of operations, equipment, and communications vital to the business. Both stereotypes are accurate; the differences are not so much ones of technology as of IS attitude—control versus coordination and business support.
tems to manage ever-growing data resources, are consolidating multiple smaller data centers. The resulting "mega" data centers also handle coordination of the networks that link corporate data stores with decentralized users. With sales of large computers rivaling the growth of small computer sales, it seems premature to compose a dirge for the mainframe.

It will be a very different type of mainframe, though. The centralized mega data center will coordinate information management, distributing as many functions as possible to PCs, departmental machines, and specialized computers that support the central complex. This is the logic of client/server computing and the data center houses the enterprise information server. TRW, the aerospace company, established such a system. In July 1993 it consolidated its data center on the West Coast and Texas into a single unit that stores and processes 2 terabytes of credit information on-line. (A terabyte is a trillion characters.) TRW's data adds up to the equivalent of more than 100 million pages.

See also: Architecture, Chief Information Officer, Hardware, Network Management, Platform, Switch, Terminal

Data Communications Data communications refers to the transmission of computer-generated information. The term has traditionally been contrasted with voice communications. The world's telephone systems, built to carry voice, are now being redesigned to handle data and, increasingly, data and voice together. Data communication relies on digital transmission, the sending of coded data in rapid pulses. Telephone systems have traditionally relied on analog transmission, in which the sound waves produced by speech are converted into a continuously varying electrical signal. Many of the advances in the technology of telecommunications depend on digital transmission.

Although telephone conversations continue to constitute the dominant use of telecommunications, the rate of growth of data communications far exceeds that of voice communications. Little
by little, voice communications are becoming a subset of data communications, instead of the other way around.

See also: Data, Digital, Transmission

**Data Encryption Standard (DES)**  See Encryption

**DBMS**  See Data-Base Management Systems

**Decision Support System (DSS)**  A decision support system (DSS) is an information system or analytic model designed to help managers and professionals be more effective in their decision making. A DSS is typically realized in personal computer software that accesses data bases organizationwide. It is not a specific technology, but an emphasis on exploiting available and accessible technologies to support managers, especially in ad hoc analysis and planning.

Decision support systems grew out of management science as much as out of information systems. “Support” emphasizes the focus of these systems on enhancing, rather than replacing, managers’ judgment. Early DSSs developed in the mid-1970s included models designed to help product and brand managers plan advertising, promotion, and pricing mixes and financial planners to explore what if? scenarios. More recently, the term has been applied to just about any hands-on managerial use of personal computers. The most effective DSSs combine access to remote data bases with analytic models and tools.

Designers of DSSs aim at providing systems that emphasize both usability and usefulness. Usability refers to a system’s exploitation of convenient, flexible, and responsive software, including spreadsheets, data base query languages, and graphical presentation tools. Usefulness refers to a system’s contribution to managers’ understanding of how complex decision tasks can benefit from the combination of computer power, analytic methods, and managerial judgment.

The term DSS is now so vague as to be indistinguishable from
"executive information system" (EIS), "end-user computing," "expert system," and even "personal computing." The real significance of decision support lies not in specific software or personal computers but in what it means to help managers "improve" the effectiveness of their decision making.

See also: Artificial Intelligence, End-User Computing, Executive Information System, Expert System, User Interface

**DES (Data Encryption Standard)** See Encryption

**Desktop Publishing** Desktop publishing is an extension of word processing. It combines sophisticated word processing and graphics software that can incorporate typesetting fonts, color illustration, and even scanned-in photographic images with high-resolution laser printers to make it possible to compose page layouts and generate camera-ready copy in the office.

Organizations are increasingly using desktop publishing to speed production and reduce costs in the creation of reports, in-house magazines, brochures, and the like. The quality of desktop publishing is now so high that a magazine like *Personal Publishing* is entirely produced on it, matching in every way the quality and appearance of any periodical at the newsstand.

A natural extension of desktop publishing is multimedia publishing, which lets companies create and edit video presentations, dub in soundtrack to slides, and provide supporting handbooks and brochures. Multimedia publishing is unlikely to replace books, but we can expect to see training material and even textbooks include complementary video material and interactive exercises on a floppy disk or CD-ROM. The tools for this medium are widely available on standard PCs at fairly low cost ($10,000–$25,000 for machine, software, scanners, camera and color printer, with studio- and publisher-quality equipment costing more). The skills needed for multimedia development and the time to create and publish first-rate training packages are not yet available.

See also: Personal Computer, Word Processing, WYSIWYG
Digital The entire field of information technology is built on the astonishingly simple ability to represent all types of information as the presence or absence of an electrical signal. These elements, termed bits, are represented as ones and zeros, just as the Morse code uses dots and dashes to indicate letters and numbers. Complex electronic circuits can transmit these digital signals as pulses at rates of millions and even billions per second. The streams of discrete bits can be stored, compressed, checked for errors, and routed efficiently, with dramatic improvements in accuracy, reliability, and speed. The 0–1 digital base, used to signal on-off, true-false, yes-no conditions, allows logic circuits to be built to handle calculations quickly.

It is helpful to contrast digital representation, processing, and communication of information with the analog techniques that have long been employed in telephone communication. A telephone creates, in the form of a continuously varying electrical signal, an “analog” of the sound waves generated by the human voice. This analog signal can be converted to a digital signal by sampling it at a sufficient number of points to enable it to be reconstructed at the other end and coding the samples as combinations of bits, which can then be transmitted as pulses. The difference between digital transmission of discrete bits and analog transmission of a continuously varying signal has been likened to the difference between a staccato burst of machine gun fire and a wailing siren of varying intensity.

The managerial relevance of the distinction between analog and digital is that the communication of information—via all media, including telephone, radio, and television—is shifting to digital transmission. This opens a wide range of new communication options within organizations and among customers, suppliers, and partners, albeit often at considerable cost in terms of investment and potential disruption associated with replacing old
systems with a new set of infrastructures.

So recent is the digital communication revolution that we can only guess what innovations it might stimulate. As digital transmission speeds increase, more and different kinds of information can be moved onto corporate networks. Coding a black-and-white photograph in digital form, for example, requires about 100,000 bits. To transmit that volume of data would take minutes over analog circuits but less than two seconds over a typical digital link. To take advantage of the innovations spawned by digital transmission, whatever they might be, firms must renew their information infrastructures.

See also: Bits and Bytes, Data, Telecommunications, Transmission

Digital Equipment Corporation (DEC) DEC was the company that gave IBM competition in the 1970s and 1980s by developing the minicomputer. DEC stood for excellence in engineering while IBM represented excellence in marketing. DEC's VAX computers were especially popular in engineering and research environments, including universities because they were designed for interactive use and fast computation, rather than transaction processing. By the 1980s, DEC was firmly established as number two in the industry, behind IBM.

As IBM slipped, so did DEC. DEC missed out in many areas, including in personal computers; its first ventures failed. It was also squeezed out by such companies as Sun Microsystems and Apollo in the UNIX marketplace; DEC's leadership publicly disdained UNIX as irrelevant. DEC's minicomputers did not match the new power workstations so it introduced a new line of machines based on its Alpha chip, but these were unable to recapture the firm's position in key markets. The firm's successes had reflected the personal vision of its founder and chairman, and many of its failures reflected his stubborn commitment to that vision. He subsequently resigned in 1992. DEC's engineering skills no longer compensated for poor marketing and customer support;
the technical edge was in companies like Sun.

Perhaps DEC's main problem was that it continued to see itself as competing primarily against IBM. DEC targeted many of its product moves and investments in standards at the same broad coverage as IBM, and it focused much of its development on the high end of the minicomputer market, which converged with IBM's low-end mainframes. IBM, with its midsize AS/400 machine, successfully held DEC off. Meanwhile, the high end of the workstation/PC market squeezed out DEC's old minicomputer niche. DEC was unable to be all things to all customers in all markets, and it also failed to protect its core markets and to develop new ones.

In late 1993 DEC, realizing its shortcomings, abandoned its ambitious strategy for a comprehensive telecommunications network management blueprint and surrendered to its old enemy. DEC adopted IBM's key network management system, NetView. It stopped major proprietary developments. The VP of production systems software said that never in her 14 years at DEC could she conceive of sharing the podium with IBM.

To business managers, it may seem that the rise and decline of firms such as DEC, Wang, the one-time leader in word processing, or Data General, DEC's main rival in minis, might only interest technicians. It is, however, a key business issue for information systems managers. While some companies have literally billions of dollars invested in IBM systems, others have many of their key systems built on DEC hardware and telecommunications. When their strategic vendor gets in trouble, they worry that the vendor will be unable to continue its R&D and product development to create new products that can exploit fast-moving technology and match sharper competitors. And dropping the vendor and redeveloping the systems are too expensive.

Vendor risk is thus a key element in IS planning. Shakeouts are inevitable in the computer industry, and no one knows if IBM and DEC can successfully turn around the recent erosion of the
past years. When a fine company like DEC loses $3.5 billion in two years (its annual revenues in these years were around $13 billion p.a.), what can happen to the average ones?

Disk Storage Disks provide an economical means to store the massive amounts of data accumulated and generated by point-of-sale, on-line customer service, computer-integrated manufacturing, and computerized reservation systems, automated teller machines, and other core IT business applications. These high-density storage devices pack billions of bits of data in a single unit, making it practical for businesses to keep large volumes of information accessible on-line to all the computers in the corporate network.

Personal computer users are familiar with floppy disks, an off-line storage medium, and hard disks, an on-line storage medium. (On-line means that the disk is directly accessible, off-line that it must first be inserted into a disk drive.)

Although relative costs of disk and memory vary widely, a rough approximation of the levels of expenditure for a large firm can be derived from the ratio of 4 gigabytes of disk storage (4 billion bytes) to one mip (millions of instructions per second) of processing power. In 1991, each mainframe mip cost about $100,000 and each gigabyte of storage about $250,000, yielding a hardware-to-disk storage ratio of 1:10—$100,000 for memory and $1 million for disk. (These figures were derived from a study conducted by the Gartner Group; although the ratio will vary by firm, the figures suggest the extent to which on-line storage is increasingly a major investment.) For a company with 100 mips of processing power, this translates to $30 million in mainframe computers and $800 million in disk storage (if all the data are stored on-line). The mainframe computer does little computing in this context; it primarily manages a gigantic on-line disk library.

The difference between the speed of computer hardware, which processes information in microseconds, or millionths of a second, and disks that provide access to information in milliseconds, or thousandths of a second, is sufficient to make disk
input/output frequently a bottleneck in on-line processing systems. A high-performance disk can access and transfer information in under 10 milliseconds. In an on-line business system that handles 500 transactions per second, adding just 3 milliseconds to each transaction will create traffic jams. Disks are inherently slower than chips because they involve moving parts.

Much of current innovation in the IT field is in the area of disk storage and management. Among the newer types of storage devices are erasable optical disks, which have far higher retrieval speeds and storage capacity—anywhere from 500 megabytes (millions) to 10 gigabytes (billions)—than conventional disks. Compare this with a typical PC with a hard disk that stores 60–250 megabytes but is not removable. The standard floppy disk, which is removable, typically stores up to 2 Mb.

Northcote Parkinson’s famous law that work expands to exceed the time available for its completion can be applied to disk storage: “data expands to overflow the additional disk capacity you installed so you wouldn’t run out of disk capacity.” Large firms need disk space to store terabytes (trillions). New PC operating systems are disk hogs; several take up 40 megabytes of hard disk. Image processing—the scanning and storing of high-resolution digital copies of documents and pictures—can quickly fill up even optical-disk storage; the industry rule of thumb is 50 kilobytes (thousand) per document.

Not all this has to be stored on-line, and disk categories, such as optical jukeboxes and digital audio tape, offer cheap backup and off-line archives. But the growth of disk storage in most companies is around 60 percent a year, and some firms literally have no time in the day to transfer data from on-line disk to back-up tape; however, anyone whose PC hard disk has crashed knows how many weeks of work can be lost. A December 1993 survey claims that the typical corporation runs at 50 percent efficiency if its key disk storage data is lost for a week.

See also: Compact Disc-Read Only Memory, Floppy Disk, Hardware, Image Technology

The approximate sizes of data items, and thus the amount of disk space they take up, are:
- a credit-card authorization request: 125 bytes
- a 1-page electronic mail message: 600 bytes
- a high-resolution fax: 12,500 bytes
- a document image: 50,000 bytes
- a 1-second full-motion video: 1,250,000 bytes
Distributed Systems Distributed systems link central "host" computers with decentralized workstations and personal computers for purposes of distributing the processing workload. This contrasts with the pre-personal computer (or pre-intelligent workstation) era in which all processing was done by the host computer, which users accessed via "dumb" terminals.

A number of industries have distributed data and functions previously maintained and performed on central computers to workstations and minicomputers. Airlines' computerized reservation systems are increasingly distributed; travel agency workstations validate dates and airports specified by agents prior to sending the information to the host computer, format information locally into easy-to-read reports, and store profiles of client seat preferences, frequent flyer numbers, addresses, and so forth.

Distribution of functions from mainframes to workstations has become a nearly universal trend in information technology; decentralized workstations, too, are increasingly serving as access points to services. As a result, telecommunications networks have become the backbone of the corporate IT resource. Decisions about the use of mainframe, mini-, and microcomputers must today be made with attention to trade-offs among telecommunications and computing costs, power, resource sharing, security, ease of operation, support, and specialized technical requirements, among other factors.

The business, organizational, economic, and technical logic of distributed systems is so compelling that the only issue is exactly how to install these systems. The mainstream movement is toward client/server computing, where clients, typically users of PCs and workstations, send messages to and from servers, which may be specialized PCs, minicomputers, or mainframes that provide transaction processing, manage information, or coordinate communications. The technical challenges involve building and rebuilding of IS organizations' skill base to meet the many needs of client/server planning, design, and implementation. This is no quick
fix but part of the positioning of a totally new generation of systems and ways of building systems.

See also: Architecture, Client/Server Model, Cooperative Processing, End-User Computing, Network, Platform

DSS  See Decision Support System

Dumb Terminal  See Terminal

EDI  See Electronic Data Interchange

EDIFACT  EDIFACT is the principal international standard for electronic data interchange. It is sponsored by the United Nations. The cost of paperwork involved in international trade transactions, such as shipping and insurance, is estimated at approximately 7 percent of the cost of the goods involved. EDIFACT establishes the basis for handling these transactions electronically, which would save both time and money and reduce the volume of errors. EDIFACT is closely related to the main U.S. standard for EDI, called X12.

See also: Electronic Data Interchange, Standards

EFTPOS  see Electronic Funds Transfer at Point of Sale

800-Number Portability  800 numbers are long-distance calls that are free to the caller; the company receiving them pays. When telecommunications were slow and expensive, only large companies could afford to lease these lines from their long-distance provider; they paid a fixed monthly cost for these (expensive) "private" lines, justifying them by the volumes of callers that made them cheaper than using the pay-as-you-use public phone system.

AT&T's market share of 800 numbers (sometimes termed inbound WATS, or Wide Area Telephone Service) was much more than 80 percent when the federal government ordered
long-distance providers to implement a complex program that would allow companies to move from, say, AT&T to MCI and retain their existing 800 number. Previously, moving to a new service provider meant changing numbers, and companies that had chosen a distinctive number were unwilling to change. Easily memorized 800 numbers were a business edge; for instance, 1-800-FOUR PAWS is a pet-products supplier whose sales doubled when it obtained the number, and British Airways’ 1-800-AIRWAYS and Teleflorist’s 1-800-FLOWERS are easier to remember than a series of 11 numbers. The low cost of 800 numbers makes them an effective way to increase customer convenience and ease of access to services.

**EIS** See Executive Information System

**Electronic Data Interchange (EDI)** Electronic data interchange (EDI) eliminates intermediate steps in processes that rely on the transmission of paper-based instructions and documents by performing them electronically, computer to computer. EDI is becoming the norm in intercompany transactions, particularly in ordering, distribution, and payables and receivables.

Consider the following examples of benefits reported by companies that have implemented EDI. The 40-member Petroleum Industry Data Exchange used EDI to eliminate “joint interest billing” documents, which often amounted to thousands of pages that were created, copied, and mailed by partners in a producing well, enabling one firm to reduce its staff by 37 percent. Westinghouse used EDI to streamline the procurement process for a customer, Portland General Electric, reducing elapsed time from order to delivery from 15 days to one-half day and processing costs from $90 to $10. Levi-Strauss’s Levilink EDI enabled one customer to reduce the replenishment cycle for its chain of 60 stores from 14 to 3 days and order delivery time from 9 to 3 days and to entirely eliminate its regional warehouses. Linking 100 customers to its purchasing and payments systems via EDI has
saved R.J. Reynolds between $5 and $10 million in costs of labor, inventory, and lead times and led the firm to offer a 5 percent discount to customers that pay via EDI. Finally, the Port of Rotterdam’s INTIS cargo-clearing system clears goods on average in 15 minutes, compared with two days, and has substantially reduced the nearly 50 percent return of export order documents for errors.

Such quantifiable economic and “softer” organizational benefits, together with the growing trend among firms to require it of their suppliers, make EDI one of the major emerging competitive uses of IT for the 1990s. Firms that have implemented EDI effectively have been able to streamline operations, shrink administration, reduce errors and delays, and generally improve service.

Companies with market dominance are increasingly requiring suppliers to link to their EDI systems and refusing to deal with those that refuse or cannot. The chairman of Sears, for example, informed the firm’s suppliers by letter in mid-1990 that they would have to link to its EDI systems. To smooth the transition, Sears offered training and free software. General Motors has had such a requirement in place for several years. As more companies move in this direction, EDI becomes a competitive necessity for small as well as large firms.

The technical base for EDI is relatively simple. Rather than require firms to use the same document formats, it exploits standards that provide for local translation of incoming and outgoing messages into appropriate formats. The relevant standards include X12, the closely related international EDIFACT, and X.400, a more general, less comprehensive standard for simple electronic messages.

To use the standards effectively, EDI partners must agree on terminology—for example, that “weight” will mean “gross weight,” not “net weight,” or that “DM” will refer to “Deutschmark.” One reason that many companies are adopting EDIFACT is that it provides dictionaries of agreed-on standard terms for many as-

Other countries are well ahead of the United States in implementing electronic data interchange as an explicit part of economic policy. In Singapore, Hong Kong, and Rotterdam EDI is used to process government documents and clear goods through customs in 10 to 15 minutes versus the typical two to three days.
pects of international trade. More broadly, industry groups are cooperating on the development of trading standards. Because all parties concerned are looking to reach a mutually beneficial agreement, the standard-setting process is proceeding more rapidly in EDI than in other areas of IT.

As is often the case in IT, the most complex aspects of EDI are organizational rather than technical. EDI requires that firms rethink business processes, not just try to make the paper chains faster and existing bureaucratic procedures more efficient. Any major IT innovation that is also an innovation in work must get by issues of standards, architecture, incompatibility, organizational change and learning, and inappropriate business justification—the old refrain of reasons for implementation failures. But impediments to implementation notwithstanding, the benefits of EDI are so great that it is safe to predict that it will be one of the fastest growing and most pervasive applications of IT in the 1990s.

See also: Architecture, Distributed Systems, EDIFACT, Network, Platform, Standards

Electronic Funds Transfer at Point of Sale (EFTPOS)

Electronic funds transfer at point of sale (EFTPOS) is the combination of electronic banking with point-of-sale retailing. The business logic is that of a cash transaction: payment is made at time of purchase. For example, you present your ATM card when you buy goods, and the EFTPOS system immediately debits your bank account.

But business logic may not match consumer emotion. EFTPOS eliminates float, the time between the writing of a check and the debiting of a bank account. With a debit card, funds leave the bank account at the instant of purchase, an event customers accustomed to credit cards may find unsettling. Consumers have yet to see sufficient benefit from debit cards to compensate for the loss of three to five days of float. Ninety-five percent of the approximately 2 million POS terminals in use in the United States handle credit card or check payment authorizations. Debit card
payments have barely grown in the past decade; although progress has been more rapid in Europe, they are still a small fraction of total payments.

Mobil Oil’s EFTPOS pilot, by eliminating paperwork and delays in handling credit cards, checks, and “real” money, enabled the company to offer service stations and consumers each a 4-cents-per-gallon reduction in price and still save money. In the past seven years, literally hundreds of comparable pilot projects have been tested in many countries, some of which have moved on to full implementation. There has been no real takeoff in wide-scale diffusion anywhere. European countries, with their national banking systems, can more easily build the needed customer base and market penetration than the United States with its regional/state systems. It is therefore likely that France or the United Kingdom will be the ones to watch.

The EFTPOS terminal market is growing. One survey estimates that it has increased by 45 percent between 1990 and 1993, with 95,000 machines in place in the United States. There were 160 million debit card transactions; that comes to only 1,600 per year per machine or about 5 per day. Credit card transactions at point of sale amounted to 3.5 billion.

See also: Automated Teller Machines, On-Line Transaction Processing, Point of Sale, Smart Card

Electronic Mail  Electronic mail enables people to send messages to one another without having to make direct contact or know one another’s location. An electronic mail service maintains a directory of subscribers, for whom it stores messages on disk. When a subscriber accesses the electronic mail facility, from home, the office, or a hotel, any waiting messages are delivered.

Electronic mail brings communication to you, the user, irrespective of time and place. It eliminates “telephone tag”; it enables you to drop a line to a colleague when a telephone call would be inconvenient; it provides a way to keep in touch casually and unobtrusively with a network of contacts.
Both public and private electronic mail systems exist. Most public services are offered by telecommunications providers, such as AT&T, CompuServe, and MCI. Private electronic mail systems are usually accessible only to authorized subscribers—typically, individuals within a single organization—and until recently, required specific equipment, networks, and software. A number of electronic mail systems that run on local area networks are offered for departmental or other in-house use. The implementation of the X.400 standard has made many previously incompatible electronic mail services interconnectable.

Interconnectivity notwithstanding, most electronic mail systems need to be made easier to use. The explosive growth of portable fax, which is relatively inexpensive, simple to use, and convenient, is in stark contrast to the slow growth of electronic mail. Despite its proven benefits and the proliferation of personal computers, which need only a modem to access public electronic mail services, "e-mail" remains underutilized. Its main users continue to be people who travel a lot, for whom electronic mail is an essential complement to the telephone. This user base is not likely to explode until the use of electronic mail is made more intuitive and simple.

Consider, for example, this X.400 address that you would have to type in to send a message to Jack Szack: "/c.US/a.MCI/p.TCROP/o.TCROP/ou.FINANCE/S.SZACK/g.SZACK." The competing SMTP (Simple Mail Transfer Protocol) gets to Jack via "szack@finance.tcorp.com." PC software vendors, including Apple, Microsoft, and Lotus have their own proprietary e-mail services, as do IBM and others.

As of mid-1994, there were an estimated 30 million e-mail users in the United States, with growth averaging more than 30 percent each year. (The estimate of 1983 users is 1 million.) Much of this is fueled by the widespread enthusiasm in the research and academic communities for the Internet, the intended base for the promised Information Superhighway, and by growth in local area
network e-mail, where Novell's MHS and Lotus Notes are growing rapidly. In 1992, LAN-based e-mail grew 42 percent.

The widespread incompatibilities among systems will be narrowed through a combination of X.400 and intelligent messaging hubs and gateways—computers that handle the conversion of formats and routing of messages between services that use different technical architectures. In the meantime, Microsoft, Novell, and Lotus will continue their jostling to persuade software developers to use their own MAPIs (message application program interfaces) rather than one of the others.

This is all a little muddled as is often in the IT field, and often makes the simple concept—"send a message to Jack"—complex in implementation.

See also: Business Television, Cellular Communication, Internet, Mobile Communication, Network, Standards, Videoconferencing

Encryption Encryption is a technique for ensuring the security of information to be transmitted over a telecommunications line. Security is achieved by scrambling the information at one end and unscrambling it at the other. Keys for scrambling the information are generated by mathematical algorithms, several of which are supposedly so complex that they could not be decoded in the lifetime of the universe. The standard encryption technique is called Data Encryption Standard, or DES.

Mobile telephone conversations that are neither encrypted nor protected by law from eavesdropping are easily tapped by radio hobbyists. The same is true for many business transactions sent over public telephone lines. Encryption removes this risk by ensuring that data tapped during transmission is incomprehensible.

An ongoing conflict between the U.S. government and businesses concerns whether businesses should be allowed to use an encryption code that could not be broken by, say, the Central Intelligence Agency in the interests of national security, or by the Justice Department investigating a scandal like Iran Contra or

An Argentinian rival of a Swiss pharmaceutical firm brought out a version of the Swiss company's patented new drug before it was launched in Argentina. The Swiss firm is sure that an employee of the Argentinian telecommunications agency copied key research documents that were sent from Switzerland through an unencrypted transmission link.
BCCI banking fraud. If Ollie North's e-mail had been unreadable, indictment would probably have been impossible.

In mid-1994, the U.S. federal government proposed that users of encryption devices must use the Clipper chip, designed to encrypt any type of information so it cannot be read by unauthorized parties but can be decoded by law enforcement agencies. The government is concerned that terrorists and organized crime will be able to make their phone calls immune to wiretapping and their records completely secret. The computer user community is equally concerned about privacy and freedom from Big Brother.

See also: Security, Telecommunications, Transmission

End-User Computing  End-user computing refers to uses of IT that are entirely under the control of business units and do not require traditional IT application systems development and operations expertise. This includes general uses of personal computers and many of the software packages that run on them, such as data base management, decision support, executive information, desktop publishing, word processing systems, electronic spreadsheets, and others.

End-user computing has grown to such an extent that in many large firms more than 50 percent of computing expenditures now fall outside the information services department's budget. Accounting systems rarely identify the full cost of IT, and many companies significantly underestimate how much they spend on end-user computing. Often, companies generate elaborate and formal business-justification procedures for the visible, central IT function, while handling end-user computing on a laissez-faire basis. Companies that sensibly require detailed justification to purchase a $2 million mainframe software package often do not accord the same attention to purchasing 1,000 personal computers at $3,500 each. End-user computing is as much a capital commitment as central information systems and should receive as sophisticated an economic analysis.

Many IS groups view end-user computing as both a priority
and a problem. It is a business priority that they must and generally want to support, especially in terms of technical advice and guidance in choosing standards, equipment, and software. It is a problem in that end-user facilities are increasingly interdependent and need to mesh with the corporate architecture, necessitating cross-functional and cross-locational telecommunications links and access to corporate data resources. Defining the role of central IS within a decentralized business and the balance between central coordination and decentralized use is an important issue for IS managers and can be a major source of tension for business units. Traditionally a systems developer and facilities operator, IS is today called on to build the infrastructures that will enable business users to get the most value from IT, without compromising the autonomy of business units in the use of their own IT tools.

As end-user computing becomes embedded in the everyday activities of organizations, business units find that they need to develop new capabilities and management processes. Departmental IT resources, such as local area networks, data-base management systems, distributed processing, electronic mail, desktop publishing, and a wide range of software, come with attendant needs for security, auditing, maintenance, and training. End-user computing has clearly become as much of a management challenge as the central IS function.

Education must be a priority to obtain value from end-user computing. Education is not the same as training. One "trains" people in the use of a particular software package, such as a word processing system, usually through short courses that mainly address the mechanics of use. One "educates" people about how to use these tools effectively in their job, evaluate and incorporate new software and uses of software, manage data resources, and ensure security. The product of a training program is a user proficient in an application. The product of an education program is a self-sufficient user.

End-users often underestimate how much they need to know...
to move beyond simple stand-alone personal computer applications. Departmental systems of intelligent workstations, local area networks, and data-base management software are technically more complex than the data centers of the 1970s. How to provide support and education needed to make these systems operationally effective is a major concern of firms today, and a large and growing, but often hidden, cost.

See also: Client/Server Model, Cooperative Processing, Decision Support System, Executive Information System

Ethernet  Ethernet is a local area network standard widely used in large organizations. Ethernet is easy to install, widely implemented in products, and well suited to connecting workstations and departmental computers. Its strength is its simplicity and ease of expansion; its main limitation is its susceptibility to congestion when handling heavy communications traffic. Ethernet is best suited to short, intermittent message traffic.

The evolution of Ethernet highlights the importance of what may seem a trivial consideration to business managers: cabling. The original Ethernet standard specified coaxial cable (the kind used to connect a VCR to a television set), which costs about 75 cents per foot. A later version of Ethernet, designated 10Base-T, specifies standard, unshielded twisted-pair cable (ordinary telephone wire), which costs 5 cents per foot. Other local area network technologies use entirely different cabling to the extent that even in 1991 many industry groups were drafting standards to help network managers deal with what one expert called “a bewildering array of wire.” In 1993, they were adding new standards to upgrade Ethernet to match the speeds of fiber optics. Fast Ethernet is a proposed standard to allow 100 megabits per second transmission; the original Ethernet specification allowed 2 to 10 mbps.

Ethernet’s principal competitor in the large-organization local area network arena has been IBM’s Token Ring standard. Ethernet and Token Ring local area networks can be interconnected, at a
cost, but their design principles and comparative advantages are entirely different. Fiber optic–based LANs are complementing or replacing both Ethernet and Token Ring. Fiber distributed data interface (FDDI) is the standard here.

In many ways, Ethernet has been an unlikely survivor of technological innovations in the 1980s and 1990s. Its easy but somewhat clumsy design has limited speed and significant performance problems in environments where the workstations on the LAN are continuously sending messages. Most commentators expected FDDI to dominate Ethernet, and between 1988 and 1992, Token Ring LAN installations grew faster than Ethernet’s. Neither FDDI nor Token Ring has yet supplanted Ethernet, whose success demonstrates that in IT, tools that work—even if inefficiently—often hold their own for decades when the alternative is an expensive conversion to new tools.

The continued longevity of Ethernet can help those trying to predict which IT innovations will take off and which current systems will retain their staying power. The entire IT field moves so quickly and with such volatility in terms of products, vendors, technology—and hype—that thinking in terms of what’s new in IT is almost automatic. In practice, what’s old is often more important in IT planning and decision making. Ethernet cabling, for example, represents a substantial investment for many firms. Key network operating systems rely on Ethernet. Demand for Ethernet interfaces is high, resulting in a drop in price. By contrast, lack of volume has, for years, kept FDDI adapters expensive. Ethernet vendors and users have every incentive to protect their installed base, and they diligently exploit improved transmission techniques to upgrade rather than replace Ethernet.

The old adage, “if it works, don’t fix it,” can be rephrased as, “if it works, fix whatever you can to keep it going efficiently.” This is why IBM’s oldest operating systems are still workhorses in many companies and why 49 percent of personal computers used in public schools in 1994 are the wonderful, venerable, and totally
out of date Apple II—the machine that launched personal computing in the late 1970s.

See also: Bridges, Routers, and Gateways; Local Area Network; Network; Token Ring; Transmission

Executive Information System (EIS) An executive information system (EIS) delivers, analyzes, and displays on a business manager's workstation information that gives him or her a clearer picture of key trends and events before it is too late to do something about them. The data, typically market figures, financial information, and industry statistics, are culled from firm's on-line business processing systems and third-party organizations.

Frito-Lay has been particularly effective in transforming traditional, report-based management information systems into executive information systems that empower executives. Frito-Lay's 10,000 sales representatives use hand-held computers daily to access central data-base information on inventory, prices, promotions, and so forth and to record their sales data. The data are transmitted by telecommunications to Frito-Lay's central computers. This activity puts the information system ahead of the accounting system; it enables the company's 32 divisional managers to examine sales figures for every one of the company's product lines in every type of store in their territory as of the time of their query. They can examine top and bottom performers, obtain information about a competitor (pressing a green gremlin displays new information on competitors), check sales for a given product at a particular store, highlight unusual or troubling data, and analyze trends, both short and long term. Senior executives can access status reports by product and/or region via a touch-screen menu on their personal computers.

Frito-Lay's EIS is not an application, but an infrastructure that includes point-of-event data capture tools (e.g., hand-held computers, point-of-sale terminals, and internal customer service workstations); communications links across the firm (extending to the distribution centers where sales representatives plug in their hand-
held at the end of each day); a massive data base engine—an enormous, expensive, complex software system running on giant mainframes that coordinates information ranging from the operational data captured by hand-held computers to purchased data obtained from market research firms); and special-purpose software designed to quickly extract, organize, manipulate, and display information in a meaningful form.

Implementation of this infrastructure has taken more than a decade, and new services are constantly being added to it. Because it would be extremely costly and time consuming to replicate, it assures Frito-Lay a distinctive competitive edge that will be difficult for other firms to match.

See also: Architecture, Decision Support System, Expert System, Platform

**Expert System** An expert system is the codification in software of the knowledge of an expert or experts in a specific domain. Digital Equipment Corporation, for example, developed an expert system called XCON that configures computer systems. This highly complex task involves many different combinations of cabling, connectors, and components. XCON outperforms humans, not because it possesses superior intelligence, but because it contains so many simple rules that experience has shown are relevant to choosing options. Another expert system success is Boeing’s Case (connector assembly specification expert) system, which tells workers how to assemble each of approximately 5,000 multiple electrical connectors for an airplane using more than 500 different types of connector. Previously, workers had to pore over 20,000 pages of manuals to find the right parts and tools. What took workers more than 40 minutes takes Case just 5.

Capturing the knowledge put into an expert system is usually accomplished by interviewing acknowledged experts. Codification of the knowledge is carried out by “knowledge engineers” using “knowledge representation” techniques. The highly specialized technology and tools of expert systems include expert system

“Expert” need not mean “learned and very important person.” Experimental early expert systems focused on medical diagnosis. The ones that have been most effective address such tasks as credit card authorization, finding the lowest airline fare, and configuring computer cables.
"shells," software tools that provide a framework for assembling and using rule-based knowledge.

An expert's knowledge and the rules that govern its application are generally coded in the form of "if . . . , then . . . , else" statements. Consider an experienced travel agent's explanation of how to find the least-expensive fare for a passenger who wants to fly from New York to Los Angeles:

"First, I check how many days notice I have. If the passenger is booking more than 60 days ahead, I know I am likely to find a deal. If it's seven days or less, forget it."

"If the journey is around the main holidays, I don't expect to find any low fares. But if it is actually on, say, Thanksgiving or Christmas Day, I can almost guarantee to find one. Why? Because the planes are full the day before Thanksgiving and the day after, but empty on the holiday itself."

Capturing and representing such knowledge is a difficult process; it turns out that the more expert people are, the more they tend to internalize their expertise and the less able they are to articulate it. We use words like "intuition," "gut feeling," and "wisdom" to summarize insights that cannot be easily articulated and hence turned into rules for expert systems.

Like so many aspects of IT, expert systems and artificial intelligence were embarrassingly overhyped in the 1980s. Knowledge engineers claimed that they could capture expertise and build systems that would make experts obsolete. They couldn't and didn't.

More realistic expert systems builders recognized the complexity of the design and implementation process, the difficulty of capturing knowledge, of building and testing the system, and of helping people feel comfortable using it. They saw expert systems not in terms of fast or magic payoffs, but as a long-term direction of effort. And they chose problems to which the rule-based approach was well suited.

One of the most promising is the neural network approach to building expert systems. This abandons the traditional ap-
approach of loading prewritten rules and, instead, lets the software literally learn by example and experience. Neural networks model what we know about how the human brain learns through connections between neurons that are generated and reinforced through behavioral conditioning. American Express and Mellon Bank, among others, report significant improvement in detecting credit card fraud from neural network programs.

See also: Artificial Intelligence, Neural Networks, Prototyping

Facsimile A facsimile, or fax, machine scans a printed page and converts it to a signal that is transmitted over a telephone line to a receiving fax machine. Fax machines have been in use for decades, but were until recently slow and expensive. Today, low-cost portable fax machines are almost as much an everyday necessity as telephones.

There are four fax standards, termed Groups. The machines used in the 1970s, which took several minutes to transmit a page and had to be connected to machines of the same group, were termed Group 1 and 2 faxes. Today's standard fax machine, which transmits a page in less than a minute, is a Group 3 fax.

Group 3 fax machines use analog transmission. Newer, more expensive fax machines use digital transmission, which is much faster. They constitute Group 4 fax. Beyond speed of transmission, digital fax has the advantage of coding a document in a form that can be processed by any other digital device, making it acceptable input to a computer program. This renders fax an integral component in firm's Information Systems platforms.

See also: Digital, Platform, Transmission

When fax machines were expensive, slow, and few in number, there was no, "I'll fax it up to your floor" in the same building, no ordering pizza by fax, no sending a fax to or from a car, and no masses of junk fax jamming up your machine. Effective IT innovations frequently go well beyond just automating the status quo, and their impacts are unpredictable. New tools create new uses.

Fast Packet-Switching In the 1980s, the technology used in public networks was stable—and slow. Public data networks offered users transmission rates of 9,600 bits per second. Large firms could lease lines that provided up to 64,000 bits a second. This meant that a firm like Rockwell could not afford to transmit detailed engineering specifications between its U.S. facilities on
the West Coast and its London engineering center. It was cheaper and quicker to fly computer tapes across the 7,000 miles. Local area network technology was fast enough to move large data files within departments but not across long distances.

Early in the 1990s, telecommunications carriers began to greatly improve the speed of transmission of their long-distance networks. The two breakthroughs were frame relay and cell relay, with the latter more usually referred to as ATM (asynchronous transfer mode). These are extensions of the concept of packet-switching that send variable-length packages more efficiently through networks, using established X.25-based technical architectures (frame relay) or pulse short, fixed-length packets at rapid rates (ATM). These devices need lines that are reliable enough to transmit the packets accurately and switches that can handle the traffic flow; this is a little like putting airplanes on highways. Many technical issues need to be resolved before ATM is commonplace, but fast packet-switching will dominate the next decade of telecommunications.

See also: Asynchronous Transfer Mode, Packet-Switching, X.25

Fax See Facsimile

FDDI See Fiber Distributed Data Interface (FDDI)

Fiber Distributed Data Interface (FDDI) Fiber Distributed Data Interface is a standard devised to exploit fiber optics' immense speeds of transmission. FDDI-based local area networks transmit data at speeds of up to 100 million bits per second. When the standard was first defined, the practical upper limit on standard LANs was one-tenth of this. The main barrier to rapid adoption of FDDI has been cost. In 1990, FDDI on fiber cost up to eight times as much as its main target for displacement—Ethernet on cable. As a result, vendors and users with a large investment in existing Ethernet set out to create CDDI (Copper Distributed
Data Interface), the cable equivalent of FDDI. A single CDDI standard was finalized in late 1993, after rival groups competed for the type of cable used.

In mid-1994, the difference in cabling cost between fiber and the highest graded type of “unshielded twisted pair” cable had dropped from a factor of 8 to about a 50 percent premium for fiber. FDDI over fiber provides many advantages: signals can be directly transmitted over great distances without needing expensive “repeaters” to regenerate them, and transmissions are clearer and more reliable than twisted pair, which generates “crosstalk”—signals that “leak” out of one cable and infiltrate another. (You occasionally get this crosstalk on the phone when you hear someone on another line talking in the background; the phone uses a lower grade of twisted pair cable, with the line twisted to reduce this type of signal leakage.) These advantages are not enough to offset the price differential for most companies, especially those that already have a heavy investment in existing cabling. Three quarters of the cost of installing a local area network is cabling (20 percent), labor (35 percent), and connectors (20 percent); network hardware is just 25 percent.

Experts widely agree that fiber is the best choice for the longer term. The new asynchronous transfer mode (ATM) ultrafast technology that is the expected base for virtually every innovation related to local and wide area networks over the coming years transmits data at 155 Mbps versus 100 Mbps for FDDI. Thus, FDDI may be a transitional standard.

Whether or not this is so, FDDI and CDDI are a step up in local area network capabilities. The 100 Mbps level of speed is essential for handling high-resolution images, such as X-rays, maps, and multimedia, including interactive video and on-line high-volume transmission of document images. Compared with the tyranny of paper, filing cabinets, photocopiers, and paper shuffling and storing, electronic document management offers immense improvements in customer service, administrative costs, and or-
ganizational coordination. As a result, the local area networks of the mid-1990s must operate at such speeds.

*See also:* ATM: Asynchronous Transfer Mode, Fiber Optics, Transmission

**Fiber Optics** Optical fiber, a glass wire thinner than a human hair designed to transmit light, is one of the true wonders of our age. One recent claim holds that a single fiber strand will eventually be able to transmit 2 trillion bits per second; the total transmission of the entire telecommunications industry today, including AT&T, MCI, US Sprint, and the Bell Operating Companies, is only 1 trillion bits per second. At present, typical fiber speeds are in excess of a billion bits per second. The SONET standard operates at up to 2.5 billion bits per second. An early version of SONET was introduced in Chicago in early 1991. MCI announced at the end of 1993 plans to build a $20 billion network to bypass the local phone companies, which charge MCI more than $5 billion a year in "access charges." This new network will initially serve 20 major cities, and SONET will be the key. MCI could never afford to replicate the Baby Bells' massive existing infrastructure of copper cables, but it won't have to; it can install fiber in the old telegraph lines, some dating back a century, that MCI obtained in its acquisition of Western Union in 1990. MCI can then transmit voice communications at gigabit speeds.

It will take time for telephone companies in the United States and abroad to replace all existing copper cable with fiber, but the process has begun. Transatlantic telephone capacity doubled with the installation of the 8-fiber strand TAT-8 system. Fiber optic-based local area networks are becoming increasingly common, with the FDDI standard (Fiber Distributed Data Interface) providing speeds of 100 million bits per second.

Fiber transmission speeds do not translate directly into transaction processing speeds any more than aircraft speeds translate into travel times. Airport congestion and delays, check-in, and road traffic all extend total journey time. Their equivalents in
communications are the switches that route traffic onto the back-
bone network, which are not yet fast enough to take full advan-
tage of fiber speeds.

Apart from speed and cost, fiber optics offers several advan-
tages over cable—among them, reliability and security. Fiber links,
unlike cables that transmit electrical signals, cannot be tapped.
The vulnerability of fiber is that if the hair-thin strand is cut,
transmission ceases. United Airlines, realizing that the fiber strands
that carry 100,000 simultaneous transmissions are usually buried
only a few feet underground, dispatched a team to post the
locations of some of its own fiber cable. Unfortunately, one of the
signs was driven through the cable it was to protect, knocking out
the airline’s reservation system and halting marketing and sales
for several hours. A British cable manufacturer had a similar
experience; it planted a Christmas tree through the main cable
of its head office building. Every large company is vulnerable to
such chance interruptions of service. The more of its fiber’s
capacity a company uses, the more it will need to provide redund-
dancy and backup linkages and establish recovery procedures.
The prospect of simultaneously interrupting 100,000 telephone
conversations, and the cash flow and customer service of any
number of businesses, is daunting, indeed.

The billion-bits-per-second speeds of fiber may seem like a
solution looking for a problem. Business communications today
largely operate at speeds from 56 to 64 thousand bits per second.
What will firms do with the extra capacity fiber affords? First, they
will share it, by “multiplexing” many low-speed transmissions onto
the fiber. They will also use it to move large data bases between
locations electronically. Most important, they will use it for novel
video, image, and engineering applications.

An example of what fiber might make practical and cost-
effective is interactive access from a computer-aided design work-
station to a full-color, full-motion, detailed design simulation of
car performance running on a supercomputer. To provide the
picture quality of a good photograph with the quality of move-

In late 1994, the relative
costs of copper cable
versus fiber were (for
36-user workstation
“drops,” or connections):
cable: $3,000 for
materials plus $2,400
for installation labor
fiber: $5,500 for
materials plus $2,400
for installation labor
This works out to $150
per drop for cable versus
$220 for fiber, a 50
percent differential.
ment on television or film requires a resolution of a megabit of pixels (the tiny dots that make up an image on a monitor display) per frame and a transmission speed of 720 megabits per second. To provide full-color, multiply these requirements by 24 bits per pixel. To ensure full motion quality, the images must be sent at 30 frames per second (the same speed used in projecting films). Clever tricks of data compression can reduce this to 15 megabits per second. Such an application is utterly impractical over copper cable across long distances.

Copper, however, is by no means the telecommunications equivalent of the buggy whip. Improvements in transmission techniques can now match FDDI’s fiber optics standard that operates at 100 megabits per second, versus the 1980s’ high-end local area network capability of 16 Mbps. Copper Distributed Data Interface (CDDI) can match that 100 Mbps speed. Bell Atlantic’s local phone system delivers pay-per-view movies at 1.5 Mbps, using the same twisted-pair cable you often untangle when talking on the phone.

But fiber is the future. Experts estimate that installing a complete national fiber optics system in every home will cost about $200 billion and take at least until 2015 to complete. New Jersey Bell has committed to make its state the first to have fiber in every customer’s location by 2010. Southern New England Telephone expects to connect 40 percent of Connecticut by 1997.

All this lengthy fragmented, but substantial, innovation is part of the so-called Information Superhighway, less a network than a network of networks of networks, provided by government, long-distance, and local communications providers and universities, cable companies, and business consortia. While no one knows how it will evolve, we do know it will be digital and fiber based.

See also: Bandwidth, Digital, FDDI, International Telecommunications, Network, Standards, Switch, Telecommunications, Transmission

Floppy Disk Personal computers, like larger computers, are provided with disk drives that allow users to load programs and
data stored on disks into the computer's main memory. Floppy disks take their name from the 5.25 inch bendable diskettes that were used in earlier models of word processors and personal computers. The more common 3.5 inch diskette that is the standard for personal computers, though decidedly not floppy, seems to be stuck with the name. The storage capacity of a 3.5 inch "floppy," which can be double-sided and/or double density, ranges from 720,000 to 2 million bytes.

See also: Disk Storage, On-Line

**Forecasting IT Trends** In general, predictions on IT trends are wildly optimistic. Attach your own labels to the axes of the following general-purpose graph taken from a 1992 estimate, and you can be a forecaster of the next IT fad.


Variants of this curve appear in many advertisements and reports. Occasionally, they accurately predict acceleration of demand for an IT component. More often, they compress into 5 years what will take 10 to 15. Vendor hopes obviously drive many of the most wildly optimistic estimates. In 1983, for example, a well-respected firm forecast 1987 sales for consumer videotex
services at $7 billion. Actual sales were well under 10 percent of that. Yet two years after the disappointing news, the same firm estimated that videotex would grow at 25 percent per year through 1993. It didn’t.

Forecasts of the takeoff of new technology and applications generally ignore the social and organizational change needed to make them effective and the long learning curve that keeps old tools and habits in place, especially when they meet existing needs. A more reliable projection of the acceleration of demand is that old stand-by, the S-curve. The S-curve breaks the introduction of new technology into three distinct stages: initiation, takeoff, and maturation.

For stand-alone personal computers (i.e., those without telecommunications capability), a short initiation phase (about 5 years) was followed by a roughly equal period of rapid and steep takeoff (personal computer sales exceeded 20 million per year by 1990) and maturation, with slowing sales driven primarily by the replacement market. The curve for videoconferencing, on the other hand, can hardly be called that as it continues to hug the horizontal axis after more than 20 years (although there are signs that it may be moving to the take-off stage).

Premature predictions of the cashless society, paperless office, telecommuting, and the factory of the future were products of overextrapolation from a few early pilots or isolated successes. Managers for whom the future turns out to be like the past are naturally inclined to be skeptical of the next set of claims. It is becoming clear that technology generally moves faster, and organizational and social change much slower, than we predict. It is a rare IT-based innovation that does not involve major rethinking, relearning, trial and error, development of new skills and processes, and an often disruptive shift from old systems and procedures to new ones.

The proven lead time for business and organizational innovations that require major investment in IT infrastructures is seven years, and it is difficult to develop any significant application in
less than two years. Even when the hardware and software can be bought off the shelf, the organizational process of piloting, design, implementation, education, and organizational learning cannot be hurried without risk of disaster and fiasco.

In 1995, several technologies have been in the take-off stage, but the steepness of the growth curve has remained hard to predict. Cellular communications and advanced fast packet-switching techniques have been growing in volume by 40–60% a year. Object-oriented techniques, a long-heralded solution to the decades-old problems of software development productivity, has been on a slower curve but well beyond the initiation stage. Multimedia has been harder to predict; it may have a longer initiation phase than the hype suggests, but a very fast takeoff.

For business managers who hear or read about expert systems replacing middle managers or that a personal digital assistant in every briefcase is the new equivalent of a chicken in every pot, then the best advice is to watch for the take-off stage, not initiation, and when it starts steepening, ask, "If this continues what are the business implications for us and our competitors two to three years out?" If the answer is "not much," then wait. The key issue is not to find out what’s happening three years from now, but to spot tomorrow’s obvious winners and move in time to leave others far enough behind that they spend the next decade trying to catch up.

The principal source of competitive advantage from IT relates to the gap between leaders and laggards. A new product or service that is based on a personal computer and a purchased software package can generally be matched fairly quickly by competitors. But with an innovation built on such complex infrastructures as a global telecommunications network or comprehensive relational data-base capability and involving major shifts in organization, learning, and skills, catch-up is measured in years.

It is important in assessing any forecast of IT innovation to question the assumptions that underlie it. Managers need to assess likely business, organizational, and social forces that may
either slow or speed progress along the curve. Then they must ask, "Is a move that will put us ahead of the pack worth the risk?" "Should we wait and follow?" "How long can we wait before we risk being unable to catch up?"

See also: Chief Information Officer, Cost of IT

FORTRAN  See Programming

Fourth-Generation Language (4GL)  A fourth-generation language, or 4GL, is a software facility designed to speed up application development, by allowing programmers to use English-like commands and step-by-step procedures that would otherwise have to be specified in detail. Report writers, for example, will automatically generate the code to handle pagination, calculate totals, and other minor but essential operations for which the programmer would otherwise have to write instructions.

The term "fourth generation" places the language in the context of the history of programming. First-generation programming languages required programmers to work at the level of the machine instruction code, an intensely slow and tedious process. Second- and third-generation languages put successively more distance between programmers and the computer's native tongue. The "higher-level" third-generation languages most widely used today, such as COBOL, generate many machine code instructions for a single line of "source code" written by a programmer. Fourth-generation languages are a further refinement in using English-like commands to tell a computer what to do. Because of the overhead incurred in translating high-level commands into machine instructions, 4GLs are most effective in speeding the development of smaller systems. They are less efficient for developing large systems and systems designed to handle heavy transaction volumes.

The term 4GL has become slightly obsolescent in the mid-1990s mainly because of power "apps" on personal computers. An app is short for application, which is short for application pack-
age, the older term for software that provides specialized capabilities, such as word processing, data management, accounting, and modeling. When 4GLs first appeared, they needed the power of a mainframe; that power is now on the desktop.


Frame Relay  Frame relay is one of the two main developments in long-distance data communications; the other is ATM (asynchronous transfer mode). Both of these are forms of fast packet switching, a technique that breaks up large messages into small variable-size (frame relay) and fixed-size (ATM) “packets” and routes them through the network. Frame relay has a special advantage; it can operate within the same technical architecture that firms built for the old standard for packet-switching, called X.25.

See also: Fast Packet-Switching, Packet-Switching

Gateways  See Bridges, Routers, and Gateways

Gigahertz  See Megahertz and Gigahertz

Graphical User Interface (GUI)  Apple’s dual innovation of the electronic mouse and icon-based menu with its Macintosh personal computer transformed user interaction with computers. The Macintosh, or Mac, displays users’ options in the form of graphic images, icons, to which the user points using a mouse, a palm-sized device attached to the computer, the movement of which corresponds to the movement of a cursor on a screen. The user selects an option by moving the mouse to position the cursor over it and pressing a button on top of, or “clicking,” the mouse.

This “graphical-user-interface” approach to using computers underlies most recently introduced, successful IT products targeted at occasional, inexperienced users. Lotus 1-2-3, the per-

The central principle underlying the design of almost all personal computer and workstation software today is that the system (not the users) should handle complexity, that users should not have to remember what options are available but be presented with them, and that users should be able to point instead of type.
sonal computer spreadsheet that transformed business use of computers in the mid-1980s, permits a user to move the cursor around the screen to select a column, and Microsoft's Windows 3.0 turns an IBM personal computer running the MS-DOS operating system into a Macintosh look-alike. This design approach to interaction between user and computer has clearly helped to bring what was a technology for specialists into the office, home, and classroom.

See also: End-User Computing, User, User Friendly, User Interface

Groupware Teams, communication, and collaboration are widely viewed as organizational priorities for the 1990s. Groupware, and its variant work-flow technology, is the technical support for making these priorities practical and efficient. The logic is that an individual's work can be carried out at a personal computer using software that coordinates interactions with and interdependencies between other people, rather like a supervisor managing the work flow of a department: keeping track of projects, alerting people to deadlines, routing messages, and checking jobs are completed on time.

The leading product in the groupware market, Lotus Notes, is one that a growing number of firms see as the base for rethinking many aspects of their basic organization. Notes includes just about every computer-based feature any group or team needs; it is, however, cumbersome to install and complex to learn. That is an almost inevitable consequence of its power and scope. Users can create, organize, and share data and work together on transactions, reports, schedules, and the like, as if they are in the same room. Notes more closely resembles a networked office than just a piece of software.

Notes also marks the shift of the leading software providers—especially Lotus, the creator of 1-2-3, and Microsoft, the dominant force in the industry—away from products primarily designed for individual PC use with limited telecommunications to networked systems intended to permeate every aspect of organizational com-
munication, coordination, and teamwork.

Frequently, in the early stages of an IT-based innovation, there are many competing concepts and tools. In 1991, according to the respected Institute for the Future, a leader in groupware studies, 77 products were on the market that offered some combination of team scheduling, sharing on-line computer screens (like a shared blackboard), group writing, data and report sharing, conferencing, managing groups, filing and retrieving, sorting and filtering messages and data (a key to avoiding the electronic equivalent of junk mail), meeting support, and managing work flow. In 1992, that number had grown to 140 and almost doubled in 1993.

It's no exaggeration to say that groupware will be the primary enabler of global work. It represents as basic a shift in the use of IT in firms as did the word processor and spreadsheet. As with these, any sudden or dramatic change in organizations are unlikely, but a fundamental and sustained evolution (where are the typing pools of yesteryear?). Groupware is generating the standard IT hype and it may be 5 or even 10 years before it becomes as standard and natural to use as word processing packages. It represents a major cultural shift and can be very threatening to managers who have been brought up with the norms of privacy, hierarchy, face-to-face meetings, and formal reports that mark most organizations. Groupware means compressing the social history of the telephone from about four decades to one.

Any large organization that isn't looking at groupware but still talks about breaking down hierarchies and creating the empowered team-based organization is similar to one in the 1980s that doesn't use 800 numbers but wants to provide the best service to its customers. Groupware enables teams to work together interactively. Historically, firms created that interaction by physically moving people to one location, which is not an option in terms of time, geography, cost, or quality of people's personal lives. The groupware principle allows people to stay where they are and extend their electronic ears, eyes, legs, and voices.
Hackers Hackers are generally thought of as amiable nerds who enjoy playing with computers and networks and who love the challenge of bypassing security and tapping into new systems. Most hackers are just that, socially harmless and often superb innovators. The Internet—the embryonic blueprint for the hyped Information Superhighway—was created mainly by hackers’ ingenuity over a 30-year period. In fact, several of the billionaires who now run leading software companies and wear Armani suits are superstar ex-hackers.

The problem is that a small minority of hackers are superstar thieves. They exploit one of the eternal dilemmas in the IT field: how to balance ease of access with control and security. The Internet, for instance, is built for students, professors, researchers, and others to easily and openly access more and more services and information. Hackers simply bypass controls, capture passwords, and raid data bases that often contain valuable private company data. Your friendly retailer needs access to your credit card company to authorize your purchase. A good hacker wants that access, too, to make an illegal purchase.

So much of our economy is now on-line that it is not surprising that small-time and big-time criminals see it as an electronic Fort Knox where you can make quick money.

See also: Encryption, Security

Hand-Held Computer See Portable Computer

Hardware Hardware broadly refers to the physical components of information technology, the computers, peripheral devices, such as printers, disks, and scanners, and the cables, switches, and other elements of the telecommunications infrastructure that connect everything together.

Hardware is the engine of computing, chips its key component. The compounded 20–30 percent improvement in price performance of chips translates directly into continuous cost re-
ductions in hardware. The same is not true for software, which remains labor intensive.

There are two main categories of hardware: processors and peripherals. Processors are computers and telecommunications controllers of varying sizes and types that operate at speeds measured in microseconds and picoseconds (millionths and trillionths of a second, respectively). Peripherals are devices that attach to processors: disk drives, printers, computer monitors, and so forth. They almost invariably include moving parts that limit their speeds to milliseconds (thousandths of a second) and even seconds. As a result, peripheral performance has not kept pace with processor performance. IDC, a leading IT research firm, estimates that between 1980 and 1990 performance of mainframe CPUs improved by a factor of seven, performance of “input/output subsystems” by a factor of less than two.

*See also: Cables, Plugs, and Sockets; Disk Storage; Fiber Optics; Mainframe and Minicomputer; Personal Computer*

**Host Computer** “Host” is increasingly being used instead of mainframe or minicomputer to describe a computer that provides services to a range of remote workstations. Often, it is called a “superserver”—in the client/server model of distributed computing, which is rapidly becoming the mainstream for business use of IT. Client workstations access servers for transactions, shared information, and coordination of communication. A host is typically a server for transaction processing and for accessing corporate data.

*See also: Client/Server Model, Distributed Systems, Mainframe and Minicomputer, Platform, Workstation*

**IBM** This is a company that has lost nearly $80 billion in market value in well under 10 years. Normally, IBM’s membership in the *Fortune* 500 “endangered species list” would not matter to most companies any more than that of such other toppled Goliaths as...
IBM's new chairman captured the essence of IBM's failings in the company's 1993 annual report:

At the heart of the turmoil is one simple fact: IBM failed to keep pace with significant change in the industry. We have been too bureaucratic and too preoccupied with our own view of the world. . . . We had all this great technology coming out of our labs, but time and time again someone else beat us to the marketplace. . . . Our margins declined and our cost structure was far too heavy to maintain profitability. . . . We believe we can fix these problems because they were caused by us.

Sears, General Motors, or Kmart (unless they are their suppliers). It would just be another oversized company in oversized trouble.

IBM's disasters do, however, matter to businesses. It's as if the nation's entire electrical utility industry got into trouble and could not be relied on in the future. Just about every large organization's basic transaction systems were built on IBM computers, telecommunications tools, data management systems, network management, and technical blueprints ("architecture"). So, too, were the careers of many managers and technical professionals in the information services field. As a result, even as these firms move to replace their mainframe computers, they still depend on IBM for many IT functions. IBM's erosion affects their ability to manage the costs of their IT base and meet growing business needs.

IBM reported its most profitable year in 1984. It netted $7 billion, a figure no other company has ever achieved; 1990 was also a great year. Its investor relations executive couldn't resist finishing a conference call to financial analysts by saying, "This earnings release is dedicated to all the pessimists by IBM." By 1993, the pessimists looked like realists. IBM had cut 140,000 jobs, and the market value of its stock had dropped $75 billion, the equivalent of the entire gross domestic product of Sweden.

The roots of IBM's decline go back many years and have many causes, most of them organizational, rather than technical. It's easy to ascribe the company's fall to the decline of the mainframe computer, the behemoth of the fortress-like computer centers, that provided IBM with 40 percent gross profits and a 70 percent market share. The company's belief that any development in the industry that did not fit into its view of the world of computing was at most an aberration contributed to the arrogance and "not-invented-here" smugness that marked IBM for so long.

Yet, even in the early 1990s, IBM's midsized AS/400 machine was bigger in sales and twice as profitable as all of Digital Equipment. In 1994, it regained its leadership position in market share
of personal computers. Once it finally accepted that UNIX-based workstations were not a niche market to be ignored, its RS/6000 machine quickly captured sales and reputation. The mainframe was not, after all, the cause of IBM’s self-immolation; however, relying on the mainframe and its profit margins blinded IBM’s managers to customer demands and industry trends.

Every expert commentator on IBM attributes its problems to internal operations. The 15-year antitrust suit that required the company to keep every document and justify every competitive move as well as the failure of the mega-project FS (Future Systems) apparently caused IBM’s extreme risk aversion, contention between business units, and near obsession with meetings. Its lack of new blood, its high cohesion and internal morale, and its record of seemingly effortless superiority also reinforced its unresponsiveness to new competitive forces and to the many customers who found IBM essential but difficult to deal with.

The irony is that despite the conventional wisdom that portrays IBM as the technical laggard, it was instead the innovator in R&D. IBM was a decade ahead in the development of its workstations and PC operating systems. Unfortunately, these products are only now coming onto the market. Its internal culture again and again prevented their introduction partly because one or more divisions, fearing the erosion of their own revenues and product base, would veto the innovation. The cumbersome, cautious, consensus-obsessed management style paralyzed innovation and also slowed implementation. In a field often burdened by products that are late to market and have cost overruns, IBM’s products were later and had more overruns.

IBM’s cultural problems seem more a constraint on its future than its technology. While the old mainframe may indeed be dead, large firms still need ever more powerful complexes of workhorse machines to handle transaction processing and information management. IBM’s next generation of machines will use parallel processing to provide these capabilities; the market for
these new mainframes remains large. IBM is gradually cutting its absurdly high overhead and administrative costs.

But . . . There are few indications as yet that the core of the culture has lost its bureaucratic attitude or learned how to listen to customers, and there are as yet no signs of rapid recovery. IBM no longer controls the direction of the computer industry or dominates and intimidates competitors. It's hard to be optimistic about the future; one can predict that, at best, IBM will hold its own and end its erosion.

One major effect of IBM's decline is on the IT managers and professionals who learned their skills during the era of IBM's dominance. They are now tarred with IBM's reputation as an irrelevant dinosaur. It's certainly true that some mainframe-era specialists do not seem capable of changing their attitude, but in most instances the problem is one of access to training in new skills.

**Icon**  See User Interface

**Image Technology** Image technology refers to the general category of computer applications that convert documents, illustrations, photographs, and other images into data that can be stored, distributed, accessed, and processed by computers and special-purpose workstations. Large-scale image processing systems have only recently become widely available.

Most major companies have at least one large-scale pilot image application under development, and a number of firms have used image technology in core business operations, with significant economic and organizational gains. One of these is USAA, a leading insurance firm that pioneered image processing as part of a long-term business vision of becoming the most responsive firm in the industry, a position it is generally acknowledged to have achieved. Image technology has enabled USAA to bring together in a single electronic folder all the records and documents relevant to a customer, ranging from correspondence to
policies to photographs to claims history, and put it at the agent's fingertips when a customer calls.

Another successful user of image technology is Northwest Airlines, which uses it in passenger revenue accounting, the time-consuming and tedious process of examining boxes of used airline tickets to audit inter-airline payments, foreign currency adjustments, accuracy of pricing, and so forth. Previously Northwest was able to deal manually with only 5 percent of the annual 20 million tickets. The image processing system audits 60,000 tickets per day with greater accuracy and produces more timely management information. The system paid for itself in a mere three months.

Empire Blue Cross and Blue Shield reduced the time required to process Medicare claims from seven days to two and cut direct costs by 15 percent using image processing, and American Express, by providing a high-quality image of each transaction on a customer’s billing statement, was able to improve the quality and differentiation of its services while reducing billing costs by 25 percent. Phoenix Mutual Equity Planning Corporation used the technology to reduce lead time for a mutual fund purchase from 22 days to one and cut staff requirements by 30 percent.

The technology base for companywide image processing comprises several components. A scanner transforms physical images into electronic digitized images, which must then be indexed and compressed. Data-base management software handles the accessing of the indexed images, and a server/controller moves them to and from storage, which is typically magnetic or optical disk or some combination of these, and routes them through the corporate network. High-powered workstations and high-resolution display screens are needed to display and manipulate the images.

Storing a high-quality image of a document consumes substantial storage space on an optical disk. In addition, retrieval time is slow compared with the numeric and alphabetic data used in transaction processing and stored on magnetic disk. For instance, the total data created and stored for airline reservations
The biggest problem in using image processing is that converting existing physical documents can cost more than the image system—2 cents to 2 dollars a document, depending on how much indexing is needed; images are retrieved from the indexes. One service bureau estimates that a typical conversion involves a million images. When it converted a university’s 8 million 3-by-5 library cards, some dated back to the 1800s. It took six months to complete the task.

is under 1,000 bytes. That can be retrieved from a disk in a millisecond. An exact image of the ticket takes up 50,000 bytes and the retrieval time, depending on the equipment used, can be as slow as 12 seconds.

"Depending on" is the key phrase here. Low-end image processing systems are widely available for roughly the cost of the personal computer they are designed to work with. Large companies like USAA that want to use image processing as a core element of customer service need massive storage with very fast retrieval time. That costs $200,000 to $500,000 for a departmental system and millions to even hundreds of millions of dollars for an enterprisewide capability. For a company like Northwest Airlines to audit 60,000 tickets daily, using 10 workstations—10 retrievals per minute per workstation—adding six seconds retrieval time would cut productivity in half.

However costly image processing might be, the potential pay-off from successful incursions in the war against the paper mountain can dwarf its expense. Given estimates by Wang that less than 5 percent of company information is stored on computers, and Exxon, which calculated that every document in its head office is copied 40 times with 15 copies being permanently stored in filing cabinets, the business and organizational opportunities that image technology presents are clearly immense. U.S. businesses are estimated to store close to half a trillion documents per year. It is not unusual for many office and administrative staff to spend 20 percent of their work day just trying to locate documents.

The 1980s was the decade of the personal computer. The 1990s is becoming the decade of image technology.

See also: Bar Code, Forecasting Information Technology Trends

Incompatibility One might expect a program that runs on one computer would be able to run on another, that a printer connected to one computer would be connected to another computer, and that data disks ought to be able to be shared between two computers. The term incompatibility is used to explain why
two components will not work together, which is all too often the case. Differences in hardware design, operating systems, data representation schemes, standards, and protocols make incompatibility the norm in IT. One of the primary goals of developing a corporate IT architecture is to evolve an integrated capability and end the chaos of components and systems that ought to work together but cannot.

The explanation for the widespread incompatibility among systems and components lies in the history of the IT industry. The IT field grew as a result of individual manufacturers developing their own hardware, operating systems, and telecommunications equipment. Specifications for these products were proprietary. There was little cooperation among suppliers and only a few industrywide standards, many of which leading vendors, especially IBM, ignored.

This situation persisted through the 1970s. Little by little, momentum built for standards, primarily in the field of international telecommunications. Today, every major vendor and user recognizes that standards are essential, but the technology changes so quickly that it is difficult to freeze specifications or keep standards current.

Although progress continues to be made toward achieving compatibility among the key elements of the IT infrastructure, there is a massive investment in existing incompatible systems that are too costly to redesign and replace. Resolving these problems is the core of the Information Systems planner's job.

See also: Architecture, Compatibility, Integration

**Information Superhighway** The concept of a national information highway is as much political as it is technical. In the 1980s, use of the government-funded networks that link universities and research centers began to grow very rapidly. As these became interconnected, the term "Internet" was coined to describe what is now the largest community of network users in the world, with the volume of messages doubling every few months in the early
The Information Superhighway is as yet no such thing—it’s just a Superconcept. The forces behind it are unfocused but powerful. These include the cooperative alliances among telecommunications and cable TV providers, the explosive growth of the Internet, the jostling between long-distance and local phone companies to enter each other’s markets, and the continuing innovations in and reduced costs of technology. At some point in the late 1990s, the roadbed of Superhighway will become clear.

1990s. The then-senator Albert Gore (D-Tenn.) sponsored additional government funding of this national infrastructure. When he became vice president, he used his influence to push forward what is now called the Information Superhighway. It is a vague concept and an umbrella term that covers many initiatives, including those proposed by long-distance carriers, cable firms, local phone companies, and others. The logic is that early in the next century, the United States will have in place a high-speed equivalent of interstate highways—hence the analogy—that connect local, city, and state roads.

Fueling the policy on the National Information Infrastructure, which was the basis for the 1992 proposed legislation, is a mass of alliances, acquisitions, new services, and court cases. These brought long-distance and local service providers and cable TV companies into each others’ marketplaces because each of their technologies can now deliver any type of information. The markets were once very separate, but the 1984 Cable Act regulated cross-ownership and the 1982 divestiture of AT&T gave the seven newly formed Regional Bell Operating Companies (NYNEX, BellSouth, etc.) a monopoly over local phone services and kept them out of entertainment, publishing, information services, and long distance.

The old regulation is dead, even before the decision to kill it was announced in January 1994 by Vice President Gore. Now, essentially anyone can play in any market. Bell Atlantic’s attempted merger with TCI, valued at $33 billion, was a dramatic first thrust that was followed by many others. The new legislation will take years to hammer out. Key issues are ensuring that “universal service” is ensured. Giving the Baby Bells a local monopoly in 1982 ensured that everyone could afford decent phone service, as will the new laws that will regulate pricing to assure schools, libraries, and poor households access to the Superhighway. The cable TV companies’ reputation for price gouging is not encouraging in this regard. The cash-rich Baby Bells will be prevented from trying to corner the local cable TV market. They will be
allowed to offer long-distance phone service but will face competition for the first time. As The Economist commented in January 1994, the main question is whether the Superhighway will spawn an information aristocracy or a digital democracy.

The plan for the Information Superhighway seems tidy, with Interstate routes, driving rules, zoning regulations, and the like; however, it is anything but tidy and has all the organization and predictability of downtown New Orleans during Mardi Gras. The highway analogy is inaccurate if not dangerous. When a traffic accident occurs in, say, New Jersey, it has no direct impact on the traffic flow in California. If the Massachusetts Turnpike closes for three hours, that has no effect on people in Georgia.

But a major crash of a node or a transmission link on the Information Superhighway can have as much impact on the overall system as a four-hour closing of JFK airport in New York. Such a shutdown ripples throughout U.S. and European air traffic systems, causing a 16-hour delay in Los Angeles. It therefore seems more accurate to change Superhighway to the Information Superairway. The FAA air traffic control system manages the entire flow of aircraft across the entire network. It has reduced the relative fatalities from accidents since airline deregulation and it is more dangerous to drive to the airport than to fly from it.

Most of the discussion of the Information Superhighway overlooks the issues of network management, end-to-end coordination, security, reliability, backup, and other centralized oversight functions that businesses regard as essential. Without them, the Superhighway may become a Supercrashway.

**Information Technology (IT)** Through the early 1980s, the term “computer” covered just about the whole field of information processing. Now, “information technology” has become the generally accepted umbrella term for a rapidly expanding range of equipment, applications, services, and basic technologies. They fall into three primary categories: computers, telecommunications, and multimedia data, with literally hundreds of subcate-
gories. Increasingly, the three elements have become interdependent. A "server," for instance, is a computer that is a key element in a client/server environment on a local area network and manages shared data bases.

Thousands of building blocks can be combined in many ways to create a firm's IT resource. Functionally, there are four types of components: (1) tools to access services, most obviously telephones and personal computers, (2) the telecommunications links that route the tools to those services, (3) transaction processing hardware and software, and (4) information stores. The degree to which these work together defines the integration of the platform. When different components use tools that cannot link together, the systems are incompatible.

The functional perspective on IT is increasingly more useful from a business viewpoint than classifying elements by their technological base. For instance, televisions are joining PCs and phones as tools that access computer transaction processing services and information stores, for example, using the TV to check out of a hotel. The telephone is becoming more effective than PCs in many areas of electronic service: buying and selling securities through a discount broker by touch-tone phone or responding to recorded instructions to get your bank balance. In many areas of personal usage, the distinction between hardware and software is invisible to the user and thus not very useful in business planning.

See also: The introduction to this book

**Integrated Services Digital Network (ISDN)** Integrated Services Digital Network is the plan for the long-promised transition of the world's telephone systems from analog to digital technology to permit the combined transmission of any and every type of information, including voice, pictures, newspapers, diagrams, and even videoconferencing. Telephone systems today are limited in the amount and type of information they can transmit and receive and the special facilities they can provide. ISDN is a
prescription for a telephone system that can deliver any type of information at 10 to 30 times today's speeds and simultaneously handle two entirely different applications on the same line, for example, a telephone call and transaction processing.

ISDN, a 1970s' concept that originated in Europe, now that it is actually being implemented is viewed by some experts and managers as obsolete and superfluous. Many of its design features, which were fairly advanced when they were defined, are already available in a variety of non-ISDN products. The design has not kept pace with newer technologies and newer applications, and there are many variations in implementations of ISDN standards.

It is unclear how effective ISDN will be in the United States. Businesses now have so many choices that they may not benefit from ISDN. Consumers should, but not until the cost of the equipment that replaces the old telephone handset and the charges for monthly use become attractive. European and Asian countries are firmly committed to ISDN, in part because they have a lot of catching up to do. Singapore, Indonesia, Japan, and Australia are well along in its deployment. France implemented ISDN in Brittany in 1987.

ISDN is primarily a concern of telecommunications providers, such as the Regional Bell Operating Companies in the United States and the national Poste Télégraphique et Téléphoniques (PTTs) abroad. These provide the public network that is the infrastructure for consumer use and much of business use.

It is difficult to assess the business importance of ISDN or its likely future development and impact. One business alternative to ISDN is the corporate private network, which uses standards entirely different from ISDN. There have been delays in the filing and approving of tariffs for ISDN in the United States, and ISDN investments and prices have created many regulatory arguments. Many regulators see ISDN as benefiting a few large businesses at the expense of the consumer base that will fund it.

A major advantage of ISDN over connection to the analog public phone system via a modem for, say, electronic mail, is speed. It takes up to 45 seconds to complete the dial-up and associated procedures versus 1 to 3 seconds for ISDN links within the same area code and just under 10 seconds across the United States.
Even the most optimistic predictions expect that ISDN will be installed in 65 percent of U.S. telecommunications providers by 1995. Usage costs are up to two times higher than using the slower standard phone lines, which operate at one-fifth the effective speed of transmission, though. Special equipment is needed, too, on the customer's premises.

Many experts still believe in ISDN after all the delays and slow rollout because it uses existing phone lines; as telecommunications companies upgrade the switching equipment that handles the routing of traffic, which is an essential, ongoing part of their modernization, ISDN will naturally gather momentum, because the new switches will include it as a core part of their services, instead of a special item.

Availability of ISDN at a low connection and usage price could greatly stimulate the use of PCs in the home to access information and consumer services. Anyone who uses dial-up lines to connect to the Prodigy service or an electronic mail service knows the frustration of waiting as the screen slowly fills or as the machine sends and receives messages.

If the telcos—industry jargon for the long-distance and local phone companies—do not bring fast, cheap digital communications into the home, cable companies certainly will, within the next two to five years in large metropolitan areas. That may move ISDN faster than at present.

See also: International Telecommunications, Network, Poste Télégraphique et Téléphonique, Telecommunications

Integration Definitions and interpretations of integration vary; in general, integration refers to making the separate components of a technology base or business service work together and share resources. Today integration is a major priority in the IT industry, and there are many different approaches to providing it, ranging from standards for open systems to devices such as bridges, gateways, and protocol converters.
Although it is generally discussed in technical terms, integration is more important as a business concept. Most information technology applications in organizations have been built up over decades, using separate software, hardware, and telecommunication systems. These systems generally correspond to functional divisions in a company. Traditionally, finance, marketing, engineering, human resources, and so forth have had little need to cross-link their information and communication systems. But with the tidy separation of business functions beginning to break down, work and communication are becoming more interdependent across business operations. It is this business and organizational interdependence that is driving the need to integrate IT applications.

The degree of integration a firm achieves strongly influences its future business options. One major manufacturer's summary analysis of its IT capabilities is telling: it was spending $46 million per year on IT for its production department, which had many different systems, much homegrown software, and very high maintenance costs, yet the department was perceived to be increasingly unresponsive to customer requests. When it was discovered that the reason for this was that processing each order involved crossing multiple business functions, pulling the processes together became a business need, indeed an urgent business priority for the firm. The process of doing so, which has involved throwing out some systems and equipment and redesigning others, converting some systems to different software, and insisting that new development conform to specified technical standards, has so far taken eight years. It is not completed yet.

For any firm that does not already have an architecture in place, integration can be viewed as a three-stage process: (1) definition of a target architecture based on key, proven, and practical standards; (2) rationalization of existing systems; and (3) selective adoption of open standards as they are proven, while providing for continued operation of existing systems.

Dataquest reported that in 1994, almost half of U.S. companies' networks supported four or more different protocols. There are 6,192 combinations to support if the firm has four different hardware systems, three operating systems, four types of LAN, four DBMS, four programming languages, three PC software suites, and three network management systems. Many firms have even more.
Technology integration is vital to the integration and cross-linking of business services and processes. It is the major opportunity and challenge for information technology in the 1990s.

See also: Architecture; Bridges, Routers, and Gateways; Compatibility; Connectivity; Open Systems; Platform; Standards; Systems Integration

Intel Intel dominates the microchip market for personal computers. Its design of ever-faster computer chips determines the speed and power of PCs. Intel’s Pentium chip has set the pace for the next generation of PC hardware and thus of PC software. Intel’s 1993 sales of $8.4 billion and profits of more than $1 billion made it the world leader and the target of attack by the rest of the industry. Its 75 percent market share can only erode, not increase, and the cheaper PowerPC product offered by a consortium of Apple, IBM, and Motorola will assuredly generate fierce price competition.

Intel is positioning itself to avoid price erosion and being locked into the PC market whose margins have eroded to the extent that PCs are no longer “high tech” but the industrial equivalent of consumer electronics—assembly-based commodities. Intel ranks second in the industry in sales of the cards with chips that connect PCs to local area networks, and it is making alliances with many companies in the telecommunications business.

Intel’s strengths have come from its commitment to R&D. It is hard to think of any Japanese company that beats it in its long-term focus, quality, and technical excellence. NEC is the closest innovator, except perhaps for Motorola, another U.S. firm. Intel must innovate and price aggressively to hold off Motorola. Intel has thrived mainly because it was the chip used in IBM PCs and PC “clones.” (IBM saved Intel from near bankruptcy in the mid-1980s to ensure a reliable U.S. source of chips; IBM pumped in the equivalent of petty cash and thus did not take any equity position in Intel, whose market value is now greater than IBM.) Apple uses Motorola’s chips in all of its products, including the
venerable Apple II, the Macintosh, and now its PowerPC-based series of machines.

One cannot predict the winner of the Pentium–PowerPC battle, and technical quality may not determine the winner (just as VHS triumphed over Sony’s technically superior Betamax). Most observers assume that Intel will remain the leader in the chip market through 2005. If so, we are in for even more radical technical innovations and price-performance improvements in the next 10 years than were developed in the last.

**Interface** An interface is a connection between two devices. A wall outlet is the interface between electrical appliances and a power company’s electric utility. IT standards relate largely to defining interfaces. For example, given a precise statement of the procedures and electrical signals for establishing a connection between a workstation and a local area network, hardware manufacturers, software developers, and local area network providers can design and implement their systems in many different ways with different internal features and, provided all conform to the interface standard, they will work together.

An effective architecture is built on standards that provide maximum clarity about interfaces and maximum freedom of choice in equipment and services.

*See also: Bridges, Routers, and Gateways; Cables, Plugs, and Sockets; Integration; Open Systems; Protocol; Standards; Systems Integration; User Interface*

**International Telecommunications** Internationally, telecommunications is usually handled by a highly regulatory, quasi-governmental agency termed a PTT, from the French Poste Télégraphique et Téléphonique. Most PTTs—some reluctantly, others willingly—are relaxing regulation (“liberalizing”) in response to global trends in technology and business, among them British Telecom (a private company in a marketplace that is being opened to greater competition), France Telecom (very much a monopoly
and an opponent of deregulation), Deutsche Bundespost (Germany's recently reformed monopoly), and Japan's domestic NTT and KDD.

Widely varying prices resulting from the vast range of policies concerning liberalization have had major impacts on international firms' choices of location for back-office services. In international banking and securities, for example, London has gained at Germany's expense. London now processes 40 percent of the world's foreign exchange transactions, equal to Tokyo and New York combined. It holds this position primarily because of the quality, availability, and cost of its telecommunications services.

Europe's leading economy, Germany, is a laggard in telecommunications. Until recently it restricted business access to private networks and kept its telecommunications prices far higher than justified by its falling costs. To date, only about 15 percent of its telephone subscribers are linked to digital exchanges, compared with more than 90 percent in France. Catching up, and moving East Germany's primitive telecommunications infrastructure out of the 1950s, has become a German priority.

That competition in telecommunications immediately brings lower prices has been true in the deregulated U.S. long-distance market and in Japan, where the newest of three providers set its prices 25 percent lower than KDD's (Japan's former PTT), which responded within months with a 16 percent cut in rates. British Telecom lowered its prices by 17 percent in real terms over a three-year period in response to competition from Mercury.

The economic importance of telecommunications is shown by the fact that when a national monopoly is privatized, it becomes the largest company in the country, based on the total value of its stock. NTT (Japan) was valued at more than $140 billion in late 1993, with AT&T second in the world among telecommunications firms, at $82 billion. Britain's aggressive BT was valued at $41 billion, even though it accounts for only 3.5 percent of world communications services. In fourth place was Mexico's Telefónicos, noted as one of the world's worst telephone systems and
valued at $26 billion precisely because it is so bad. Analysts predict massive growth opportunities fueled by Mexico’s opening up of trade and by the North American Free Trade Agreement.

The United States accounts for 22 percent of global telecommunications services, with Japan holding 10 percent and Germany 8.5 percent. However, almost 70 percent of international traffic flows to and from the United States, whose providers receive only 32 percent of the total international services revenues. European countries charge 27 to 69 cents a minute for handling international calls, which cost them around 10 cents. This is a $4 billion a year subsidy that gives them little incentive to change the cost-sharing formula agreed on in the 1980s.

Telecommunications has become a contentious political issue and an increasingly important element in economic policy. It is analogous to the automobile industry in terms of capital costs, import/export and quota issues, and labor union concerns. PTTs' procurements tend to favor major national manufacturers, and trade wars in the $100-billion telecommunications equipment market are forcing many mergers and acquisitions.

A major concern for transnational businesses is the lack of one-stop shopping for telecommunications. A company wanting to link French, Italian, Swedish, and U.S. operations must negotiate each end of each link with the appropriate PTT.

The competition between AT&T and MCI should change this situation. In 1993, AT&T announced several proposed global alliances; this is as routine in the international telecommunications business as plans for cutting the federal deficit, and just about as frequently consummated. The difference here is that AT&T and its proposed partners, such as the German DBP and France Telecom, must act because cash-rich BT bought 20 percent of MCI, the technology rich, marketing smart U.S. provider. BT and MCI are well positioned to dominate the telecommunications equivalent of the JFK-Heathrow airline routes to Europe.

Business managers and information technology specialists cannot presume that international and domestic telecommunications

“We may squawk about the cost of [leased lines] in the United States—but we have them. And there's usually a half-dozen competitive carriers that can supply them. But imagine having to pay 10 times the price for one-tenth the bandwidth. That's how bad it is. In my mind, it is the main reason Europe is a decade behind the United States in networking.”

—Communications Week, November 22, 1993
will be similar in terms of cost, availability, quality, security, or technology. In some areas Europe is well ahead of the United States (e.g., Scandinavia in cellular communications, France in ISDN). In other areas it lags not so much in terms of technology, but in the responsiveness of the PTTs to business needs. Because the continent is starting from a smaller base of installed telephones, telecommunications growth has been and will continue to be far more rapid in Asia than in either Europe or North America. The geography of such countries as India and Indonesia calls for a mix of telecommunications strategies, with satellites playing a major role.

See also: Backbone Network, Cellular Communication, Mobile Communication, Network, Packet-Switching, Satellite, Telecommunications

Internet The Internet—meaning the one and only, the biggest, and the core of an entire culture and almost a cult—is a network of networks that grew, rather than being planned, to comprise an estimated 50,000 subnetworks in 90 countries, with approximately 15 million users accessing 2 million "host" computers. In the 1990s, growth in traffic was about 8 percent a month. These figures are educated guesses; no one really knows the size of the Internet.

The original base for the Internet was the Arpanet, a network funded for use in civilian research by the Defense Department in the 1960s. This encouraged experimentation, and graduate students developed many tools and protocols to facilitate the open flow of information among universities and research labs. Some of these homegrown efforts became major elements in UNIX-based uses of the Arpanet, including many components of TCP/IP, the pragmatic standard that is used not only by the Internet but by more and more businesses. TCP/IP was never really designed, but it worked and people used it. TCP/IP is a simple standard for telecommunications messages, lacking many features, such as security and error-handling, that standards for business-centered data communications include. For many years, TCP/IP was confined to the research and academic community, but it has now
become widely adopted in businesses, mainly because it was built to support the UNIX operating system, which most of the Internet community used in their computing. As more and more companies across the world connect to the Internet, TCP/IP, old, inefficient, and limited as it is, has become one of the core standards of IT.

The start of the true Internet was NSFnet, a high-speed network funded by the National Science Foundation to provide communications between supercomputers, which need to transmit large data bases at speeds far higher than were available over the leased lines used by businesses or public networks. More and more networks were linked to NSFnet, largely on an ad hoc basis and with no central planning, control, security, or strategy for network management. The Internet, as this backbone came to be known, took off rapidly for four reasons: (1) it was basically free to the academic community, (2) it provided access to a massive range of information on virtually every topic, (3) it was an excellent vehicle for communicating and sharing information with others, and (4) as personal computers and local area networks gained popularity on campuses, it became an integral element of college life, creating a huge new group of users.

The Internet has more services than can be counted—literally. Some of the most popular are Internet Relay Chat, a talk facility for participating in public conversations; Gopher menus for extracting just about any textual material (there are locally managed Gopher sites across the country); Usenet, a worldwide news broadcast system; Big Fun List (fun resources); Subject Trees; E-mail; Talk Facility; Worldwide Web; and Veronica and Jughead; to name just a few. Accessing the services tests your typing. You get to the Big Fun List by entering "~/pub/bigfun/bigfun.txt.z" and you may use an "anonymous" identification of "cerberus.cor.epa.gov" to search Big Fun List for free without a special password. New services are constantly being created. The Internet is a culture as much as a network.

Historically, most users of the Internet have been academics,

In early 1994, a lawyer used the Internet to broadcast a discrete ad. There were 20,000 "net surfers" on the Internet who expressed their electronic outrage via e-mail. The Internet is the most widespread, freely open network in the world. It's also unplanned and unregulated, and it lacks coherent policy. That's what net surfers want to keep, and many of them want to keep business out.
researchers, and engineers in public and private organizations. As the network’s resources of available information grew, so did the interest of the business community. Companies wanted to tap into its abundant information and use it for transferring their own information, handling electronic mail, and logging on to remote computers. Businesses began adopting the TCP/IP communications protocols as an internal standard in their organizations, and as a result the Internet became easier to use. By early 1994, nearly 50 percent of user organizations have registered as commercial, compared with less than 30 percent at the end of 1992.

Many of the Internet’s newer services are directly targeted to commercial use. For example, major carriers such as AT&T and Sprint link their e-mail services to it. A consortium of more than 100 companies joined Sprint to offer EINET (Enterprise Integration Network) that augments basic Internet services and adds security. A group of Dutch firms created Digicash, a secure mechanism for handling cash transactions over the Internet.

Security has been a problem for commercial users. Perhaps the biggest difference between the philosophies of business and academic computer and communications users is that businesses, as a matter of course, require controls, security, and protection of information. The academic community prefers open, easily accessible, and free-flowing information, which is the reason UNIX, TCP/IP, and the Internet are, in general, wide open. However, companies that provide security for Internet users are growing quickly.

The free flow of information means just that, too, for the academic community. A growing and contentious issue is who should pay for this national infrastructure in terms of both funding and usage. An ancillary debate is whether business or government should drive its development.

The Internet is seen as the base for an Information Superhighway for the United States. This would be a national infrastructure of complex, interconnected roads that provide so-called on- and off-ramps to smaller roads. The Internet fills a major gap in
U.S. telecommunications: the lack of a national public data network available to all subscribers. The French and others who argue that this is a key social requirement have justified their protection of the national telecommunications monopoly on this basis. The Internet is the only “national” infrastructure, and this may be the reason for its success.

See also: Information Superhighway, TCP/IP, UNIX

ISDN  See Integrated Services Digital Network

IT  See Information Technology

Jargon and Acronyms  IT, like any other field, has its own language to differentiate options and features relevant to specific decisions. One well-respected reference book of computer terms contains more than 3,500 definitions, and it is by no means complete enough to cover the range of terms relevant to a typical large organization’s IT resource. The field is now so broad that technical specialists in one area are unlikely to be familiar with terms used by those in another.

The key to dealing with IT jargon is to know what you need to know. Specialists clearly need to know the jargon of their specialty and probably need to know a subset of the jargon of related specialties. This book presents a subset of IT terminology across all specialties that has relevance for business managers who need to be conversant in the discipline.

The danger with IT jargon is less with the esoteric terms than with the familiar terms that have different meanings in the IT field than in everyday life. “Architecture,” “standard,” and “system,” for example, mean different things in different contexts. Relating them to issues of business integration and technical architecture provides the basis for a common context. A business manager should ask three simple questions about any term in the IT jargon: (1) Does it have any significance for our architecture or our ability to integrate business processes? (2) Which business

Megaslops, phase jitter, fourth-order normal form, POSIX, GOSIP, ROM BIOS, OOPS, WYSIWYG, gender changer, fault tolerant, dithering, dialogue box, demand paging . . . some of the arcane vocabulary of IT has an almost poetic ring.
opportunity or business impact does it represent? and (3) Does it require me, as a business manager, to rethink any aspect of my business plans?

**Keyboard**  See User Interface

**Knowledge Engineering**  See Expert System

**Knowledge Representation**  See Expert System

**LAN**  See Local Area Network

**Laptop Computer**  See Portable Computer

**Legacy Systems**  This is a very recent term for what is now the biggest barrier to exploiting new technology: old systems that cannot be replaced or rebuilt. Most large firms have accounting, inventory, payroll, and billing systems that would literally cost $1 billion or more to redevelop. These must be maintained and adapted to handle changes in tax laws, new business needs and regulations, and increased volumes of information. One software firm estimates that the average programmer responsible for handling old systems makes more than 4,000 changes a year.

The emerging strategy for handling legacy systems, most of which are based on IBM or IBM-compatible mainframe computers, is to leave them as they are and place at the front-end—the service agent's desk or the sales branch, for instance—a powerful workstation that converts incoming and outgoing messages, thereby making the system if not user friendly then at least user tolerable. New facilities are added to the workstation as needed, and the legacy systems are gradually left to erode via selective replacement of software.

"Legacy" suggests something valuable—Grandpa leaving you a palace in Venice in his will. But legacies are more often ancestral
curses. Grandpa raging from his deathbed, “You will have to live with the COBOL accounts-payable system into the nineteenth generation!” Legacy systems are the IS department’s burden, consuming valuable resources of people and money.

Legacy systems are rather like legacy airports, such as JFK; it would be wonderful to tear them down and begin again, but that is not a practical option.

In addition, the old skills are still important. What IBM and those who work with its systems know well is what may be termed “enterprise technology,” the integration of the tools needed to provide reliable, secure, and efficient large-scale operations. Mainframe bigots at one time disdained the new “amateurs” who worked with PCs and local area networks. Now it’s the PC bigots who too often disdain enterprise skills.

**Local Area Network (LAN)**

Local area networks or LANs, provide a means to link computers and workstations within a single location such as an office or building. LANs can be interconnected, with one another or with wide area networks (WANs), using interface devices called bridges, routers, and gateways.

Local area networks evolved as a subfield of telecommunications at a time when “telecom” meant primarily telephones. They were a response to the need for departmental personal computers to be able to share programs and data, data bases, and high-speed printers. This local need gradually expanded into an interdepartmental need, necessitating the development of devices for linking local area networks together and connecting them to wide area networks that could provide links to geographically dispersed LANs.

Initially, choices of local area networks were driven primarily by departmental needs, price, and ease of installation and operation. Demands for business and technical integration have made this case-by-case approach less practical. Increasingly, departmental business needs and corporate needs must be handled together.

The current annual growth rate in units of local area networks is about 24 percent, with the growth in dollar sales under 10 percent.
Resolving the many incompatibilities among existing LANs and establishing LAN-WAN interconnections are among the most pressing problems in the IT field.

Smaller firms generally have different requirements for local area networks and fewer constraints than larger firms, which almost invariably have mainframe-based transaction processing systems and data resources and wide area networks linking geographically distributed locations.

LAN technology along with its management requirements are increasingly becoming more complex because of the growing importance of the LAN within the wider enterprise infrastructure. In early 1993, an estimated 800 LAN vendors were on the market, offering 5,400 products, up from 600 vendors and 3,000 products the year before.

Distinctions between local area networks, campus networks, metropolitan networks, and wide area networks are blurring. With specialized bridges, routers, and gateways, complicated wiring, interface boards that connect personal computers to LANs, and front-end processors and data switches that link LANs to wide area networks and remote services, what began as a simple concept of tying together systems within a building quickly, efficiently, and cheaply has turned into a morass of technical complexity. It is a critical issue that must be addressed in the corporate architecture at the level of corporate policy.

Many experts believe that local area networks represent the mainstream of telecommunications and that organization-wide networks will be built of interconnected LANs, using bridges and routers. That opinion should be respected; the growth in LAN capabilities over the past five years has been extraordinary. LANs can be used as the base for a telecommunications infrastructure that builds on the workstation as the core element of distributed computing and service. An alternative view, reflected in this guide, sees the backbone wide area network as the central component of the infrastructure, to which local area networks must be con-
conected coherently and efficiently. Whichever view is adopted, integration of separate technology bases is the central goal.

See also: Architecture, Ethernet, FDDI, Integration, Network, Platform, Standards, Telecommunications, Token Ring, Transmission

Macintosh See Apple Computer, Personal Computer

Mainframe and Minicomputer Because size and processing power have historically been correlated, the largest computers have been termed mainframes, those of intermediate size have been called minicomputers, and the smallest ones have been tagged microcomputers. An additional category, supercomputers, is beginning to have relevance outside the research community in businesses such as telecommunications, which require extremely high-speed processing to manage the switching of extensive networks. Mainframe computers, usually centralized in data centers, have long been the workhorses of business computing. Today they are often connected to thousands of workstations that share the mainframe's resources through wide area telecommunications networks. Minicomputers targeted at departmental computing needs were a distinct market segment in the 1970s and 1980s.

Today, mainframes and minicomputers are more usefully viewed in the context of “distributed” systems, in which they function as “hosts” or “servers” to numerous and potentially widely scattered “client” workstations. In fact, with role becoming more relevant than size, client and server are a more useful distinction than personal computer, mini, or mainframe.

Each major computer vendor has been strongest in one segment of the mainframe/mini/micro market. IBM, for example, has long been seen as the provider of mainframes and protector of their role and market. Yet, sales of its mid-sized AS/400 machine amounted to more than all the peak sales and profits of Digital Equipment Corporation (DEC), the number two firm in the industry, and just as universally identified with minicomput-
ers. Companies like Apple, Compaq, and Toshiba are firmly identified as providers of micro, or personal, computers, but Compaq is a major player in high-end server markets, which are essentially minis and mainframes.

Today, all vendors, regardless of their strength or market niche, must consider how well their products link to other elements of a firm's IT resources. Amdahl, Hitachi, and Fujitsu have sold their mainframe products on the basis of being IBM "plug compatible"—unplug an IBM machine and plug in one of theirs; the hardware fully supports the IBM operating system. Compaq has an edge over Apple with many companies because its personal computers can link directly into an IBM environment.

As integrated and open—that is, vendor-independent—systems become a priority for leading customers, they also become a priority for vendors. In fact, some vendors, wanting to establish themselves as the preferred option within an integrated IT base, are competing on the basis of how vendor-independent their products are. Because of IBM's historical dominance of both the mainframe and (initially) personal computer markets, many key business-processing systems now in use will be run on IBM equipment. Thus most vendors can be expected to make IBM-compatibility, IBM-connectability, or even IBM-substitutability a key element of their strategies.

The main question is simply, can mainframes survive? Old mainframe-based systems, which have to be maintained, require IBM-compatibility. The new mainframes are being built on a variety of smaller, more specialized systems. Sales of mainframes roughly equalled those of PCs and workstations in 1989, about $25 billion. By 1994 mainframe sales had slipped to $23 billion, while PCs and workstations had grown to $43 billion. Some of these PCs have power equivalent to a mainframe.

The survival of the mainframe depends on the success of IBM's comeback. For this to be assured, IBM must (1) offer drastically lower prices on smaller machines that can be clustered to work together to make the mainframe an efficient equivalent
of a central shared library of data (technically, a “shared” file “server” or “superserver”); (2) ensure that its new machines run its existing complex and often cumbersome operating systems, data-base management systems, communication systems, and other types of IBM software; (3) greatly speed up delivery cycles, one of the largest problems for both IBM and its customers that was created by its monolithic bureaucracies and internal competitions; and (4) persuade customers that mainframes are essential as enterprise information “repositories” and servers.

In October 1993, IBM's announcements of key initiatives portrayed the company's go-for-broke strategy that includes using advanced chips to cut the cost per million instructions per second (a basic measure of mainframe horsepower) to $15,000, from $100,000 in 1989. IBM must also end its dependence on older chip technology that produced only a 15 percent improvement in price/performance compared with the 40 percent competitors such as Fujitsu and Amdahl have been making. IBM will have to rewrite its flagship software systems: MVS (operating system), CICS (communications transaction processing), DB2 and IMS (data-base management systems); this is required by the change in the chip technology and by the replacement of traditional processing with parallel processing. Parallel processing uses many hardware units that work literally in parallel, instead of a central processing unit that sequentially carries out instructions. The new machines are due in 1996. If they succeed, the old mainframe is dead, long live the new. If not . . .

See also: Architecture, Client/Server Model, Connectivity, Data Center, Distributed Systems, Host Computer, Network, Open Systems, Personal Computer, Platform, Supercomputer, Terminal, Workstation

Maintenance  Maintenance consumes 50–70 percent of staff resources of most Information Systems units. The term is in many ways a misnomer, suggesting routine repair and adjustment. Software maintenance is much more. It is a follow-on investment to development and installation that keeps a system functioning in
There are close to a million programmers in the United States whose daily task is to maintain and enhance existing COBOL systems on mainframe computers; this is where a firm’s core computing resources have to be invested, because rebuilding these in one quick swoop using new tools and technology is as practical as closing down JFK Airport to redesign and rebuild it.

its technical environment and current with the business requirements it was designed to address. A firm does not, for example, have the option of ignoring tax-law changes, but must make the necessary modifications to its payroll, pension, sales, and financial reporting systems. When the transactions processed by an existing application increase to a level of volume that degrades performance, the system may have to move onto a larger computer or new telecommunications facilities added. Frequently, this requires changes to the computer programs.

All such accomplishments and revisions come under the heading of maintenance. Maintenance costs for a “legacy” system will amount to one to three times the original development cost. An old system that was insufficiently documented, has been modified many times, and was poorly designed to begin with is a programmer’s nightmare to maintain. Unfortunately, many major transaction-processing systems possess all three of these characteristics.

For new development, the best solution to the maintenance problem is to improve design techniques and use tools that make programs self-documenting. For older systems, the problem is less tractable. Tools that restructure program code and generate accurate documentation have not as yet provided much payoff, though it is likely that they will do so eventually. In the meantime, existing systems must be maintained, diverting skilled staff away from development. Junior programmers learning their trade tend to view maintenance as a chore; skilled application programmers who perceive themselves stuck in it, regard it as a major career blockage.


Management Information Systems (MIS) Management information systems, or MIS, is a catch-all term used to describe mainstream computer use in the 1970s and 1980s. MIS replaced the “data processing” focus on automation of clerical activities
with an emphasis on providing paper-based information for management reporting, planning, and control. Today, the term “Information Systems” is more frequently used, partly because the MIS era provided managers a great deal of paper but very little information.

The principal sources of information through the mid-1980s were companies’ internal transaction-processing systems. Most were batch systems, run daily, weekly, or monthly, depending on the application. The information these systems provided management was only as timely as the frequency of processing. It was also based largely on historical accounting data.

As on-line systems, data-base management systems, personal computers, and easy-to-use software became available, new approaches to providing managers with meaningful and timely information emerged, approaches that were deliberately contrasted with MIS. The earliest of these were decision support systems, small-scale systems based on analytic modeling techniques such as simulation, forecasting, and financial projection, that were designed to meet individual managers’ needs. Executive information systems added a new focus on capturing and manipulating the data most relevant to top managers’ needs—for example, external competitive data and key operational indicators.

The most recent and far-reaching extension of decision support and executive information systems is the use of point-of-event data capture to move information to a central data store where it can be accessed from personal computers. Point of event includes point of sale in retailing, point of reservation in airlines and hotels, and point of order in manufacturing. As firms’ core systems process transactions, they send the data to the central system, often immediately, but certainly no later than end of day, providing management information that is completely up to date.

Leading retailers such as The Limited and Toys "R" Us use this approach to manage their entire logistical system on a continuous basis, enabling them to spot trends within days, know the details of every product in every store, and link their systems with

*Traditional management information systems had little to do with management, were accumulations of accounting data, and seldom added up to a comprehensive system of tools. Today's systems focus on alerting managers to problems and trends, answering their ad hoc questions, and providing information in the form they want, when they want it.*
those of suppliers, shortening the replenishment cycle. Systems that provide such capability are management-alerting rather than management-reporting systems. Top management of retailers that have come to dominate a market niche, without exception, view the information provided by such systems as a priority.

See also: Computer-Integrated Manufacturing, Computerized Reservation System, Decision Support System, Executive Information System, On-Line Transaction Processing, Point of Sale

MCI  MCI broke AT&T’s monopoly of long-distance telephone services by prompting the federal antitrust case that led to the divestiture of “Ma Bell” in 1984. This breakup created the world’s first fully competitive telecommunications market.

During most of the 1980s, MCI and US Sprint, AT&T’s other main competitor, painstakingly built market share mainly by lowering their prices, a gap AT&T increasingly closed. In response, MCI became a product innovator. Its “Friends and Family” program grabbed about 5 percent of AT&T’s market share, worth approximately $2 billion in sales. MCI also changed the rules of competition by selling 20 percent of the company to BT (British Telecom). This created the first significant global player and also provided MCI with capital to challenge local phone companies’ monopoly.

If AT&T is the establishment player in telecommunications, then MCI is the maverick. (Sprint lags both, with strengths in several niche markets but no distinct edge.) The competition between AT&T and MCI guarantees continued product, price, and technical innovation. Many telecommunications managers use one of the Big Three for most of their firms’ business but preserve a share for one of its rivals. This keeps both providers honest and aggressive.

AT&T has a slight product edge in most of its major business markets. MCI’s strength is in its sales force, who tend to be very young, highly responsive, and ultra-aggressive.
Megahertz and Gigahertz Megahertz and gigahertz are high-bandwidth radio frequencies that define the information-carrying capacity of telecommunications facilities such as satellites and the speed of the internal circuits of central processing units.

See also: Bandwidth, Central Processing Unit, Fiber Optics, Satellite, Transmission

Microcomputer See Personal Computer

Microsoft Microsoft dominates the personal computer software industry. It plans to dominate every other PC-related industry including enterprise networks, object-oriented development tools, satellite communications, groupware, and multimedia. Today, Microsoft effectively controls the desktop with its MS.DOS and Windows operating systems running on approximately 90 percent of all personal computers. In addition, many of its other software packages are either the market leader or among the top three products.

Microsoft is very aggressive, reflecting the style and personality of its founder and president, Bill Gates. This aggressive style has generated many enemies in its industry. It has a reputation for dealing harshly with small firms. (In fact, in 1994 Microsoft paid heavy damages to a firm whose product it had, in effect, pirated.) The FCC investigated Microsoft for antitrust violations. Software developers regularly accuse Microsoft of not revealing the special features of its operating systems that make Microsoft applications run faster or that add new features to the applications. Microsoft and Gates, whose identities are interchangeable, have the toughest reputations in the industry.

Microsoft has had nonstop success, until recently. It has since shown signs of slowing growth if not slippage. Because it operates on so many fronts, it has become increasingly difficult for Microsoft to dominate all its markets. Its NT operating system, the successor to Windows and precursor to Chicago, has not met predicted early sales; its rival, IBM’s OS/2, has made a strong

There are an estimated 125 million PCs in use across the world. Given that only 30 percent of homes have one, there is still plenty of untapped market. Business Week predicts that PCs will become information appliances, with homes having two to three, just as they have several TVs and phones. For this to happen, though, PCs must be made much easier to install and use. Microsoft is aggressively sponsoring a “Plug and Play” approach to combining hardware and software that allows you to unpack your PC, plug it into the wall, and use it immediately. It’s easy to add power and features to PCs, but making them people-natural not “user-friendly” is the key now.
recovery from its low sales and poor reputation and many large firms now prefer it to NT. Microsoft has missed several key delivery dates for its new versions of NT, and Chicago has fallen far behind schedule.

Lotus, Microsoft's main software rival, has become the leader in groupware, with its Lotus Notes. Novell's networking products have so far also withstood Microsoft's challenges.

Despite this looming competition, Microsoft continues to lead the industry. In March 1994, Gates announced a personal planned alliance with the founder of McCaw Communications, which AT&T acquired the previous year, to implement a global network of communications satellites that would give any personal computer wireless access to data communications; this will be a $9 billion venture. Microsoft has also developed a "Plug and Play" capability that is desperately needed in the PC field. This standardizes hardware and software installation so that a user can literally unpack a new PC, plug it in, and start "playing" with the software. Microsoft produced four of the ten top-selling software packages in 1993.

*Computers compute in microseconds, but move information in and out to disk in milliseconds. That means that a faster computer may not mean faster processing, if the machine is "I/O bound"—this is rather like a traffic jam at the toll booth.*

**Millions of Instructions per Second (MIPS)** Millions of instructions per second, or MIPS, is a rough measure of the power of a computer, rather like horsepower is an approximate measure of the performance of an automobile engine. In 1980, IBM's top-of-the-line computers provided 4.5 MIPS for $4.5 million. The 1993 models cost $45,000 a MIP. By 1990, the cost of a MIP on a personal computer had dropped to $1,000, driving the trend toward "distributing" computing power, instead of relying solely on large central machines. When 75 to 100 MIPS workstations became commonplace in the 1990s, this ceased to be a useful unit of measurement. MIPS, like horsepower, is an incomplete indicator of capability. Just as horsepower does not directly tell you how long it takes a car to go from 0 to 60 mph or how much fuel it consumes, MIPS does not indicate performance of specific types
of application, such as computation-intensive scientific ones versus data management.

See also: Central Processing Unit, Mainframe and Minicomputer, Personal Computer, Portable Computer, Supercomputer

Millisecond and Microsecond The speed at which components of computing and communications facilities operate varies widely. Watches record seconds because that is the smallest unit of time in which humans operate. Disks operate at speeds measured in milliseconds (thousandths of a second), computers process at speeds measured in microseconds (millionths of a second), and chips function at speeds measured in nanoseconds (billionths of a second) and picoseconds (trillionths of a second).

Much of the complexity of the design and operation of an IT resource relates to coordinating and synchronizing components that run at entirely different speeds in order to ensure that none becomes a bottleneck to others. If we artificially redefined a nanosecond to be an hour, a millisecond becomes 41 days and a second 112 years; it becomes easy to see how a nanosecond speed CPU might be kept sitting idle while a disk accesses data at millisecond speeds.

See also: Central Processing Unit, Chip, Satellites, Telecommunications, Transmission

MIPS See Millions of Instructions per Second

MIS See Management Information Systems

Mobile Communication Wireless telecommunications transmission is termed mobile communication because it can accommodate continuous changes in the physical locations of sender and receiver. This is the mechanism by which cars, ships, and aircraft receive communications while in motion. The most common transmission medium for mobile communication is radio
frequency signals broadcast via terrestrial microwave (particularly for cellular telephones) or satellite facilities.

The emerging extension of mobile (hence cableless and location-independent) communications is wireless local area networks. Cabling buildings is expensive, complicated, and often slow. Some older buildings are unsuited to it. The senior manager looking admiringly at an architect’s design for a new office complex is well advised to keep in mind that a building now must be configured on the assumption that there will be at least one workstation for every two staff who work in it. Wireless LANs using radio frequency signals or infrared beams can facilitate the movement of personal computers around an office building and reduce the need for cabling.

Mobile communication is one of the obvious major waves of innovation emerging in the 1990s. Among the problems that have made it slow in forming are regulation, standards, supplier stability, and FCC allocation of radio frequencies for transmission.

See also: Cellular Communication, International Telecommunications, Local Area Network, Satellite, Standard, Switch, Telecommunications

**Modem** A modem is a device that makes it possible to link a digital computer to the analog telephone system. It “modulates” a computer's digital bit stream into an analog signal that can be transmitted over telephone lines and “demodulates” incoming analog signals into digital bit streams; hence “modem” for modulator/demodulator.

A modem determines the speed at which information can be transmitted and received. A standard “voice-grade” telephone line is capable of carrying data at speeds of up to 9,600 bits per second, but many personal computer modems operate at only 2,400 or 4,800 bits per second. Data centers often employ high-speed modems that operate at 19,200 or even 38,400 bits per second and may provide additional features such as data compression, automatic redialing, and error control.
Modems also perform a variety of technical functions. For example, they match the characteristics of the sending device’s transmission with those of the receiving device. Hayes and Hayes-compatible modems, which relieve users of most of the work involved in defining transmission speeds and protocols, dominate the personal computer market.

Modems are essential today for enabling firms to make efficient use of transmission links. Eventually, as digital networks come to predominate, they will go the way of the punched card.

*See also:* Digital, Network, Telecommunications

**Monitor**  See User Interface

**Mouse**  See User Interface

**MS.DOS**  MS.DOS is the operating system that was responsible for transforming the personal computer into a standard tool for business and professional activities and creating the base for today’s massive personal computer software industry. Once IBM adopted MS.DOS as the operating system for its own product, software designers practically ceased to develop software for rival operating systems, which helped to establish MS.DOS as the dominant operating system in business use.

The limitations of MS.DOS lie in its original design, which restricted the size of programs that could run under it to 640K of memory, a huge amount at the time but trivial today. It is also, in comparison with the operating systems of later personal computers such as the Apple Macintosh, difficult to learn and cumbersome to use.

MS.DOS is the last and greatest product of the 1970s approach to developing software. It makes the user rather than the operating system handle complexity; it is intolerant of mistakes and obscure in its responses; it is devoid of grace or charm. In short, it represents just about everything people have come to dislike about computers. Nevertheless, it remains the workhorse

*The world’s telephone systems were designed around a technology that transmitted information in a form entirely different from how computer information was coded. Modems are the necessary device for making the conversion. The new “digital” networks do not need them.*
of professional users and is compatible with a wealth of available software.

It is also guaranteed a long life as Microsoft extends and improves it to fend off several competitors that offer a better "DOS" than DOS (being careful only to match its functions and not to copy the way those functions are implemented in the operating system). In addition, Microsoft, IBM, and Apple have made their new generation of operating systems compatible with DOS-based programs, thereby preserving users' investments in them.

See also: Operating System, Personal Computer, Portable Computer

Multimedia  Multimedia is a catchall term for the transmission and manipulation of any form of information, whether it is words, pictures, videos, music, numbers, or handwriting. To a computer, this is just digital bits—zeroes and ones—as it is to a digital telecommunications link that carries information in bit form.

Historically, "data" meant numbers and characters. As late as 1980, only a supercomputer could manipulate the millions of bits needed to code a video image; even the standard personal computer of 1990 could not process them. Computer disks lacked the capacity to store them. And transmitting video images over the telecommunications networks of the 1980s was too expensive and too slow.

Since the mid-1990s, PCs and networks have been able to handle video images, which can now be stored on CD-ROM. The new generation of computer chips used in high-end PCs—Intel's Pentium and the Motorola/IBM/Apple PowerPC—outperforms the old supercomputers. As a result, a desktop computer can routinely handle an increasing variety of media. In fact, Apple Macintosh computers are being used to create and edit training videos. In addition, the Encyclopedia Britannica can be accessed over the Internet, and for under $200 Grolier's encyclopedia is available on CD-ROM, including sound effects, videos, and music.

Multimedia requires increased computer power and telecom-
communications capacity. Here are a few comparative figures for personal computer operations over a network:

- Retrieving alphanumeric data can be efficiently handled at transmission speeds of 9,600 bits per second; a typical application can take half a minute of working at the screen.
- The same application involving an image database containing electronic documents requires approximately 80,000 bits per second transmission speed.
- TV-quality video needs a speed of 6 million bits per second.
- High-resolution scientific images (such as those used in biology, weather forecasting, and fluid dynamics) need speeds of 16 to 800 million bits per second.

Local area networks with speeds of 100 million bits per second, costly high-speed wide area communications with large bandwidth (transmission capacity) on demand, and personal computers and workstations with specialized chips to handle multimedia have made visual information as commonplace as alphanumeric, opening up a wide range of opportunities: Maps replace lines of numbers on the PC screen, using geographic information. Photos and documents can be scanned and accessed. Interactive video can be used for training.

The areas of education, health care, and the sciences are moving fastest to exploit multimedia. Businesses will increasingly use multimedia to create electronic catalogs for marketing purposes, to exploit visual displays of geographic information, and to develop training programs.

Nanosecond  See Millisecond and Microsecond

Network  Networks are the telecommunications highways over which information travels. The information can originate from and be directed to all manner of devices, including telephones,

The medical field is one of the leaders in using multimedia, despite its laggardly adoption of most traditional uses of IT. This is because multimedia allows health care providers to access and share all types of patient medical data—ranging from X-rays to correspondence from other hospitals to medical histories—on-line rather than on paper.
televisions, satellites, sensors and alarms, and computers of all sizes and descriptions, ranging from large mainframes to minicomputers to personal computers and specialized workstations such as automated teller machines and automated cash registers. In effect, a network is a directory of contact points that operates much like the public telephone network, which publishes its contact points as telephone numbers in a directory. Although networks can be connected internationally in the same way that international telephone systems can be connected, the problems associated with linking networks built on entirely different transmission techniques and technology bases are daunting.

Networks are variously described in terms of their geographic extent and ownership. A local area network, or LAN, connects devices in close physical proximity, for example, within an office or building. Transmission media for LANs include wire, coaxial, and fiber optic cable, with wireless media such as infrared being gradually adopted, too. Devices connected to a LAN, termed "nodes," require a special interface card. LANs are connected to one another via "bridges," "routers," and "gateways." Bridges and routers connect like to like networks (i.e., networks that use the same transmission protocol), the latter having the added ability to select the least-congested and least-expensive route. Gateways are more complex devices used to connect dissimilar networks. All of these devices add overhead, which is likely to degrade performance as well as add cost.

The technology of local area networks limits the geographic distance they can cover. Metropolitan, intercity, national, or international networks need long-distance transmission facilities such as those provided by telephone companies or satellite transmission. Networks that span such distances are termed wide area networks. To overcome the weakening, or attenuation, of signals transmitted beyond a certain distance, "repeaters" are employed.

Wide area networks can be either private or public. Private networks are fixed-cost services leased from a telecommunications provider such as AT&T, MCI, or US Sprint in the United
States, British Telecom or Mercury in Britain, and various national communications providers elsewhere that guarantee levels of capacity and performance. With a private network and skilled network managers, a company can manage its communications traffic so as to achieve the maximum rate of throughput at a fixed cost. A variant of the private network is called the "virtual private" or "software defined" network.

Public data networks, or PDNs, provide small and large firms alike with easy access to telecommunications transmission services. Users pay as they go; the more traffic they put through the network, the more they pay. Regional and national telephone services are examples of public data networks. Outside of the United States, public data networks continue to dominate because of the far slower pace of deregulation, which creates alternatives to public networks.

A commercial network that adds something of value to transmission—electronic data interchange services, electronic mail, information services, and so forth—is termed a value-added network, or VAN. VANs are more common in Europe than in the United States, largely because industries there have worked more closely together to share resources, whereas larger U.S. firms have tended to build their own "private" facilities. The growing importance of intra-industry and intercompany electronic transactions is making VANs an attractive option, especially internationally, where they are referred to as IVANs. VANs are particularly useful for intra-industry transactions such as electronic data interchange and payments systems.

Although it is the key enabler of business innovation and the strategic infrastructure for business in the 1990s, telecommunications is still too often thought of as part of operational overhead. For airlines and banks, the network is the franchise for their products and customer service. For manufacturers, it is the coordinator of just-in-time operations. For distribution-intensive companies, it is the basis for customer service.

Although stand-alone computers and local area networks can
provide benefits to individual users and departments, the creation of a business resource that links them, shares their business capabilities, and facilitates cross-functional, cross-locational, and cross-product services and operations relies on the development of a more pervasive network architecture.

A key part of this architecture is the backbone network. This is an organization's central information highway system, which can be shared by many business units and many applications. It can be likened to the principal routes of a major airline, which connect with smaller, subsidiary feeder lines (analogous to local area networks) and the routes of other major airlines (analogous to supplier, customer, and public data networks).


**Network Management** Network management is one of the most vital aspects of managing an on-line business service. Complex electronic-processing bases that support many subscribers are often built on an extensive array of equipment and transmission facilities. The monitoring of diagnostics, management alerting and reporting, and even repair of such facilities is increasingly being handled by automated network management systems.

The average business experiences two hours of network downtime per week, according to a *Benchmarks* magazine survey. This is equivalent to 12 days per year. Ten percent of large and 6 percent of smaller businesses in the study put the cost of this downtime between $5,000 and $50,000 per hour, between $500,000 and $5 million per year. These are significant losses.

Because network failures now constitute business failures, network management is a strategic business issue and skills in network management and automated network systems are crucial investments. Automated network management tools have become
vital to large organizations that manage computerized reservation, computer-integrated manufacturing, or retailing point-of-sale systems that rely on a variety of devices, transmission links, and switching equipment functioning at levels above 99.9 percent availability and reliability. There are as yet few established standards for network management and the existing tools are fragmented and limited.

The Simple Network Management Protocol (SNMP) has been widely adopted in networks that are independent of proprietary communications networks because SNMP works and works simply. It is not adequate for really complex, high-volume transaction processing networks. IBM-based networks, for instance, rely on its NetView product. Hewlett-Packard has very successfully made its OpenView network management system for UNIX-based systems. Novell dominates the local area network market and has positioned its NetWare 4.0 product to extend LAN management across the enterprise; Microsoft aims at doing the same with its NT.

*See also: Architecture, Distributed Systems, Maintenance, Network, Platform, Security, Switch, Telecommunications, Transmission*

**Network Operating Systems (NOS)** Until recently, the two mainstream operating systems have been the massive, long-lived software that manage mainframe computer operations and the simpler operating systems that manage a single personal computer. Now a new type of operating system has emerged to manage the interactions between computers and telecommunications networks, such as sharing files over a local area network, transmitting electronic mail, and client/server computing, which lets machines and applications share resources and functions via the network.

NOS perform such functions as supervising the communications flow, optimizing traffic, and controlling access. The marketplace leader is Novell, whose NetWare product dominates 65 percent of the local area networking market whereas Microsoft's operating systems dominate the PC market. These aggressive ri-
Novell's NetWare NOS dominates large enterprise networks, with around 60 percent market share. This is the new battleground for Microsoft, IBM, and UNIX providers. Values aim at intruding into each other's territory. Microsoft's NT, for instance, combines traditional PC and network operating system capabilities. In the era of standalone PC use, the key to market positioning was to dominate at the desktop screen, as Microsoft did with MS-DOS and Windows. Now the network is the battleground. NT's success depends on demonstrating its strengths in enterprise networking. Novell's new versions of NetWare similarly focus on managing a network of networks—local and wide area—across the organization.

NOS are sometimes classified as middleware because they sit between machines that need to communicate with each other. Key features are which PC operating systems they can support, how comprehensive are their directories of device locations (PCs, printers, and computers), and how many individual networks and devices the NOS can handle simultaneously.

Any complex IT resource is only as efficient as its bottleneck. For example, a superfast PC that can manipulate information at speeds of 100 million computer instructions per second (routine now, but the standard PCs of the 1980s rarely reached 1 MIPS) and that is linked to a fiber optic transmission link running at 100 million bits per second is ultrasonic if the NOS cannot process its communications at high speeds or cannot link to the device that is sending and receiving the data. This is the reason that NOS—middleware—are key to efficient business operations; the network, not transmission links or computers.

See also: Operating Systems

Neural Networks Efforts to build systems that imitate human thought (generally termed artificial intelligence and expert systems) have been underway for more than 30 years, with mixed progress. Their "knowledge" has been coded as a set of rules, often derived from interviewing experts, which is complex and cumbersome. A newer and more promising process uses computers to develop their own knowledge and rules by mimicking the way human brain cells form connections and build patterns of
recognition, the same way a baby learns to identify shapes and build concepts.

Neural networks learn through pattern matching and the equivalent of behavioral reinforcement. Obviously, a computer has no “mind,” but given many instances of, say, patients’ medical symptoms, treatments, and outcomes, it can build connections between data, reinforcing those that succeed in predicting the correct outcome. This trial-and-error “training” generally takes the computer days of churning and learning. It continues to update itself as it gets more examples. The examples constitute its experience, and it “learns” from it.

Neural networks are primitive and their learning is narrow compared with a human brain that has 100 billion neurons and 100 trillion connections between them. By this measure, a PC is the equivalent of a housefly.

Business use of neural networks is scattered. They have been successfully used to predict credit card defaults, medical treatment outcomes, and to spot trends in the stock market. For instance, you can buy PC-based neural network software for $200 to $500 that includes stock prices of all companies quoted on the New York Stock Exchange going back 10 or more years. The software can track price patterns and generate a predictive indicator for a stock’s likely price movement. This is really just an automated extension of the chartist’s approach to market analysis, but neural nets work well enough for leading investment firms like Fidelity and the World Bank to use them.

One credit card firm reduced its delinquency rates 15 percent by using neural nets to spot patterns in spending that are associated with defaults and fraud. Given that credit card write-offs in the United States are more than $5 billion a year, this 15 percent figure is well worth the investment, even if the system does have an insect-sized brain.

Newton Newton is one of the first “personal digital assistants” on the market. A product of Apple computer, it is the first major
effort to offer pen-based computing, where you write on the screen instead of typing at a keyboard. It has not sold as well as was predicted, and it generated a backlash when it did not meet its absurdly overtouted claims. In 1993 approximately 55,000 were sold; the total market for personal digital assistants was about double that.

Newton’s main limitations were its lack of communications features and its inadequate level of accurate handwriting recognition. Just as Governor Jerry Brown ("Governor Moonbeam") and Hunter Thompson were semi-immortalized through belittle- ment in the Doonesbury comic strip, the Newton also got skew- ered by Garry Trudeau. Even for the many people who point out that the Newton works pretty well, it was hard not to laugh at the cartoons.

The laughter will probably end by 1996. Newton was a first- generation product. It did work, and it or its successors and competitors will simply ride the 30–40 percent annual price- performance curve of microprocessor technology—each version will be cheaper and better. In the 1990s, wireless communications markets have been growing at yearly rates of 40 percent, and in some niche areas at even 60 percent, making Newton a forerunner, not a dead end.

**Notebook Computers** Early portable computers were called laptops in contrast to desktop computers. As companies succeeded in shrinking their size while increasing their power, they empha- sized that their products could fit in a briefcase and were the size of a notebook—the base is the size of a standard 8 1/2 by 11 inch piece of paper and 1 to 2 inches high. There are now subnote- book and palm computers, so that the term is mainly a marketing phrase. The only laptops/portables that are now bigger than notebooks are the few upmarket high-end power machines with applications that require massive processing power and very high resolution display screens. These generate substantial heat and need plenty of battery power; that, rather than chips and disk
storage, makes them bigger and heavier.

**Novell** Novell leads the industry in the network operating systems (NOS) market. NOS manage the interactions between personal computers, local area networks, and the servers that let PCs access shared information, transactions, and coordination of communications. Novell’s sales grew at 50 percent a year during the late 1980s and early 1990s, from $422 million in 1989 to $1.1 billion in 1993. When its growth began to slow, Novell, needing new sources of revenue, went on a $450-million buying spree, acquiring a company that makes a DOS clone, Unix Systems Laboratories, and WordPerfect, a leading word processing software package. All these purchases have put Novell in head-on competition with Microsoft, whose LANManager, which competes with NetWare, has been a relative failure. Microsoft’s NT, introduced in late 1993, is NetWare’s main competitor.

The ongoing hostile relationship between Novell and Microsoft has reportedly stemmed from personal tensions between Ray Noorda and Bill Gates, the two firms’ founders. These tensions resulted from a failed effort to merge the two firms. Given that many companies will install both NT and NetWare as the base for their IT operations, cooperation between the two will be demanded by this powerful user base. They will continue to jostle each other.

In the spring of 1994, Novell acquired the WordPerfect Corporation. (WordPerfect and Microsoft’s Word are two of the top three word processing packages.) Novell can now offer a software “suite” that competes with Microsoft’s Office. (A suite is a set of software packages that includes and links the most widely used PC applications: word processing, spreadsheets, graphics, etc.)

*See also:* Microsoft, *Network Operating Systems*

**Object-Oriented Programming Systems (OOPS)** Object-oriented programming systems, or OOPS, address one of the
This may—just may—be the long-awaited breakthrough in systems design and development. It uses a Lego-block approach to linking “objects” together. The objects may be data bases, software routines, videos, photos, music, or communications commands.

longest standing concerns in IT—how to improve the quality of software and the productivity of software development. It takes a building-block approach to program development. Each block, termed an object, is independent and able to run by itself or be simply and automatically interlocked with other objects. Entire systems can be created that reuse existing objects, and, because they are independent, each object can be changed without affecting others. The concept, though simple, transforms both the methods of systems development and the tools for programming.

Objects interact by passing information between one another. For example, an object that calculates the rate of return on an investment might link to an object that displays a graph of the results. The first object needs to know nothing about how the second plots the graph. Each object must contain information about itself (“encapsulation”) and the objects it can relate to (“inheritance”). The vocabulary of object-oriented programming includes classes and subclasses, parents and subordinate objects. Its specialized programming languages include Smalltalk, C, and C++.


OLTP  See On-Line Transaction Processing

On-Line  On-line is a term used to indicate that data is immediately and directly accessible from a computer or workstation. It contrasts with off-line, which indicates that data is stored on an external device such as a magnetic tape or floppy disk and must be loaded into a computer for the program or service that needs it.

See also: Batch Processing, On-Line Transaction Processing

On-Line Transaction Processing  On-line transaction processing has supplanted batch processing in most time-sensitive applications. In banking, for example, customer account informa-
tion has to be put on-line in order for deposits and withdrawals made at automated teller machines to be transacted immediately. Because it incurs added costs for overhead and for ensuring security, back up, adequate response time, and the ability to manage highly variable processing loads, on-line transaction processing tends to be much more expensive than batch processing. One major bank has calculated that the 4,000 lines of software code per customer required by the batch systems that handled current account processing grew to 44,000 lines per customer in the on-line environment of automated teller machines and to 120,000 lines per customer to handle processing from other banks' ATMs.

Although batch processing remains a viable alternative for applications such as payroll, every system that is part of just-in-time business and customer service is likely to move on-line. Indeed, on-line transaction processing was a prerequisite for such innovative services as automated airline reservation and point-of-sale systems.

See also: Electronic Funds Transfer at Point of Sale, On-Line, Point of Sale, Terminal

OOPS See Object-Oriented Programming Systems

Open Systems Users and vendors have a mutual need for vendor- and product-independent standards. "Open systems" are implicitly vendor-independent and, by extension, interconnectable and "interoperable." The problem is how to get to open systems from the preponderance of proprietary systems.

The primary blueprint for a general framework for open systems is Open Systems Interconnection, or OSI. The object of OSI is to make all devices and services interoperable. Progress toward OSI has been steady but slow and there remain many problems of definition as well as implementation. Limited other frameworks for open systems are being developed in specific areas of IT.
A practical definition of an open system standard includes four parts. It must (1) be fully defined, allowing vendors and suppliers of services to work from the same definition; (2) be stable, affording vendors and suppliers a fixed instead of rapidly moving target; (3) fully publish its interfaces so that they are accessible to vendors and suppliers; and (4) not be subject to control by any one player. This is not the definition used by many telecommunications specialists, who tend, instead, to view open systems in terms of the formal proposals by standard-setting committees that lead to agreements on definitions of a standard. They ignore the issues of implementing the defined standard that frequently result in so many variations in features, products, or interpretation of the standard that the variants are in effect proprietary. In practice, open systems are often created through overwhelming customer demand for a particular product, which leads other vendors to tailor their products to it. Thus what is established as a "proprietary" standard can become an open standard in terms of implementation. MS.DOS is an example of this.

However defined, open systems are the key to the future of information technology. They will most likely come about through a combination of committee definitions, de facto standards created by user demand, and vendor decisions about which committee and competitor standards to follow.

See also: Architecture, Compatibility, Integration, Interface, Open Systems Interconnection, Standards, Systems Integration

Open Systems Interconnection (OSI) Open Systems Interconnection, or OSI, is the major framework for creating vendor- and equipment-independent systems that can work together. Conceived in Europe in the 1970s, OSI was adopted in the mid-1980s by telecommunications and computer vendors as a consensual direction toward resolving the long unsolvable problems of incompatibility. The plan was for OSI to create a reference model that can be used by designers of telecommunications networks
and networking equipment to develop equipment and services that might be entirely different in terms of technology but will be able to work together.

OSI is only a blueprint. It does not specify how systems should interconnect, only the interfaces for doing so, which it defines as a series of seven layers. Layer 1 specifies the interface for establishing a physical connection between a sender and receiver; layer 2 the interface for transmitting data between them.

The concept of layers is central to OSI and also to IBM's systems network architecture (SNA), which was long seen as its competitor but is now its complement. Each layer is complete in itself, with control passed from a layer to the one above. Designers of equipment that interfaces at level 1 need know nothing about how equipment that interfaces at level 2 operates. The lowest layers are the easiest to implement because they address physical interconnections and build on well-established standards. The higher levels define interfaces for transaction formats and procedures for handling application requests. Progress here is slow and fragmented. The layered architecture has enabled OSI subcommittees to work independently on individual standards within the reference model.

Once defined, an OSI standard must be implemented in real products. Because the details of the standard must cover so many contingencies and types of activity, there will invariably be differences in how that is done. In late 1990, a group of aerospace industry users discovered that vendors' implementations of FTAM, one OSI standard, were incompatible, preventing them from exchanging certain types of files. Communications Week for November 1990 observed that "The problems with FTAM are . . . a microcosm of the challenges ahead for businesses and organizations implementing OSI products. The myriad attractive features offered as options within each OSI standard also can backfire on users, leaving them with implementations that can't even communicate."

The business jury is still out on OSI. In 1983, just about every

In late 1993, Texas backed off from its 1991 10-year plan to make its 250 agencies conform to the OSI model. OSI products promised for 1998 in negotiations with communications suppliers won't be fully implemented before 1997. Texas still plans to stick with OSI as its long-term blueprint.
trade press and academic article waxed lyrical about it being the panacea for every problem of interoperability. By 1993, most Information Services managers had given up waiting for OSI products and adopted a highly pragmatic approach to open systems, including using OSI ones that worked. The notion that a committee-based comprehensive model could not just be defined but implemented has been overtaken by the recognition that technology and vendors move faster than the committees can.

There is no open systems tooth fairy. OSI will not suddenly be complete and instantly implemented. It will no doubt be a major element in the evolution of open systems, but it will be overtaken by new developments in IT. The original definition of OSI did not encompass network management, for example. New subcommittees rushed to include it, but network management products were developed ahead of the standards.

The best advice one can provide to nontechnical business managers about OSI is that it represents a long-term movement toward true open systems and that its overall goals are more important than its details. Full implementation will take a decade or more, if it is ever achieved. Managers should recognize that there are no shortcuts to open systems and integration. Ask IS managers not, “Why aren’t we implementing OSI?” but rather, “How does our architecture balance the constraints of old investments, uncertainty about the direction and progress of standards, and the opportunities of OSI?” The architecture, not OSI, is the strategy, although OSI may be a key element of the architecture.

See also: Architecture, Open Systems, Platform, Standards

Operating Systems An operating system is the extensive and complex set of programs that manages the operation of a computer and the applications that run on it, such as word processing on personal computers or airline reservations on mainframes. Increasingly, operating systems also link computers to telecommunications services, including local area networks and wide area
networks. The term "network operating systems" has been added to the vocabulary of IT; these operating systems manage the flow of communications traffic within and across networks.

Mainframe operating systems are among the most complex intellectual artifacts ever created, requiring literally thousands of person years to develop and thousands more to maintain and enhance. The operating system determines which applications the computer can run. Many "legacy" systems—that is, past systems development and operations—in large companies are 10 to 20 years old. These systems represent a total investment by the Fortune 1000 of literally trillions of dollars and cost an estimated $30 billion a year to maintain. As a result, mainframe and mid-sized computer makers, especially IBM and Digital Equipment, in developing new operating systems, must determine ways to let user firms run their existing applications while migrating their older operating systems to the new world of open standards (those not vendor-specific that allow interoperability of products from many suppliers). These user firms must also be able to use client/server computing, which exploits a new generation of operating systems for personal computers and workstations.

The term "operating system" is identified with personal computers. Very few managers or IT professionals working on PCs and LANs today could name IBM's or DEC's flagship operating systems. Just about all of them can name MS.DOS, Windows, UNIX, Apple Macintosh, OS/2, and NT (or Windows NT). These are the operating systems that have competed, first, for control of the desktop PC in large companies and, more recently and more viciously, to be the base operating system for firms' "enterprise" computing and communications systems, with the client/server model as the driver of its planning and pace of development.

Initially, each main operating system was incompatible with all others. So, for instance, no applications built to run on IBM PCs or clones could work on a UNIX machine or a Macintosh. This was mainly because of the specific type of computer chip
used in the machine's central processing unit. The IBM PC and clones used Intel chips, and the Macintosh used Motorola chips.

For anyone using a stand-alone PC with occasional need for simple dial-up (dialing a phone number using the public phone system) telecommunications for, say, electronic mail, there is no risk involved in choosing any of the established PC operating systems. Thus, for instance, many people chose the Mac for its ease of use or an IBM clone from Dell, Compaq, AST, Toshiba, or others on the basis of price or wide availability of software applications. Software developers wrote their packages to run on specific operating systems. In effect, they often determined the winners in the OS marketplace. When the IBM PC first came out, Pascal and CP/M were at least as popular as Microsoft's DOS. As developers focused on targeting their products to the PC, they helped establish DOS as the new leader. Clone manufacturers reinforced that leadership by building low-cost machines that were IBM compatible; they used the same chip and same DOS operating system. DOS soon dominated the personal computer market because of the number of machines it could run on and the number of applications available.

By 1990, three main operating systems were established and all were incompatible: DOS, Macintosh (the operating systems were technically called System N, with a number indicating the version; in 1990, System 6 was the standard, later replaced by System 7), and UNIX. UNIX was the only one of the three that could run on different vendors' hardware; while there were many incompatibilities among versions of UNIX developed by these vendors, the operating system was both portable and fairly open; it was practical to take code written for, say, a Hewlett-Packard machine, and "port" it to a Sun Microsystems workstation. In addition, UNIX exploited microprocessor technology far better than did PCs in that it allowed for very fast development of applications.

In this context, DOS became the workhorse of business, for reasons of cost, telecommunications, and availability of low-priced
software. DOS, however, was a primitive and clumsy system, more
difficult to learn, use, and support than the Macintosh, and far
less powerful than UNIX. But DOS-based machines could be
networked to allow some degree of access to legacy systems on
mainframes, unlike the other two operating systems. Apple’s ne-
glect of telecommunications locked it into a niche position in the
academic world, with very limited corporate use. UNIX was simi-
larly a niche product, with its power and flexibility offset by its
complexity, lack of security, and highly specialized range of capa-
bilities.

Increasingly, the focus of operating systems development and
use shifted from stand-alone personal computers to networked
organizational computing. Microsoft’s Windows operating system
offset the Macintosh’s distinguishing advantage of an easy-to-use
graphical user interface (look at the screen, point to the option you
want to select, and just click versus the DOS equivalent: try to
remember the command, type it—or often lines of commands—
in and press the Enter key). Windows, after early problems, took
over the PC world. It ran DOS applications, preserving the PC
equivalent of legacy systems. It provided many new features, in-
cluding the ability to link PC applications to each other and to
remote applications. It was backed by Microsoft’s treasure trove
of individual applications, such as those for word processing,
spreadsheets, and graphical presentations.

IBM had worked with Microsoft to develop OS/2. Windows
competed directly with OS/2 and the two companies moved from
collaborators to rivals. OS/2 fell badly behind Windows but gained
a strong niche position in large companies because it was the first
operating system on the desktop to exploit the extra speed and
memory size of applications made practical by new chips (tech-
nically, this means that OS/2 is a 32-bit operating system). Mi-
crosoft maintained its challenge through its NT (New Technol-
yogy) version of Windows, released on the market in late 1993; NT
aimed at providing the features needed to preempt OS/2 and
others as the operating system of choice for enterprise network-

In 1990, DOS held 85 percent of the PC
operating system market, with Windows at 15
percent and OS/2 at 1 percent. In 1994, DOS
had dropped to 50 percent, just ahead of
Windows, while OS/2 had grown to 8 percent.
Overall, the market is Windows’ to lose;
Windows is strongly entrenched—but strongly
under attack today by OS/2 and tomorrow
perhaps by the IBM/HP/Apple joint
venture, Taligent.
ing, challenging Novell whose network operating system, Net-
Ware, dominates local area networks. Microsoft also announced
Chicago, the next evolution along the DOS-Windows-NT path.
Reviews comparing NT with OS/2 were mixed, and Microsoft
missed key delivery dates in 1993 and 1994. DOS remains by far
the most widely used OS and is likely to continue as such. UNIX
has lost some of its gloss; NT and OS/2 incorporate the multitask-
ing—that was a distinctive strength of UNIX. Apple has been pushed on the
defensive with the Macintosh no longer able to command a pre-
mium price.

See also: Central Processing Unit, Compatibility, Mainframe and
Minicomputer, MS.DOS, OS/2, Personal Computer, Portable Computer,
Proprietary, Standards

Optical Disk  See Compact Disc-Read Only Memory

Optical Fiber  See Fiber Optics

OSI  See Open Systems Interconnection

OS/2  IBM developed the OS/2 operating system for its PS/2
series of personal computers. OS/2 supports “multitasking,” that
is, running more than one application simultaneously and
“multithreading,” which means that it can initiate several proc-
ceses at once within a single application.

There is a widely held view among many personal computer
users and commentators that Microsoft Windows has severely
damaged the prospects of OS/2. The opinion of a sizable plurality
of top IS planners and executives, however, is that OS/2 is essential
for the multimedia applications they are planning.

Sales of OS/2 in 1993 and 1994 were substantially higher than
most industry forecasts, and comparisons with its newest and
fiercest rival, Microsoft’s NT, in 1993 generally favored OS/2 for
business use in a networked environment. Even so, sales of Mi-
Microsoft Windows across the business and consumer PC market have totally dominated those of OS/2. IBM has had little success in the 1990s in reaching the consumer market, which buys 4 out of 10 PCs sold in the United States; IBM sells only 2 of those 10 machines to this key segment. That strongly suggests that Microsoft Windows will continue to dominate the entire market, but also that Microsoft's NT is not guaranteed the same easy and spectacular success as Windows.

To use PCs for such standard applications as word processing and e-mail, OS/2 offers no added value over the venerable MS.DOS and Windows, both of which it can run—indeed, one of IBM's claims has been that OS/2 runs Windows applications faster than Windows can. DOS will be around for many years; newer versions of successful applications are generally built to exploit the extra capabilities and features Windows provides. OS/2 is an industrial-strength product, as is NT and its recent, much delayed successor, Chicago.

See also: MS.DOS, Operating System

Outsourcing Outsourcing is the practice of contracting with an outside firm that can afford to hire top technical specialists by spreading their time over a number of contracts. The outside firm may run part or all of a company's IT operations, including networks, data centers, maintenance, and/or software development.

Outsourcing is variously viewed as a means of reducing costs, off-loading work to enable a firm to concentrate on a smaller number of critical aspects of IT development and use, and accessing expensive skills that would be too expensive to provide in-house. Seeking a long-term commitment to fixed-price services can further reduce costs. Outsourcing firms that are eager to gain market share are often willing to cut prices for the first few years, betting on their ability to increase efficiency and reduce their own costs.

Many nonstrategic aspects of IT operations can be efficiently and effectively contracted out. The argument most often raised
against outsourcing is that the firm risks losing control over a key business resource. But the complexity of outsourcing should also not be overlooked. Contracts that ensure that all relevant levels of service, quality, and responsiveness are explicitly stated often run to thousands of pages. Outsourcing has become highly controversial in IS circles. Firms fearful of losing control of strategic elements of IT relevant to competitive positioning liken outsourcing of IT to outsourcing of R&D.

Outsourcing is a relatively new term, but in practice most large Information Systems organizations have been multisourced for many years. No firm can afford all the IT resources or locate all the essential expertise it needs. Many contract out some aspects of systems development, participate in shared industry networks, and have special arrangements with suppliers for service and maintenance. This being the case, outsourcing versus in-house management is less an either/or than a both/and issue.

The decision to outsource some or all of a firm’s core IT development and operations is a major one and not easily reversed. Senior business executives in most firms are likely to see it on the agenda several times in the next few years.

See also: Application Software and Application Development, Data Center, Maintenance, Network Management

Package A software package is a set of programs that can be bought off the shelf and used as is or modified to meet specific needs of the purchaser. Packages usually address a particular, usually generic, business application, vary widely in quality, and frequently require as much planning as customized software development.

Too many firms underestimate the extent to which they will have to adapt work processes to use a package effectively or modify a package to fit the work at hand. No package can economically provide sufficient flexibility to accommodate all the variants in firms’ business processes. In evaluating the trade-offs between purchasing a package and developing a system in-house,
a company must examine the interdependencies among the software and its own organization, work flows, skills, and informal communications, and the strengths and availability of its own systems development staff. Such an analysis will help a firm make a purchase or begin development with a clear organizational as well as technical plan.

See also: Application Software and Application Development, Programming, Prototyping, Software

Packet-Switching Widely used by public data-communications networks, packet-switching is a technique whereby large messages are split into small, fixed-length units, or packets, for transmission. Each packet contains the necessary information to route it through the network, handle any transmission errors, and ensure that it is reassembled with its constituent packets into the original message at its destination.

This "bursty" traffic can be efficiently and cheaply moved across the nodes of a large wide area network. The alternative, circuit-switching is more suited to transmitting large units of data that need synchronization of sending and receiving equipment.

The principal standard for packet-switching has been X.25. It is nearly impossible for a firm to develop an international telecommunications infrastructure that does not include X.25, because there are so many countries in which the only access to wide area network transmission is through the public X.25 data network. In 1993, fast packet-switching took off; it was a dramatic improvement over X.25 and one where U.S. telecommunications providers have pulled away from almost all PTTs in providing high-speed, low-cost transmission to businesses. Frame relay is compatible with X.25 and relatively simple to implement. Cell relay, also called ATM (asynchronous transfer method), is more complex but also offers more benefits; it is close to the "all-dancing, all-singing" dream network of any telecommunications manager and runs on local as well as wide area networks, whereas X.25 and frame relay are WAN-based technologies. Cell relay and
frame relay provide bandwidth "on demand" and their speed greatly reduces the need for circuit-switched transmission links for transmitting very long messages, such as engineering design specifications or megabyte data files.

See also: Asynchronous Transfer Mode, Fast Packet-Switching, International Telecommunications, Transmission, X.25

PC  See Personal Computer

PDN  See Public Data Network

Pen-Based Computing  Historically, anyone who wanted to communicate with a computer, telex machine, or automated teller machine had to type in commands. The keyboard they used to do this has not changed its layout in 120 years. Indeed, the QWERTY arrangement was designed to slow down typing to prevent the jamming of keys that was a constant problem in early machines. Efforts to introduce more productive keyboards failed because it is too hard to relearn well-established motor skills—similar to a right-handed person trying to write with the left hand.

Making a computer truly easy to use requires making it natural to enter commands. The first step toward less user-hostile computers was the Apple Macintosh's "graphical user interface," where most commands were entered by using a "mouse" to manipulate a pointer on the screen, but even the Mac requires typing skills.

The two most natural modes of interaction are writing and speaking. Both are now practical though not yet effective and efficient enough to use as standard features on personal computers. They eliminate the keyboard and its accompanying size and weight. This is important for PDAs (personal digital assistants), the small machines with wireless communications that will surely be part of the next wave in personal computing of the smaller-is-better and smaller-and-mobile-is-better-still mindset. Apple's Newton and AT&T's EO (a neat machine that didn't find a market
and was abandoned by AT&T in 1994) were early PDAs that use electronic pens, as do more-specialized devices that couriers use to get signed receipts for goods and that traffic wardens use to write out parking tickets that are automatically entered as computer records.

Pen-based computers have to recognize handwriting that can vary from the stereotypical copperplate of the elderly bookkeeper to a doctor’s scrawl. The early versions’ accuracy rates of 95 percent are impressive in themselves, but of course that means a 5 percent error rate. For instance, when this author (whose handwriting veers toward scrawl) writes “Pick up car” on his EO screen’s day planner, the first attempt, made hastily, comes out as “Pck up ear,” but a second effort gets it right. Given that he often makes more mistakes than this when typing, the EO’s performance is fully acceptable.

Writing into a computer is surprisingly different from hitting keys, not so much in terms of the technology itself as with the thought process involved. When we write, we use skills that we developed from the age of about four. When we type, most of us older than 30 are using semi-skills acquired in our 20s or older, and because it is less natural or comfortable than writing, it can interfere with our thinking. People in their 20s may find this the opposite. In either instance, the issue in effective use of IT is making systems not user-friendly, which is industry-hype for a little less user-hostile than last year, but rather people-natural. Pen-based computing in 1994 has its eccentricities, to put it mildly, and can be similar to writing with a paintbrush. There can be little doubt, however, that the technology will improve quickly and that PDAs will soon become practical for sales reps, field service staff, executives, doctors, and anyone who frequently writes on paper.

**Pentium** Intel’s Pentium chip, made available in late 1993, is one of the new generation of superchips—with super superchips on the immediate horizon. It packs 3.1 million transistors into a
space smaller than a postage stamp; that is three times the number on Intel's 486 chip, the current leader in PC products. It is two to four times as fast as the 486. It is also expensive—around $1,000 (as of mid-1994)—though the price will drop rapidly as volumes and reliability of production increase.

Pentium is part of the chip makers' battle for tomorrow's desktop, PC hardware vendors, and software companies. The chips used in PCs prior to the Pentium have mainly allowed faster processing of such standard applications as spreadsheets and word processing; each new generation of Intel chips—the 8080 series, 80286, 80386, and 486—also made it practical to add complexity and richness of features to such applications without degrading performance. Using a Pentium-based machine for word processing would be overkill. Using it to redraw a complex manufacturing design, calculate a complex financial analysis, or run an economic model will be where the Pentium and its rivals, such as Digital Equipment's Alpha chip, the Apple/IBM/Motorola-led consortium's PowerPC, and Intel's own extensions of the 486, will attract PC and workstation customers. Even with a chip that costs $1,000 (the PowerPC's cost begins at $400), the machine it runs on will only be about $5,000.

Throughout the history of personal computers, the top-of-the-line new generation of PCs have cost $5,000. Of course, every five years, you get much more for that $5,000, but now you can buy a PC for $750, so why pay more? The issue for managers to address is not cost or even immediate value but the longer-term business opportunities adding PC power opens up. That varies by industry. In manufacturing, research and development, and other such computation-intensive industries, Pentium will seem underpowered in a few years. In publishing, advertising, film and TV production, and similar graphics- and video-intensive businesses, the superchips allow them to have a studio on the desk. For insurance companies, retailers, banks, and airlines, it is not yet clear what opportunities they create. The most likely area of development will be in software development, where the new capabilities will
be used to make their products easier to use and to add TV-like multimedia facilities.

For Intel, the Pentium is its move to maintain its global leadership against aggressive competitors. In 1993, its revenues were $8.4 billion, with NEC coming in second ($6.4 billion), followed by Motorola, Toshiba, Hitachi, and Texas Instruments. The remaining top ten are Japanese firms, except for Korea’s Samsung, a fast-rising star.

**Personal Communications Systems (PCS)** This is a catch-all term for a class of wireless devices for voice and data communications that resulted from the FCC’s 1993 decision to award licenses in mid-1994 to operate on the once tightly restricted radio spectrum. This will greatly expand the range of services for businesses and consumers to include paging, cellular communications, personal digital assistants, wireless fax, and provision of electronic information such as stock market quotes.

Because the FCC will not allocate the spectrum to any one company nationwide, the PCS market will be driven by regional competition and national alliances.

**Personal Computer** Originally just that—a self-contained computer designed for an individual to use—personal computers today are viewed increasingly by business as part of a larger information infrastructure; hence the growing emphasis on networking, interactive program and data sharing, and distributed computing.

Personal computers are small and getting smaller. They range from television-sized desktop machines to laptop computers that weigh about 12 pounds and newer notebook computers that weigh as little as 2 pounds.

A personal computer comprises both hardware and software. Hardware includes the central processing unit and main memory in which programs are run, the screen or monitor on which information is displayed, and disk drives from which programs
and data are transferred into the central processing unit and memory, as well as peripheral devices such as printers and scanners. Software includes operating systems (e.g., OS/2, MS.DOS, Windows, NT, and UNIX), utility programs (e.g., for copying or sorting files or retrieving files from damaged disks), and application programs (e.g., spreadsheet, statistical analysis, and word processing programs).

Personal computers have historically followed three "streams"— (1) IBM personal computers, (2) IBM-compatible personal computers (marketed by firms such as Compaq and Zenith), and (3) Apple personal computers—plus one rivulet, UNIX-based computers. IBM leveraged its long-time dominance of the mainframe computer arena to carve out a sizeable chunk of the business market for personal computers in the early 1980s.

Apple had a harder time building market share for its Macintosh computer, which featured a more intuitive, graphical, icon-oriented user interface. The Macintosh built a strong base of individual personal computer users, but its deliberate decision to make the Mac incompatible with any other system slowed its adoption by large organizations. Contenders for the compatibles market hitched their generally cheaper machines to IBM's star, making sure that any standard software that runs on a true blue IBM PC runs on theirs. Although IBM remains the leader with about a 12 percent market share, it lost its dominance to what are termed the "clones," or the IBM-compatibles. These really were the Microsoft and Intel family, not IBM clones. Microsoft took control of the operating system market through MS.DOS, which, ironically, it developed for IBM, and through Windows, which it developed at the same time it was working with IBM to develop OS/2, with which it now competes (the Microsoft-IBM story is a soap opera par excellence). Intel took control of the PC chip market, again ironically through an infusion of cash from IBM at a time when it was close to failing. An IBM-compatible thus became any machine that used an Intel chip and ran DOS applications, of which Microsoft quickly became a leading inventor.
In 1984, Apple introduced the Macintosh as “the computer for the rest of us,” meaning those not captured by IBM, which Apple likened to Big Brother in Orwell’s *1984* (literally so in its early ads).

The advantages of the Mac’s graphical user interface in terms of ease of use and speed of learning made it a target for imitation. By choosing to shift the complexity of operations from the user to the machine, Apple changed the philosophy of computing, and IBM and IBM-compatible computers increasingly incorporated Apple-like user interfaces.

Microsoft created Windows, a Mac-like interface built on DOS. The first versions were clumsy and slow, but Windows 3.0 (version 3) rapidly took off and by 1992 was the de facto standard for PCs, along with DOS. The mainstream market thus stabilized in terms of basic technology until mid-1993. As a result, 1992 and 1993 saw massive price wars. PCs became a commodity, with, by definition, little differentiation between, say, a Compaq machine with an Intel 386 chip running Windows and one from Dell or IBM. Dell exploited telephone ordering from catalogs instead of stores, customized assembly instead of finished goods inventory, and delivery by UPS instead of its own distribution system to transform the industry by becoming both the low-cost supplier and best-service provider. IBM belatedly moved to recapture its leadership in volumes of PCs sold through aggressive pricing of its ValuePoint products. A machine that cost $7,000 in 1991 and $3,000 in 1992, was available for $1,700 in January 1994. Its ThinkPad product was such a winner in 1994 that IBM couldn’t make it fast enough to meet demand.

The founder of Dell Computer, Michael Dell, commented to *Business Week* in late 1993 that a year ago he had felt that the industry had run out of innovation, but had totally changed his mind. In 1993 and early 1994, innovations in hardware, software, and applications flooded the market. Intel launched its new Pentium chip and Apple, IBM, and Motorola countered with their PowerPC chip that is targeted by Motorola at ending Intel’s domi-
An estimated 100 million people use PCs, with the DOS operating system. Twenty million use Windows-based machines; Macintosh users total 10 million. nance; by Apple, which is scrambling to repair its position as the provider of premium PCs; and by IBM to end the rapid sequence of today's high-end PC being tomorrow's commodity that has so benefited its archrival, Microsoft. Microsoft has countered on three fronts: (1) greatly improving DOS, which remains the workhorse of PCs for the home and small business; (2) launching Windows NT, called NT, to both retain its dominant position in corporations created by Windows 3.0 and strengthen its main area of weakness—support for enterprisewide telecommunications (here, its enemy is Novell, whose NetWare product dominates local area network operating systems); and (3) packaging its key application software products such as Excel (spreadsheet), Word (word processing), and Powerpoint (graphics) as a "suite," called Microsoft Office, priced very aggressively with additional volume discounts; here, the competition is with Lotus and WordPerfect.

In applications, the main area of PC innovation comes from the greatly increased raw speed and power of the new generation of chips. "Multimedia" is the general-purpose term for applications that combine video, audio, documents, photo, and even television. All four major high-end PC operating platforms—Windows, Macintosh, OS/2, and UNIX—can be used to create and edit your own movies, add music and commentary, record from television and scan in images or extract, and crop or augment photos stored on an optical disk. This is a desktop studio that will substantially impact training programs, entertainment, and publishing, including the development of interactive books.

Many of these high-end innovations may not affect the typical PC users who will be satisfied with a basic machine. For the next few years that is likely to be one based on the Intel 486 chip. The trend toward packing increasingly more features into increasingly smaller boxes (notebooks, subnotebooks, palmtop computers) will continue, as will the more recent move that combines wireless communications with an electric pen that recognizes handwriting, thus eliminating the keyboard (the glitches are being ironed out; early on, such personal digital assistants such as Apple's
Newton accurately transcribed around 95 percent of what was entered, but that still leaves room for many and often quite funny errors).

A major shakeout will inevitably occur in the PC industry, especially in the commodity hardware and retailing areas. In 1993, a number of manufacturers of low-cost PCs folded, as did several mail-order suppliers. When that happens, the owners of their products can face major problems getting maintenance, support, and parts. Margins are small and pricing aggressive, so that operating and distribution costs must remain very low while marketing and service must be kept high. This suggests that the same oligopolistic trends that have resulted in a relatively small number of software giants, most obviously Microsoft, Lotus, and WordPerfect, will narrow the hardware field, too.

It will be hard to predict the winners. Clearly, IBM is once again an innovator, not the clumsy laggard of the past years. Clearly, too, Microsoft will be as aggressive in the future as it has always been, making new enemies; the term is chosen carefully, since there are sharp personal hostilities in many of Microsoft's relationships. Apple's future is cloudy and rests on the PowerPC. Lotus's Notes groupware package is creating a new industry and hits Microsoft's main area of comparative weakness. Intel is eying the multimedia and wireless market to build on its commanding lead in PC chips, exploiting its magnificent research base.

It's increasingly hard to keep up with what's happening in the PC market and the technology. Each issue of MacWorld, one of the dozens of monthly trade press publications, contains over 300 pages. The typical issue of Windows magazine has over 500 pages. For businesses, the key issue in planning is increasingly to choose an architecture, a choice of a combination of hardware platforms, operating systems, networking standards, and key software—increasingly a software suite—that meets today's needs but allows for continued expansion of power, storage, and features and that also allows maximum integration of software, data, and communications. Microsoft wants that architecture to be: Pentium-based...
hardware, Windows NT for the PC and LAN network operating systems, and Microsoft Office and Microsoft Access for data management. IBM hopes for PowerPC-based systems running under OS/2. Novell wants anyone but Microsoft, with NetWare the communications environment, and WordPerfect, which it acquired in 1994, its new software arm.

See also: Apple, IBM, Intel, Microsoft, MS.DOS, OS/2, Portable Computer, Terminal, UNIX, User Interface

**Personal Digital Assistant (PDA)** PDA is a term that may or may not take hold as a generic label. It was popularized by Apple Computer to distinguish its Newton machine as new and special. A PDA is a small computer that you can carry in your pocket without worrying about the weight, batteries, and connectors. It uses wireless communications for electronic mail and fax. It is likely to use a special pen that allows you to write, instead of type, commands and text that are then converted on the machine's screen to the typed equivalent. This technology currently has an accuracy rate of about 95 percent in recognizing handwriting.

PDAs are as yet a niche market and mainly of interest as a leading indicator of what features we can soon expect to see on any PC, whether it is a PDA, notebook, laptop, or desktop machine: liberation from the tyranny of the traditional keyboard, wireless communications, very powerful software and storage capabilities even in the smallest machines, and decreased power requirements that allow PCs to run on standard AA or AAA batteries.

The benefits to businesses from such developments will mainly come from the portability and mobility of PDAs. Pen-based computing is becoming a standard tool for receipt of packages by courier, writing and recording parking tickets, and filling out forms for jobs that involve moving around, such as checking inventory in a warehouse or reading electrical meters.

At the moment, PDAs are mainly an upmarket novelty for whatever yuppies turned into when they matured. That means
that people think of them as an alternative to an existing PC. An interesting opportunity for managers is to think of them as an extension of communications and computing to people who do not have much of either. For instance, almost every white-collar worker has a desk with a phone; very few blue-collar workers have phones and must either share them or find a pay phone. How many have cellular phones? Why not?

PDAs represent the next generation of portable tools that can give power to the people—the people who do the work, wherever they are. The management question is, can they do their work more effectively given that power?

**Plugs** See Cables, Plugs, and Sockets

**Point of Sale (POS)** Point of sale, or POS, refers to the on-line linking of sales transactions with planning, ordering, pricing, inventory management, and other business functions. In a point-of-sale system, as a business transaction occurs, information flows to other relevant planning and operational areas of the business. Increasingly, POS systems are being linked to financial networks, primarily for credit card authorization.

Equipment at the point-of-sale end of POS systems usually includes computerized cash registers and such ancillary devices as bar code scanners and credit card readers. These POS terminals are linked to a store or central computer, allowing sales, inventory, and pricing data to be updated immediately. This capability can be used to support just-in-time purchasing, alert management to shifts in consumer patterns, reduce errors, monitor sales promotions, rapidly update prices, and generally improve effectiveness and efficiency.

Like computerized reservation systems and automated teller machines, point-of-sale systems demand high reliability, high-speed telecommunications facilities, and powerful data-base management and transaction processing systems. Tandem Computer created an effective niche by providing “fault tolerant” systems.

Toys “R” Us can spot a sales trend in days. The point-of-sale system lets managers know what customers are buying on a daily basis. In 1986, Toys “R” Us tried out yellow scooters with a small order of 10,000. They sold out in two days; the computers spotted this from the POS data and automatically reordered. The firm sold a million scooters.
Today's portable computers offer myriad combinations of size, price, power, and storage. Increasingly, the differentiating features are quality of screen, battery life, the ability to connect to desktop machines by cable or infrared, the ability to share resources, and wireless communications.

built around sets of linked machines that work in parallel; if one goes down, another immediately picks up the work.

See also: Distributed Systems, Electronic Data Interchange, Electronic Funds Transfer at Point of Sale, On-Line Transaction Processing

**Portable Computer** Portable computers are the fastest-growing segment of the personal computer market. They are part of the "small is beautiful" movement that aims at packing as much power as possible in a device whose base is the size of a sheet of paper, its height less than three inches, and its weight between four and eight pounds. Portable computers come in varying sizes and range of categories: laptop, notebook, subnotebook, and personal digital assistants; the new models are not yet labeled.

Portability adds costs and also requires manufacturers to compromise on design. For example, the keyboard of a desktop PC is usually robust with keys that are better made. The monitor will be better lit and offer higher "resolution"—clarity of image. Reducing the size of a notebook computer means shrinking the keys; unfortunately, you can't shrink your fingers.

These problems can be solved through ingenious design. The problem that is nearly intractable for portable computers is the battery. A desktop computer plugs into the electrical utility; the cable weighs just a few ounces and the machine can run for months or even years without a loss of power. Portable computers can run for two to four hours without a battery recharge or connection to an alternative power source. But not if you're running "power apps," which are software applications that consume memory and constantly access disk storage. High-resolution color screens similarly consume power.

The experienced Road Warrior carries a spare battery plus a cumbersome battery charger and cable or buys a subnotebook computer. These can run on AA batteries and weigh under four pounds. They are a marriage of consumer electronics makers' skills in packaging (dominated by Japanese firms) and PC vendors' skills in design. Hewlett-Packard's "palmtop" machine can
run DOS-based programs and fits in a coat pocket.

The emerging trend in portable computers is either to pack more power into the standard $2,000 to $3,000 machine or reduce size and power requirements. The latter approach often includes adapter cards and cables for transferring data to and from a larger desktop machine; the logic here is that your main computer is in your office or home and you use a secondary one when you travel.

Subnotebook computers, pen-based computing, and personal digital assistants will be the next mainstream of innovation in portable computing, with wireless communications becoming a main selling point. Batteries will remain a problem, though; the technology is mature—more than a century old—and no breakthroughs are in sight.

Laptops are a buyer’s market. They are also a necessity for many executives, consultants, sales reps, writers, lawyers, and other professionals who no longer have to leave critical files and software in their offices when they travel.

Regarding price, simple mathematics show that it is worth investing 65 percent of an individual’s salary on a personal computer, laptop, or desktop, to gain an average of one hour per day of more effective work. That amounts to close to $20,000 to leverage productivity at this level for someone earning $35,000 per year. This guide was written entirely on a laptop and would have taken at least an extra six months to create without it.

Hand-held computers, the smallest of the portable computers, are special-purpose machines widely used in retailing and distribution. They are robust, able to withstand shocks, dust, and beverage spillage. Supermarket clerks use hand-holds to check inventory and input orders; Federal Express delivery staff use them to record package pickups. Most hand-holds incorporate a bar code reader and will generally upload data to central computers via a telecommunications link.

See also: Bar Code, Modem, MS.DOS, Personal Computer, Personal Digital Assistant
Swiss Telecom is typical of most PTTs' shift away from restrictiveness, toward liberalization and service. In 1989, a Switzerland to New York leased line cost 10 times as much as one from New York to Switzerland. Now the PTT has invested $10 billion to position itself as a hub for European communications. Rates for leased circuits were slashed by 30–40 percent in April 1991.

**Poste Télégraphique et Téléphonique (PTT)** The Poste Télégraphique et Téléphonique, PTT, is a national quasi-governmental agency responsible for telecommunications. Historically, PTTs have tried to control business exploitation of emerging technical advances in telecommunications in order to preserve their own revenues. This highly restrictive environment is rapidly breaking down as PTTs around the world liberalize, deregulate, and even privatize at varied rates and with varied degrees of enthusiasm.

The typical PTT's control of its nation's communications infrastructure has largely had a negative impact on costs and innovation. In the past few years, the United States has become the leader in telecommunications services, with the customer benefiting from low-cost convenience in accessing services, sending faxes, and using PCs; businesses gain a productivity and cost advantage over their European rivals (Asian countries are racing to liberalize telecommunications, recognizing its critical role in economic growth).

The losers are the transnational companies struggling to build a global communications platform for their global operations. Volkswagen's situation is typical. The fourth largest automaker in the world views telecommunications as the key element in integrating its "patchwork" of plants, suppliers, and dealers; without this, VW cannot achieve economies of scale, efficiencies of production, or effectiveness of distribution. In Germany, it must pay 20 times more than in Japan and the United States for high-speed lines. In Spain, VW can obtain only ultrasonic data communications links that operate at 9,600 bits per second. VW needs 2 million bps; U.S., U.K., or Japanese sales reps from competing providers would be beating on the door, with U.S. firms offering 45 million bps or higher. VW pays about the same for a link between Germany and France as for one between New York and Mexico. In the United States, AT&T promises that if its network is...
down for even an hour, it will cancel affected customers' monthly bill. VW's Swiss link was down for two full days in 1991. Analog Devices, a U.S. multinational, spent eight months waiting for the installation of 9,000 bps links in Italy and the Netherlands; a few U.S. providers will install these links in eight hours and most well within eight days.

PTTs are belatedly responding to business needs. BT (British Telecom) acquired 20 percent of MCI in mid-1993, AT&T announced an alliance with Deutsche Telecom and France Telecom around the same time; these two PTTs have historically been the fierce bastions of monopoly and BT, the fierce exploiter of international competition. Australia, New Zealand, the Netherlands, and many other small nations have privatized their PTTs. When Japan, Britain, Spain, and Mexico did, the new companies became the most valuable firms in their countries in terms of stock market capitalization. That is an indicator of the role of telecommunications in economic growth and business innovation.

*See also: International Telecommunications, Public Data Network*

**PowerPC** The PowerPC is a new generation of personal computer CPU chips created through an alliance between IBM, Apple, and Motorola, whose basic goal is to attack Intel, which has 75 percent of the PC chip market and which has introduced its own new chip, the Pentium. The PowerPC-versus-Pentium battle will strongly influence the direction of personal computers in the mid-1990s, with the odds favoring Pentium although the PowerPC offers a potential new avenue for Apple to become a mainstream rather than niche player in large companies.

**Private Network** The private/public network distinction can be misleading inasmuch as both are typically provided by a telecommunications supplier such as AT&T, MCI, or US Sprint in the United States; British Telecom or Mercury in Great Britain; and PTTs elsewhere in the world. The difference is that a private network is a fixed-cost capability leased from the telecommunica-
tions provider, which guarantees levels of capacity and performance, whereas a public network provides a general access, pay-as-you-go service.

The advantage of a private network is that it allows a company with skilled communications professionals to manage its communications traffic more efficiently. The user has no control over traffic on a public network, and no way to ensure a given service level or security. Virtual private networks, a variant on private networks, offer many cost advantages for large firms. The provider of a virtual private network guarantees a contracted level of service without providing dedicated facilities.

The providers of public data networks have an immense advantage of scale. They are upgrading their systems rapidly with advanced technology, particularly fiber optics, to lower costs and improve performance. During the 1980s, the cost, security, and quality trade-offs between private and public networks led large firms to favor private networks for their high-volume processing and communications systems. The choice is less clear now, and the distinction between private and public networks is blurring as the top providers offer a growing range of options to small and large businesses alike.

See also: International Telecommunications, Network, Telecommunications, Transmission, Value-Added Network

Productivity Paradox Economist Stephen Roach coined this term to describe the negligible payoff from more than $100 billion spent on information technology by financial services companies in the 1970s and 1980s. The paradox is, that after this massive investment, which more than doubled the IT capital deployed per worker, productivity increased by only 0.7 percent a year, whereas that of U.S. manufacturing during the same period increased 3.5 percent a year.

Roach attributes the lack of improvement in productivity to misallocation of priorities and overinvestment in administrative
systems. He now sees a major shift that targets marketing, customer service, and value-added applications. He, along with many other observers, argues that U.S. productivity in banking is now the highest in the world.

The productivity paradox reflects an ongoing concern of business executives that their own firms have poured money into IT with little if any return and an ongoing concern of researchers and consultants about how to measure the value of IT. There are many problems (including in Roach’s analysis) in assessing the true costs of IT, especially regarding support, education, and maintenance; choosing a fair time frame in which to determine payoffs from long-term capital investments; and defining and measuring productivity. Most accounting systems provide little help because they do not track IT capital and do not connect the indirect costs of a $5,000 personal computer with the extra costs it generates—typically $8,000 to $18,000 a year for, say, support and communications.

There have probably been more studies of IT payoff than of any other aspect of the field. Most show no relationship between firms’ investment in IT and performance. Periodically, wild claims are made that IT really does generate massive benefits, but the research methods and assumptions are generally questionable. The most likely conclusion is a simple one: as with R&D, product development, and human resource management, some firms get great results and some get none. When every major firm in an industry has access to the same technology base, it is the management difference that determines the competitive advantage.

**Programming** Programming is the process of transforming a description of a system design into instructions a computer can interpret. Ultimately, these instructions must be specified in the binary coding (0–1) used to represent the electrical states stored in the circuits of computer chips. Because binary coding is extraordinarily tedious and time consuming, multiple levels of pro-
Programming "languages" have evolved, each with its own vocabulary and rules of grammar. Compilers—translation software supplied by the hardware vendor—link the application programs written in higher-level languages to what occurs in the circuits of the computer. A compiler converts the request "add this to this" to machine-readable code, which will look like "00111100111001111111." There may be as many programming languages as there are human languages. Some of the main ones are COBOL, the 30-year-old workhorse for larger-scale business transaction processing systems; FORTRAN (Formula Translation), the equally venerable scientific programming language; and C++ and Smalltalk, the newer object-oriented languages.

Programming languages are distinguished by their level—low to high. High-level languages, such as COBOL, allow the programmer to write English-like statements, such as "TAX = (GROSS-PAY-DEDUCTIONS) * (MARGINAL-RATE)." A compiler—translator—converts this to machine language code, something like "0473900086E53." Some software packages include programming language capabilities. One industry observer estimates that the most widely used language in business, in terms of numbers of lines of code, is Lotus 1-2-3 "macros"; these are routines in the 1-2-3 spreadsheets that automatically handle functions users would otherwise have to work out in their minds and then enter lots of commands. Data-base management systems, application generators, and fourth-generation languages (4GLs) are all examples of high-level tools that aim at simplifying programming.

Everything that happens in a computer has been programmed. Systems programmers write the operating systems that perform all the utilitarian but essential operational tasks, including reading application programs and data into memory, performing the required processing, and seeing that everything is properly stored when it is finished. Applications, both custom applications commissioned for specific tasks and the many general-purpose packages developed to support generic applications, are written by
teams of programmers. The growing use of very high level languages, which hide the complexity of the programming task to enable users to do some of their own programming, is consistent with other trends, such as distributed computing, networking, and the client/server model of computing that puts more responsibility on the user to define requests, letting the machine, rather than a programmer, determine ways to meet those requests.

Programming productivity has not kept up with demand for software. There is hardly any large company or public sector organization that has all the systems it needs to meet its business priorities or that does not have backlogs of development projects. Any tool that frees users to create their own applications and technical specialists to concentrate on complex large "mission critical" developments should be quickly grabbed.


Proprietary Proprietary refers to products that are specific to a single vendor, in contrast to open systems, which are vendor independent. Historically, computer equipment manufacturers relied on proprietary systems and often tried to limit or prevent software and equipment makers from selling add-on products and services. IBM, Digital Equipment, and Wang followed this path for decades. Apple maintained its proprietary focus at a time when the personal computer industry was moving toward the building-block approach that dominates it today. This approach enables an MS.DOS or Windows-based PC to come from any of a thousand manufacturers, link to printers from a different group of providers, and attach to many types of local area networks.

It's no coincidence that IBM, DEC, Wang, and Apple, all of whom were major successes with their technical innovations in the 1960s to 1980s lost market position when the momentum of
user demand and new vendor supply broke their strongholds. It's also no coincidence that companies such as Novell, Cisco, and Microsoft flourished; their focus was on systems that operated on and/or linked to many vendors' platforms.

Likewise, it's no coincidence that in early 1994 Microsoft and Novell were battling to keep their own key systems at least a bit proprietary. Microsoft's NT operating system is challenging and being challenged by Novell's NetWare 4.0 as the choice for large companies managing their enterprisewide communications. Novell dominates local area networks, while Microsoft dominates desktop computing, neither wants to make it easy for firms to substitute the other's flagship product (the contention seems partially personal, since the companies' leaders are not mutual admirers).

These companies have little choice but to make their systems open. Proprietary systems largely represent the past, not the future, of computers and communications. It is no longer practical for any vendor to maintain complete control of a promising line of development. What typically happens is that pressure from large companies using new products with proprietary features pushes vendors to make sure these products interoperate with key operating systems, networks, and data bases. Increasingly vendors facilitate openness through agreeing on a standard or licensing a product. Finally, vendors are quick to ensure that their systems can interface with any hot product.

But... there is always a "but" concerning proprietary systems. Almost inevitably, in any use of ground-breaking technology—personal digital assistants, multimedia, image processing, and digital signal processing chips—there are few if any proven standards. Even when there are, they often have proprietary dialects and special features. Perhaps, instead of the black-white, all or nothing terms, proprietary and open, we need to respect the shades of gray in the IT field and think of proprietary-ish and open-ish. Then the business issue is that choosing a proprietary system means betting on one vendor's success; choosing a proprietary-ish
system means betting that many vendors can ensure a growing range of options; picking open-ish systems is the mainstream commonsense option, and expecting completely open systems a sure guarantee of disappointment.

See also: Compatibility, MS.DOS, Open Systems, Operating System, OS/2, Standards, Systems Integration, UNIX

Protocol A protocol is a procedure for establishing a telecommunications link. Indeed, protocols are the language of telecommunications interconnection. They reflect many aspects of protocols in the diplomatic sense, the signals exchanged by sending and receiving devices, for example, being termed "handshaking" and "acknowledgment."

Protocols are primarily concerned with three aspects of the communication process: how data are represented and coded, how data are transmitted, and how errors and failures are recognized and handled. Much of the incompatibility between telecommunications facilities relates to the use of different protocols, and much of the discussion on telecommunications standards centers around protocols. Open standards, gateways, bridges, and protocol converters all address incompatibility in different ways and with varying degrees of effectiveness.

See also: Compatibility, Interface, Network, Packet-Switching, Proprietary, Standards, Telecommunications, Transmission

Prototyping Prototyping refers to the process of building a small working version of a systems design as a means of hedging risk, encouraging experiment, and fueling learning. The use of prototyping to get a clearer idea of user needs is a surprisingly recent innovation. Early systems development techniques, which focused on automating clerical procedures to improve efficiency, relied on well-defined design specifications, often running to many hundreds of pages. Changing a design once it had become the base for a set of software programs, together with the inherent
and continuing complexity of systems development, testing, and operation presented major difficulties.

In retrospect, it is apparent that reliance on functional specifications and detailed design at the start of a major project increased risks. Users could not know what they wanted, having little if any experience with computers, and the technology was inflexible and experimentation impractical, making development an all-or-nothing endeavor. A system worked or it did not, but it took two to five years to find out.

It is increasingly being applied to business activities for which no written set of procedures exist. As emphasis has shifted from automating processes to supporting how people work, ensuring ease of use, flexibility, and adaptability have become key design requirements. In helping to satisfy them, prototyping has become for systems developers what wind tunnel models are for bridge builders and "breadboarded" systems for systems engineers.

Care must be taken to ensure that prototyping does not become a substitute for systematic analysis. Imagine a bridge builder saying, "I have no idea what we need, let's knock up a prototype," then building some models and concluding, "OK, that looks right. Let's build it." Prototyping is a systematic discipline; it should not be a substitute for planning. Too often a prototype, instead of being thrown away and the learning gained from it used to ensure a first-rate design, becomes the base for the full design.

Prototyping is a powerful vehicle for bringing designers and users together, allowing designers to get a sense of how a system is intended to work, and enabling users to evolve their stated needs by using a real system. A sound prototype is the best evidence that a proposed design is likely to work, both organizationally and technically.

See also: Application Software and Application Development, Computer-Aided Software Engineering, Programming, Testing

**PTT** See Poste Télégraphique et Téléphonique
Public Data Network (PDN)  A public data network, or PDN, is a telecommunications system that anyone can subscribe to and use on an as-needed basis. As with the public voice network (the telephone system), the tariff for a PDN is volume sensitive. Users pay as they go; the more traffic they put through the network, the more they pay. In many countries, public data networks are the only available option for businesses, private networks being either unavailable or prohibitively expensive.

Almost all international public data networks use the well-established X.25 protocol. This is as close to a universal standard as English is to being the universal language of business. The limitation of X.25 is its slowness compared with the fast packet-switching techniques that are transforming telecommunications in the same way and to the same extent that microprocessor technology has transformed computers. A hybrid combination of public and private networks is emerging as the blueprint for both the leading U.S. and international service providers. In the United States, companies can get high-speed “bandwidth on demand” over special service equivalents of PDNs, sometimes termed virtual private networks because they do not lease a full high-speed circuit but are guaranteed that the capacity they need will be available as they need it. When telecommunications transmission was slow and leased lines expensive, PDNs offered adequate access, price, and performance. That is no longer true; the gap between international capabilities is widening rapidly, with the United States well ahead of most European nations. Many multinational firms report substantial, ongoing problems in Germany, where high-speed lines, if available at all, can cost 10 to 20 times more than in the United States and Japan. France has excellent technology but many restrictions and high prices, and Spain and Italy are very backward in all areas. The standard PDN operating at 9,600 digital bits per second, about 1,000 typed characters, is increasingly inadequate for manufacturers that need to send design specifications, orders, inventory, and production information around the PDNs worldwide vary substantially in quality, one reason for large firms’ frequent use of private networks where that practice is legal. In northern Europe, 9 to 12 percent of transmissions fail (the equivalent of your not getting through on the phone) and in southern Europe, the figure is 25 to 30 percent. The U.S. figure is less than 1 percent.
world. Those companies need 2 million bits per second on key links and at least 64,000 bits per second on most routes.

*See also: International Telecommunications, Network, Packet-Switching, Poste Télégraphique et Téléphonique, Private Network, Telecommunications, X.25*

**RAM** See Random Access Memory

**Random Access Memory** Computer memory is called "random access" because the central processing unit can directly access any part of it to retrieve and store information and the time required to do so is independent of the location of the information previously accessed. This contrasts with magnetic tape storage, which must be accessed sequentially.

*See also: CD-ROM, Central Processing Unit, Chip, Disk Storage, Image Technology, Millisecond, Response Time*

**RBOC** See Regional Bell Operating Companies

**Read Only Memory (ROM)** Read only memory, or ROM, is a computer chip that stores data or instructions in a form that cannot be altered. It is contrasted with random access memory (RAM), the contents of which can be changed. The contents of a ROM chip, unlike those of a RAM chip, are not lost when power is shut off to the computer. There are several variants of ROM, including programmable ROM (PROM) and electrically erasable programmable ROM (EEPROM).

ROM chips are widely used to store computer game programs and to store the operating system and application programs for some laptop computers. Automobile engines contain ROM chips that control many functions.

*See also: Chip, Random Access Memory*

**Recovery** See Backup and Recovery
Reduced Instruction Set Computing (RISC)  Reduced instruction set computing, or RISC, is a type of chip logic that contains electronic circuits that provide a very limited number of computer instructions (for multiplication, addition, comparing values, and so forth). Most application programs use only a few instructions for almost all their processing. RISC technology exploits this fact by providing only a small set of instructions that execute very quickly. Because they are less expensive to produce than general-purpose logic chips, RISC chips are the basis for many of the powerful new workstations that provide computing power at very low cost.

RISC technology is not suited to all types of applications. So far, it has mainly been used for functions that require raw computation speed but do not involve complex information handling.

A test comparing the performance of RISC versus CISC (complex instruction set computing) shaped up in 1994 as Intel's new Pentium chip (CISC) competed with IBM's and Apple's chip PowerPC (RISC) that was developed with Motorola. The PowerPC is expected to run programs two to four times faster than Apple's most powerful existing Macintosh machines, which use a Motorola RISC chip. Hewlett-Packard introduced a new RISC chip in December 1993 that is about 25 percent faster than PowerPC or Pentium equivalents. HP, the leader in RISC developments, is targeting this chip to UNIX workstations and aggressively escalating the war between UNIX machines and the Pentium machines that use Microsoft's NT operating system. It's interesting to note that the competition here is being driven by both hardware and operating systems, with the PowerPC/Apple System 7 operating system moving earliest, the Pentium/Microsoft NT following closely, and the HP RISC/UNIX and the Pentium/IBM positioning themselves to control high-end PCs and workstations for the mainstream business users. All the key players interestingly enough are U.S. firms. Japan dominates the production of memory chips, but central processor chips and the operating

It is ironic that simplifying computer chips and eliminating many of their most powerful instruction capabilities has led to dramatic increases in the overall power of workstations. RISC technology is the base for all the leading Unix workstations, and has increased their price performance by factors of 20 in two years.
system software that exploits them remain a U.S. preserve of fierce innovation.

See also: Central Processing Unit, Chip

Regional Bell Operating Companies These are Ameritech, Bell Atlantic, BellSouth, NYNEX, Pacific Telesis, Southwestern Bell, and US West. They are the holding companies for your local phone company. Thus, Bell Atlantic owns Bell of Pennsylvania, C&P, New Jersey Bell, and others. The seven RBOCs were formed as part of the divestiture of AT&T in 1984. They were given a monopoly of local phone services, whereas the long-distance market was open to competition. The logic behind maintaining a monopoly in the “local loop” was mainly to ensure the continuation of the social principle of universal service; every home should have access to a phone at an affordable cost. In return for their monopoly, the RBOCs were forbidden to enter the long-distance, entertainment, and publishing markets.

Over the next eight years, the RBOCs were money machines. Prices in the long-distance market, however, dropped 40 percent in real dollars as a result of aggressive competition and technical innovation. The Baby Bells, which were notoriously overstaffed, faced no competition; thus their prices dropped only slightly. While none of the seven were among the Fortune 50 in terms of revenues, all were in the top 20 in terms of profits. One of their most lucrative sources of profit was the local “access charge” paid by the long-distance carriers to link the caller’s phone to their own network and then to the receiving party. This charge has been as high as 60 cents on each $1 of long-distance revenue, and remains 45 cents, which amounts to $30 billion a year.

The restriction on entering the entertainment and publishing markets pushed the cash-rich Baby Bell’s into foreign investments and diversifications. Southwestern Bell, for instance, purchased 10 percent of Mexico’s newly privatized Telefonicos for under $1 billion. In addition, NYNEX has become the largest cable opera-
tor in the United Kingdom, and US West is deploying Hungary's first cellular system. Most of these diversifications, however, failed. Bell Atlantic, for example, bought a chain of personal computer stores that it sold at a loss only a few years later.

In the early 1990s, the tidy, even smug world of RBOCs came under attack from many sources. Cable TV companies began eyeing the profitable residential phone market (which regulation banned them from entering). These cable companies recognize that the massive bandwidth—telecommunications transmission speed and information carrying capacity—they were installing could easily add low bandwidth, low-speed voice communications and that the fiber optics they expected to install into the home could make them the supplier of virtually any type of consumer communications and information service; this is now termed "multimedia." State and local governments ate away at the local phone companies' monopolies, allowing limited competition, and companies began to provide special services to businesses and long-distance carriers to bypass them.

The technology bases of the local and long-distance phone companies began to converge, so that the regulatory barriers made increasingly less sense and were more difficult to enforce. Bell Atlantic in 1992 announced that it could now send pay-per-view movies on standard phone lines, which are already installed in 85 percent of U.S. buildings. It challenged restrictions on providing such entertainment services, arguing its First Amendment rights. In 1993, it launched the first main move toward breaking down the boundaries between the many players in the transmission of information, communication, and entertainment, when it announced a $33 billion merger with the largest U.S. cable TV firm, TCI. This was called off in late February 1994 over problems the deal created in pricing ostensibly resulting from the FCC's 7 percent reduction of basic cable TV prices. This price drop sizably reduced TCI's forecast cash flow, the base for valuing the company for exchanging TCI and Bell Atlantic stock.
Other RBOCs had already bought shares of cable TV firms, and the derailment of this massive deal had no effect on the movements of the main players. MCI announced in late 1993 that it would spend $2 billion of a planned $20 billion network enhancement to bypass the Bells in major metropolitan areas, thus bypassing the expensive access charge that almost cuts its revenues in half. The RBOCs petitioned to be allowed to enter the long-distance market. MCI, which created the pressure for competition in the long-distance market and was the primary force behind the divestiture of the Bell system, petitioned against this. Congress began to dismantle all existing regulations, with the issue of balancing competition with universal service. A particular concern is ensuring that schools in poor and rural areas have access to what is now being termed the Information Superhighway. The main opposition to deregulation is now coming from print publishers.

In the early 1990s, most observers were betting that the aggressive cable TV industry would beat the sleepy Bells in capturing the consumer market. Technology and the wakening of the sleeping giants to face the realities of competition had changed this. The Bells have the advantage of occupancy, with the wires already into the home and the advantage of access to the billions of dollars of capital for deploying the fiber. The Bells must move speedily now. Their core local voice market is growing only at 3–5 percent a year; volumes have increased 7 percent, but technology and new competition is driving revenue per unit down; the long-distance and data communications markets are growing 8–25 percent a year, depending on segment.

See also: Cellular Communication, Information Superhighway, Mobile Communication, Network

Relational Data Base A relational data base is organized so that its contents can be cross-referenced. A major area of development in computer science, software, and business applications,
the relational data base is a deceptively simple concept that is immensely complex to implement technically and organizationally. It involves entirely new types of software and extremely high overhead for processing and operations. Despite unsolved problems in many areas of high-volume processing, RDBMS are a key element in creating organizational data resources that can be classified, analyzed, and accessed as if they were part of the indexed contents of an enormous library.

The industry leaders in RDBMS are Sybase, Oracle, and Ingres, though every major computer manufacturer offers the product; DB2 was IBM's flagship data base software through the early 1990s, but the erosion of the mainframe market has slowed growth of installations. All RDBMS have very different design principles, data structures, and performance features. This, of course, means they are incompatible; however, the widespread implementation of the Structured Query Language (SQL) standard for querying data bases allows applications to interface to a wide range of RDBMS.

A much bigger problem is that an estimated 90 percent of the data in large companies is not structured relationally but is maintained in older, hierarchical systems, largely because it is the most efficient structure for high-volume transaction processing or because redesigning and converting the files and the data-processing software would be prohibitively expensive. RDBMS inevitably add overhead from interpreting SQL queries, locating data, checking validity, and synchronizing information. Until recently, this limited RDBMS to either small applications or those that did not involve continuous on-line updating of data. This is changing as computer power reduces the overhead created by the processing delays. But no airline, credit card provider, or large bank could possibly use relational data base technology today to handle reservations, card authorization, or ATM transactions.

The relational model is the mainstream for data-base management, subject to the provisos above. Another approach combines the hierarchical model's efficiency of processing large-scale trans-
actions and the relational model's effectiveness in information retrieval. A hierarchical system cannot handle ad hoc queries such as "list any customer in New York City whose average balance in June or July was greater than $25,000" because this requires parallel processing—a set of linked small and very fast computers, each accessing a small part of the data base. This is similar to using 500 people to handle an ad-hoc query, where each has 50 customer profiles, monthly balance reports, or branch addresses to search. They work in parallel, double-checking with each other at fixed intervals.

Indications are that IBM intends to gamble that parallel processing is the only viable way for the company to recover its failing mainframe business. The company predicts that mainframes will be the data "server" with attached parallel processors off-loading heavy functions. IBM launched its Highly Parallel Query System early in 1994.

The term "computer" originated in the early 1940s to describe the jobs of those who did calculations for the scientists working at Los Alamos on the A-bomb. Machine computers replaced human computers. Now computing is much less important for most businesses than the functions of the librarian and the reporter. The relational model is the most effective effort to date to build machine librarians and reporters.

See also: Data, Data-Base Management System, Structured Query Language

Response Time The quality of a system from a user's perspective is strongly dependent on response time, the time it takes the system to respond to a request. Network managers and designers of on-line services set response time as a service measure, aiming at X seconds response in Y percent of cases, typically, three to five seconds in 95 percent of transactions. Heavy traffic on a network or a large number of transactions accessing the same software or data base can quickly degrade response time. Few business applications require single-second response time (human response
time is much slower as they reflect and make their next choice). But when response time approaches 15 seconds, user patience begins to be taxed.

See also: Automated Teller Machine, Computerized Reservation System, Electronic Funds Transfer at Point of Sale, On-Line Transaction Processing, Terminal, User

RISC  See Reduced Instruction Set Computing

ROM  See Read Only Memory

Routers  See Bridges, Routers, and Gateways

**Satellite** Communication satellites move in a geosynchronous orbit 22,300 miles above the earth, which makes them stationary from the perspective of terrestrial facilities. Information is transmitted as very high frequency radio signals (in the gigahertz range) to a satellite’s transponder, which boosts the signals and transmits them back down to any receiving antenna within its broadcast range (termed its footprint). Satellites are used by television stations to broadcast programming to millions of television sets and by businesses to broadcast data bases, training programs, management reviews, and product announcements to any number of offices and personal computers. Ground stations can also initiate transactions, which are routed by satellite to a central computer.

Satellite transmission has two advantages over “terrestrial” transmission: (1) the costs are the same whether two or two million downlinks are receiving the information being broadcast, and (2) they do not require massive infrastructure investments in cables. This makes them very well suited to serving the communications needs of countries such as India and Indonesia, in which the principal business, government, and university centers are separated by vast distances. A disadvantage of satellite communication is the “propagation” delay of one-quarter second, the time it takes a transmission to make the nearly 50,000-mile round trip. The main advantages of satellites over “terrestrial” transmission are they do not need an expensive investment in a national infrastructure, and they can be used for broadcasting data; adding another earth station receiver does not add any transmission cost. Countries like Indonesia and India could not possibly afford to install fiber optics across their broad geographic spread. A third advantage, of course, is that satellites can send messages to ships at sea and airplanes in flight.
The international satellite market is intensely political and dominated by one organization, Intelsat, which is jointly owned by 114 countries. U.S. telecommunications providers were required from the 1960s until the 1980s to send a large proportion of their international traffic over Intelsat’s 13 satellites. Satellite communication will face greater competition as the economies of fiber optics, which also provide massive bandwidth, become more attractive. Satellite transmission technology has not changed as dramatically over the past decade as that of terrestrial communications and computer hardware. Part of this is due to civilian satellite services, which represent the commercial rather than the research state of the art. Military technology is typically 10 to 20 years ahead. For instance, the civilian LANDSAT can provide images that show the general features of a wooded area, but a military satellite designed to spot a tank on the ground can pick out individual trees.

The cutbacks in Defense Department expenditures after the collapse of the Soviet bloc has decreased the value of this costly military capacity. Many initiatives are underway to convert the technology for civilian use. The high-resolution images, for instance, can be invaluable for scientists studying problems of ocean warming and soil erosion. One successful innovation is GPS, Global Positioning System, a satellite service that pinpoints on a map the location of a car, boat, or even a bicycle within 20 square meters. This is an option that can be accessed via a PC with a special card.

Civilian technology was badly affected by the Challenger Space Shuttle disaster in 1988. For the next three to four years, there were no launches of new satellites except for military purposes. China and the European Diane consortium offered low-cost launches of smaller satellites.

The next generation of “supersats” is on its way. Hughes, among others, has launched Direct Broadcast Satellites. These offer 100 channels of broadcasting that can be picked up by a two-foot diameter antenna. Motorola’s Iridium project is at last
making progress in funding its ambitious low-earth orbit satellite (LEOS) network that will literally create a global cellular phone service. Very small aperture terminals (VSAT) are widely used in retailing to provide even the smallest store with first-rate communications links between the head office for ordering, pricing, inventory, and other information.

PTTs and foreign governments have generally restricted business and consumer access to satellites because they cannot easily control their use, any more than Saddam Hussein could stop CNN from sending pictures of the Gulf War by satellite using portable “fly away” dishes. Britain, in the early 1990s, opened up competition to permit almost any telecommunications company, cable provider, or satellite entertainment service to offer movies, but it censoriously blocked pornographic films. How do you prevent a British satellite from receiving dirty movies broadcast unscrambled from the Netherlands, just a few hundred miles away? How can U.S. satellite TV providers, such as HBO, prevent their signals from being received in Mexico? They can’t and this is why, despite Mexico’s tedious government-dominated television services, the city with the reported highest number of satellite dishes per capita in the world is Monterrey, Mexico’s dynamic commercial center.

See also: Bandwidth, Business Television, International Telecommunications, Megahertz, Mobile Communication, Telecommunications, Transmission, Videoconferencing, Very Small Aperture Terminal

Scanner See Image Technology

Security All electronic services face a conflict between access and control. The purpose of ATMs, electronic mail, and on-line information systems is to provide easy and convenient access to information, which makes control of that information difficult.

Passwords are a means of restricting access to information to authorized users. They are a primitive form of security that can generally be broken by skilled hackers. Encryption is a technique
The results of a November 1993 survey of 100 data security managers showed that 80 percent felt that companies face much bigger security risks now than two years before. Half knew of at least one instance of unauthorized access, with disgruntled employees more a problem than "hackers" trying to break in.

for scrambling information to make it unintelligible during transmission. Encryption can add another level of protection to passwords by preventing an accidental intruder, hacker, or computer criminal who gains access to information from making any sense of it. An emerging strategy of large financial services and telecommunications companies is to develop expert systems that scan for patterns of activity that suggest misuse. Network management software is also providing more in the way of "sentinel" facilities, audit controls, and so forth.

Security is a time bomb. Many of today's IT systems are about as secure as alarms and locks on Porsches in New York City; they deter amateurs but are easy for professionals to break into. Online services are particularly vulnerable to deliberate attacks on security and credit card and telephone calling card fraud and ATM thefts run into many billions of dollars per year.

Most surveys of security issues emphasize that negligence and incompetence are greater problems than computer hackers, criminals, or "viruses" (hidden programs introduced into a computer system for the purpose of damaging other programs and data files). The biggest single impediment to ensuring security is business management's lack of real interest in the topic. Many companies have no effective protection against accidental loss of service, deliberate intrusion, and sustained efforts to steal information and money electronically.

Most surveys report that information managers feel their companies have nowhere near adequate security for key systems and that senior management and budget approvers are largely unwilling to spend money on it. Security is as much a management discipline as a technical issue. It is rather like buying flood insurance for your home; you may never need it, but if you ever do...

See also: Architecture, Backup and Recovery, Encryption, Mobile Communication, Network, Virus

Servers Servers are computers that, as the word suggests, provide services to clients—hence the term client/server computing,
which is emerging as mainstream technology for organizations moving away from large-scale mainframes to lower-cost microprocessor technology and high-speed telecommunications links. These links share information and software (stored on file and application servers) and connect users to each other and to remote software and communications services (communications servers).

Basically, a server is a specialized, souped-up PC with lots of connections for communications links, far more speed, internal memory, and disk storage so that it can efficiently serve many users at once. Servers also have a wide range of software features that remove the need to install an operating system on each PC. Instead, the server provides a central management capability. Souping up the hardware means adding chips to give a PC race car speed and efficiency.

The same firms that are leaders in PC hardware are competing for the same spot in the server market, obviously because top-end machines provide higher prices and profit margins than do commodity desktop PCs. Compaq, Dell, Hewlett-Packard, and IBM are thus all players. Software companies also provide server packages, targeted to work with specific computer operating systems, data-base management systems, or groupware systems. Servers are highly specialized devices that vary widely in capability and cost. A $2,500 PC is big and fast enough for a small department, but a heavy-duty server that links workstations to data bases with high transaction volumes can add several zeroes to that price. For example, Hewlett-Packard's HP 9000 E-Class server, targeted to small businesses, costs $4,000. Sun's SPARCcenter 2000 server costs $1.2 million and is targeted at the same business applications as the smaller HP machine, but it handles far more users.

Personal computers have created a revolution in providing computing power at your fingertips. Servers in many ways create an even bigger revolution by bringing information, applications, and communications to those fingers.
Shell  See Artificial Intelligence

Smart Card  Often thought of as a credit card with an embed-
ded computer chip, a smart card is, in effect, a personal computer
in a wallet. To date, there have been only scattered applications
of the smart card, but many commentators see a wide range of
opportunities in a device that contains enough memory to store
records and handle transactions without the need for telecommu-
nications links to remote facilities.

Every year, articles appear in the IT press that announce that
this really will be the year of the smart card. We have yet to see
it. Smart cards are a solution searching for the right problem.
There have been many successful small-scale applications but no
single blockbuster application capable of moving smart cards into
the mainstream of business and consumer use.

A smart card is effectively a key that is inserted into a work-
station, pay phone, ATM, or other access point to obtain IT-based
services. The card’s memory can store profile information, up-
date balances, and incorporate security features.

The Royal Bank of Canada uses smart cards to control access
to its cash management services. The cards contain a portion of
the program instructions for cash management transaction pro-
cessing and an encryption feature that scrambles the transaction
information. The system works only if the smart card is on-line at
the cash management workstation.

Pay telephones in France have for several years accepted smart
cards that store a prepaid amount of money. The cost of a call is
deducted from the amount remaining on the card. Many ob-
servers see such debit cards as the principal long-term opportu-
nity for smart cards.

The most extensive application of smart card technology to
date in the United States is the Department of Agriculture’s program
for managing government-supported quotas for peanut growers. Each
farmer in the program is provided with a smart card con-
taining agreed-on quota and price information. As farmers sell
their crops, sale amounts are deducted from the quotas on their cards and the transactions are approved and processed directly on the basis of the stored card data. The system has cut the time needed to complete the processing of crop sales from two weeks to less than 15 minutes.

See also: Chip, Encryption, Security

Sockets  See Cables, Plugs, and Sockets

Software  Software is what gives hardware functionality. There are three major classes of software. Systems software handles operating system and related functions that provide the facilities for application software to run efficiently. Customized application software for specific business functions is developed by business analysts and programmers. Application software packages, designed to serve more generic needs, often must be modified to meet company-specific requirements.

Customized application software development is expensive and a major bottleneck in many firms. Software productivity has not kept pace with improvements in the cost-effectiveness of hardware, largely because, being intellectually difficult to master, manage, maintain, and document, it is dependent on skilled and experienced human staff. Computers are typically replaced every two years by faster, less-expensive, and more powerful machines, but the software that runs on them may be several decades old.

Software and services account for more than half of the worldwide $500-billion computer industry. One multinational firm calculates that it has in use today more than 30,000 programs with 70 million lines of code that cost more than $1 billion to create and that would require $3 billion to $7 billion to replicate. This is not unusual. Because software development is expensed (the major cost is salaries), it does not appear on firms’ balance sheets. Many Fortune 1000 firms have spent a billion dollars or more to create software and do not know it. If they did, senior management might recognize that software is a major capital asset that
should be managed as such, and devote more time and attention to it.

Software, especially the operating systems that are the brain that makes the computer run, has historically been a preserve of the English language. Even the French, linguistic chauvinists to an extreme, speak of typing "le back slash" and writing "un do loop." Increasingly, though, software development has become a worldwide industry. India in particular has for decades aimed at becoming a world leader in software exports. One major U.S. retail chain used an Indian firm to build a system for $500,000 that would have cost $1 million to develop in-house and $1.5 million using a U.S. software company. While still small, the market for overseas development is growing at 50 percent a year. There are many problems in coordinating such development, and some firms have horror stories to tell. Where close coordination and collaboration with users is key, having programmers working 8,000 miles away is a massive risk.

U.S. programmers are 5 to 10 times more expensive than those in Latin America and developing countries in Asia, but most of them are not 5 to 10 times better.

See also: Application Software and Application Development, Computer-Aided Software Engineering, Programming, Prototyping, Systems Programming, Testing

Spreadsheet  See Software

SQL  See Structured Query Language

Standards  Standards are agreements on formats, procedures, and interfaces that permit designers of hardware, software, data bases, and telecommunications facilities to develop products and systems independent of one another with the assurance that they will be compatible with any other product or system that adheres to the same standards. They are the single most important ele-
ment in achieving integration of the corporate information and communications resource.

The standard-setting process—because it involves negotiations among IT providers and users, formal agreements and definitions, certification and testing procedures, and documentation and publication—can be extraordinarily cumbersome and lengthy. It can take more than a decade to complete the process of defining a standard and implementing it in commercial products.

A recent report identified nearly 50 committees and organizations involved in setting standards for international telecommunications. It should not be surprising that the work of so many different entities often overlaps and conflicts. Literally thousands of standards exist for the principal elements of information technology. Being voluntary, these standards have no legal weight, hence they are not enforceable except by government agencies and companies that mandate compliance with particular standards as a precondition for bidding on contracts.

Committee-based organizations such as the American National Standards Institute (ANSI) and its international equivalents, the International Standards Organization (ISO) and Consultative Committee for International Telegraphy and Telephony (CCITT), have historically dominated the standard-setting process. But because technology is today evolving too fast for the slow, debate-oriented, and often contention-ridden committee process (which tends to be dominated by academics, vendors, and the largely quasi-government national telecommunications providers), computer and telecommunications vendors and leading users and industry groups are playing a growing role both in defining standards and influencing their adoption in the marketplace. Examples include the U.S. Department of Defense, which defined its own standard for programming languages and established a list of requirements that contractors must follow, and the U.S. grocery and transportation and European automotive industries (among others), which have established electronic data interchange standards to govern intercompany transactions.

Standards take time. They often lag the products that need to use them. The first wireless local area network products hit the market in 1990. In April 1991, a standards subcommittee was formed by the Institute of Electrical and Electronics Engineers. In June 1993, it received 11 proposals. In September 1993, Xerox and NCR combined these in a proposed new standard called DFWMAC (Distributed Foundation Wireless Medium Access Control), which was approved by the standards committee. It was approved by ISO (International Standards Organization) in 1994. DFWMAC products are expected to come onto the market in 1995.

In November 1993, an observer of this process commented that the MAC group had made little progress because of "the religious wars going on among the different protocol camps."
Standards establish the pace for what is practical for business, yet many leading U.S. companies are unfamiliar with the standard-setting process and the industry groups that coordinate and try to influence it. Individual businesses are now beginning to take a more active role. A group nicknamed the Houston 30, for example, established the User Alliance for Open Systems, and vendors and users alike have joined organizations such as the Open Systems Foundation and the Corporation for Open Systems, though with varying success and influence. The technology and technical innovators rarely slow down to meet committees' needs and pace of progress.

To remedy heretofore weak representation in the standard-setting process, U.S. companies should encourage senior Information Services staff to participate actively in user and industry standards groups. The perspectives and priorities of business users are often very different from those of the national telecommunications authorities and computer vendors that have historically dominated the standard-setting process. Business must drive what is increasingly a business issue.

The tight control that national government monopoly PTTs have held over telecommunications standard-setting committees is a substantial reason why leading developed nations, such as France and Germany, have not made it a priority to give businesses access to high-reliability, high-speed, low-cost communications.

U.S. vendors are obviously interested in standards, sometimes lobbying for their own interests and/or products. At other times they cooperate to prevent unnecessary, costly, and in the end ineffectual proliferation of multiple competing systems. Also, U.S. vendors work to ensure a uniform blueprint for individual design, implementation, and competition.

Some of the more prominent standards relevant to the design of a firm's information systems architecture are described briefly below. Those elaborated more fully in separate entries are listed in the "see also" reference.
EDIFACT, the leading standard for international electronic data interchange, includes procedures for defining trade- and industry-specific EDI standards. To date, EDIFACT has generated more than 50 message sets that cover the most important and common types of international transactions in trade, transport, banking, insurance, customs, construction, and tourism.

Ethernet, a local area network standard initially developed by Xerox, is today widely implemented in commercial products. Ethernet is particularly well suited to connecting workstations and departmental computers that traffic heavily in messages that are brief and intermittent. Recent extensions of Ethernet such as 10Base-10 and the proposed fast Ethernet keep it in the mainstream of business use.

OSI (Open Systems Interconnection) is a blueprint for resolving problems of incompatibility. It creates a "reference model" that allows designers of telecommunications networks and networking equipment to develop products and services that are able to interconnect independently of the technology used. OSI establishes interfaces at seven levels: the lowest governs physical interconnections; the highest, interconnections between applications.

X12 is the principal domestic technical standard for electronic data interchange. It is closely related to EDIFACT, and the basis for most industry cooperative agreements on standards for EDI transactions.

X.25 is the principal standard for public data networks and international telecommunications. It is by far the best-established standard for wide area networks. Newer standards, notably frame relay, are extending X.25 to take advantage of tremendous improvements in reliability and speed of transmission since X.25 was defined in the 1970s.

X.400 is an important emerging standard for all forms of electronic messaging, including electronic mail, telex, and fax. Defined in 1984, X.400 began to be widely implemented by leading electronic mail service and software providers in the early 1990s.
X.500 is an emerging standard that defines electronic network directories for purposes of allowing devices on different networks to locate one another. Thus it will eventually provide a basis for automatic linkages across international networks, an impossibility today.

IEEE 802.1, 802.2 . . . 802.5 are standards for local area networks defined by the Institute of Electrical and Electronic Engineers (IEEE). Key standards from a business perspective are 802.3 (Ethernet) and 802.5 (Token Ring).

FDDI (Fiber Distributed Data Interface) is the fiber equivalent of IEEE 803. CDDI (Copper DDI) took away much of its momentum by offering equal performance over existing cable.


Structured Query Language (SQL) Structured Query Language, or SQL, has become the standard interface for relational data-base management systems, including those that run on personal computers. It enables a user to access information without knowing where it is located or how it is structured. SQL is easier to use than a programming language but more complex than spreadsheet or word processing software. A simple SQL statement may generate a set of requests for information stored on different computers in scattered locations, and hence consume a significant amount of time and computing resources. SQL can be used for interactive inquiries or ad hoc report generation or embedded in application programs.

See also: Data, Relational Data Base

Subnotebook Computer Smaller is more beautiful is the watchword of the personal computer marketplace. Subnotebooks
are portable computers that weigh under four pounds and easily fit into whatever the user carries when traveling. The main limitation to reducing size is that average-sized adults find the tiny keyboards difficult to use. Other compromises, such as screen size and lighting, also must be made, but the new generation of subnotebooks have as many features and are faster than the desktop computers of five years ago.

A computer has only a small number of key components; the rest is packaging. It needs a flat sheet on which are glued sets of chips and connectors, including the central processing unit (CPU) chip, and random access memory (RAM) chips that determine the speed and capacity of the machine. Other chips handle specialized functions, such as synchronizing the flow of data between the RAM, CPU, display screen, and disk storage unit. On top of that flat sheet is placed the keyboard, and the screen folds up and down over it, like a book on its side. The third key component is the hard disk unit that stores data and programs. That typically fits snugly between the chip sheet and keyboard layers of the machine.

**Supercomputer** Supercomputers are ultra high-speed “number crunchers” used primarily for scientific and engineering applications. The new generation of supercomputers differs from conventional mainframe computers in its use of parallel processing. A business computer processes instructions one at a time in a single CPU. Parallel processing involves the use of up to thousands of small CPUs to simultaneously process the parts of a mathematical task that have been broken down into many sub-tasks. The difference is like asking someone to find all the names in a telephone directory for which the first name is “James.” A conventional computer would begin at “A” and move page by page through “Z.” A parallel processing machine would assign page 1 to microprocessor 1, page 2 to processor 2, and so on.

The hardware, operating systems, and application software for...
supercomputers are entirely different from those for standard business computers. Most companies will never need a supercomputer. But computer-aided design in manufacturing, micro-economic analysis, bond pricing in the securities industry, and even animation for films are moving supercomputers out of the lab. Parallel processing may be a major direction for handling very large scale data bases.

See also: Computer-Aided Design/Computer-Aided Manufacturing, Mainframe and Minicomputer

**Switch** Telecommunications transmission relies on techniques for sharing a high-speed link among many slower devices and routing messages through a network along the most efficient transmission path. Switch is a generic term for the hardware that manages the traffic routing and transmission. These devices include multiplexers, PBX (private branch exchange) and ISDN switches, and such related devices are cluster controllers, X.25 PADs (packet assemblers/disassemblers), and ACDs (automatic call distributors).

Switches coordinate and synchronize the operations of a network. They are very expensive and their selection, implementation, and operation demand highly specialized technical expertise. One of the key factors influencing a firm’s choice of private versus public networks and in-house operations versus outsourcing is the capital cost and skill base needed to manage an advanced telecommunications network. Having someone else handle the complexities of the technology may be a sensible choice for many firms, but others feel that they can achieve a comparative cost or even competitive advantage by designing and managing their own networks.

See also: Network, Network Management, Telecommunications

**Synchronous Optical Network (SONET)** See Bandwidth, Fiber Optics
**Systems Development** See Application Software and Application Development

**Systems Integration** Systems integration refers to providing a technical solution to a business need that involves fitting together the relevant technical components. These generally include existing incompatible hardware, software, and data bases as well as new systems. The rapid growth of the systems integration market reflects the degree of systems disintegration in most large firms. Incompatible systems have become a blockage to business effectiveness by preventing the cross-linking of services and the sharing of information and communication networks.

The systems integrators that deliver fully integrated systems of software, hardware, and telecommunications are an outgrowth of the systems development contractors of the 1980s that built software systems for client firms’ mainframe computers. Systems integration is thus neither new nor special. What is new is the growth of a small number of firms competing to establish themselves as leaders in a fast-growing and very large market. The Big Eight accounting firms (down to six following several mergers) saw early the opportunity to add systems integration to their auditing and consulting base. Andersen Consulting, an offshoot of Arthur Andersen and Company, is the third-largest single systems integrator, behind IBM and EDS. Major computer vendors, including IBM and Digital Equipment Corporation, seeing systems integration as a priority market, are accepting that they must be able to provide skills in other vendors’ products as well as their own.

The systems integration market is growing at close to 20 percent per year, far faster than the overall IT market, primarily because firms have neither the skills nor the spare development staff to handle the often massive projects they need to undertake to position themselves for the business context of the 1990s. Information Systems units are increasingly multisourcing their
development, handling some in-house, contracting some out to systems integrators, handling some through joint ventures, often with firms that have already implemented the main base for a system they can use and outsourcing some operations for fixed annual fees.

The reality of applications development has always been that demand exceeds supply of skilled staff. As long as business needs drive the demand for integrated systems to meet the demands of cross-functional business coordination and development, the systems integration market will continue to expand.

**See also:** Architecture, Compatibility, Integration, Open Systems, Platform

**Systems Life Cycle** Systems life cycle refers to the sequence of steps from the inception of a new application to its eventual termination and replacement. The main phases and the amount of development time they should take are planning and design, 40 percent; program coding, 10 percent; testing, 30 percent; and installation, 20 percent. In the five years after development, maintenance and operations will cost from 100 to 300 percent of the original development cost. Exact percentages will vary, of course, depending on the type of application, but these numbers should hold for most large-scale application development projects.

The most important point to note is that programming represents just 10 percent of total development effort. Testing, by comparison, accounts for three times as much time and effort. In the early days of application development, programming was the main focus of planning and budgeting. The new profession was, after all, called computer “programming.” But over time it became apparent that this focus was totally inappropriate. A complex system requires very detailed planning, and design issues must address ease of use and flexibility. Furthermore, specifications must be checked and rechecked because the cost of correcting errors is greater the later into the development process they
are discovered. An error that costs $1 to correct in the planning and design stage costs $10 to correct in the programming stage, $100 in the testing stage, and $1,000 after the system is operational.

The length of time major systems development projects take can be very frustrating for business managers who need them operational as soon as possible. But pressures to cut corners and speed up projects generally add to the cost in the long run. Bugs that are not located in the testing process will turn up when they will not only be more expensive to correct, but when they may damage customer service and operations.

**Systems Programming** Systems programmers are technical specialists in some aspect of operating systems, data-base management systems, or telecommunications network software. These are the technical wizards whose job is to ensure efficient operation of the overall IT resource. Their knowledge is generally highly specific in terms of vendors and operating systems, and most have a strong computer science background and little interest in the business issues that concern applications programmers.

Systems programmers play a critical role in firms where cash flow depends on the quality of their IT operations. When a bank's ATM network is down, so is the bank. With the emphasis on Information Systems departments being service- and business-oriented and bridging the historical culture and attitude gaps between IS and its business users, there is a tendency to dismiss or even disdain "techies." But the more complex a firm's IT base and the more critical it is to business operations, the more vital it is that the firm have access to the best systems specialists.

Skilled systems programmers and their equivalents in telecommunications are becoming harder to find, reflecting a nearly one-third decline in enrollments in computer science in U.S. universities in the past five years. Meanwhile the technology con-
continues to develop at a dizzying pace, making it hard for experienced systems programmers to keep up-to-date in their field.

See also: Computer-Aided Software Engineering, Network Management, Operating System, Programming

**TCP/IP** TCP/IP (telecommunications communication protocol/Internet protocol) is a standard for sending data communications messages across networks. It lacks features for diagnosing and correcting errors and for ensuring security. Its strength is its simplicity and that it is designed for the UNIX operating system environment that is as central to scientific, engineering, and academic computing as Windows and DOS are for business and personal computing. TCP/IP is the key standard for the Internet, the rapidly growing—ever explosively growing—foundation of the Information Superhighway.

See also: Information Superhighway, Internet

**Telecommunications** Telecommunications is the electronic movement of information. Telecommunications used to imply telephones, telex, and a much slower and more expensive facsimile than we are familiar with today. A rough rule of thumb that held through the mid-1970s was that voice accounted for 85 percent of a company's communications traffic. The remainder, largely digital data generated by computers, was distinguished as "data communications," and had to be converted to analog form by a device called a modem before being transmitted over the telephone network, often using leased lines specially conditioned for data traffic.

Today, the proportions are reversing. Data communications traffic generated by computers has become a key element in business operations. As a result, telecommunications providers are scrambling to convert the communications infrastructure to digital and evolve standards that will accommodate the simultaneous transmission of voice and data traffic over the same lines. (This is being done to a limited extent today.)
Until recently, telecommunications has embodied a separate set of skills and experience and has been a separate organizational unit from Information Systems. Few heads of IS have come up through the telecommunications field, which, until the late 1980s, tended to be a specialist area heavily focused on the highly complex technical details of telecommunications operations, with little emphasis on business planning and Information Systems strategies.

Changing this situation is becoming a priority for many organizations as the perception of telecommunications shifts from that of a support technology to that of an infrastructure technology that provides a base, or platform, for computing applications. Most major issues in standards, integration, and architecture center around telecommunications; networking, rather than computing, now drives most major initiatives in the business deployment of information technology.

Telecommunications is a major political issue internationally, because every country except the United States has historically run its telecommunications system by a quasi-government monopoly that did not permit competition. Thus companies have had little choice in telecommunications, and prices and use have been highly regulated. The trend toward liberalization in telecommunications is well established today. Liberalization permits limited competition and choice, but retains monopoly regulation. Some countries have entirely deregulated or even privatized their PTTs.

See also: Architecture, Backbone Network, International Telecommunications, Network, Network Management, Platform, Standards, Terminal, Transmission

**Terminal** Terminals are devices that access remote computer services via a telecommunications link. The term has become obsolete as personal computers combine “stand-alone” capabilities (word processing, spreadsheets, etc.) with communications. Computer terminals first allowed flexible, occasional, ad hoc access to

*Each dollar invested in an undeveloped country's telecommunications infrastructure generates about $16 in new GNP. Nowhere is such stimulus more needed than in Africa. AT&T proposes to wire the entire continent by 1997 for the relatively small cost of $1 billion to $1.5 billion. AT&T will use its excess capacity of submarine cable-laying ships to surround Africa with a 20,000-mile-long fiber optics cable with links to 39 shore locations.*
central information stores and "time-shared" computer processing. Early computers processed work sequentially, one task at a time. Time-sharing divided a computer's processing among many tasks simultaneously, and computer terminals provided a way to submit work remotely, from locations physically removed from the computer. Except when the location was close enough to be cabled directly to the computer, the connection was usually established over telephone lines using a modem. Early terminals were typewriter-like devices; later terminals incorporated video displays, giving them much the same appearance as today's personal computers. Terminals are distinguished from PCs in that they can do no processing independently of their connection to a computer. (Exceptions were so-called smart terminals that possessed some storage or limited processing capability; they constituted an intermediate stage in the evolution of the personal computer.)

See also: Data Center, Mainframe and Minicomputer, On-Line Transaction Processing, Personal Computer, Response Time, Telecommunications

Testing Any large-scale application system will inevitably contain errors, or "bugs," as they are known in the trade. The testing phase of development aims at finding as many bugs as possible before a system is released. But even with the most rigorous testing, at least four errors per thousand lines of code will typically be found in an operational system during its first 12 months of use.

Testing is done primarily by running sample transactions—routine transactions, special cases, and deliberate mistakes—through the system in a systematic manner. Programmers can check the logic of a program to ensure that calculations are made according to the design specifications, but only people who are familiar with the business and work context can spot output that looks correct but is not, or can anticipate unusual but occasional combinations of inputs that need to be tested. Testing a system generally takes three times as much time and effort as writing the program code.
There is no substitute for testing. Professional programmers are well aware of the need for it and of the arcane and tiny bugs that can crash a program. Personal computer users may not be aware that even the simplest spreadsheet may contain bugs and that it needs careful testing.

See also: Application Software and Application Development, Bugs, Maintenance, Programming, Systems Life Cycle

**Token Ring** The Token Ring standard was an important development in the evolution of local area networking and constitutes the principal rival to the popular Ethernet standard. Token Ring is the basis for IBM local area networks and their integration into wide area networks.

See also: Ethernet, Local Area Network, Network, Standards

**Transmission** Transmission refers to the movement of information through a telecommunications network. It is concerned with establishing links over which to send information and ensuring that it arrives accurately and reliably. The medium used to create the path between the sending and receiving device may be some type of physical cable or through-the-air radio signal. Copper cable, fiber optics, satellite, and microwave are all equivalent in that each provides the means to carry a signal.

Transmission links may be point-to-point, which means that a single device links to another single device as in a telephone call, or point-to-multipoint, in which one sender transmits to many receivers, as in broadcast television.

Transmission speeds are measured in bits per second (bps). Dial-up telephone lines typically operate at speeds of up to 9,600 bps. The fiber optic links that are expected to be the base of the networks of the middle to late 1990s will provide speeds in excess of two billion bps (2 Gbps). These high-speed transmission links will be shared among many simultaneous users through techniques called multiplexing. One related technique, called packet-switching, is the basis for most international public data networks.

Telecommunications providers have mainly focused on transmission—moving bits from sender to receiver. They were not interested in the nature of those bits and of the applications they were part of. There is a widespread feeling among most IS and business managers that they need to broaden their thinking and their services.
that use the X.25 technical standard designed to provide low-cost transmission to thousands of users at the cost of some loss of efficiency in throughput. Fast packet-switching techniques, particularly one called asynchronous transfer mode (ATM), provide low-cost, exponentially faster transmission. ATM is the revolution of the 1990s that follows and builds on the revolution of fiber optics in the 1980s.

See also: Cables, Plugs, and Sockets; Cellular Communication; Connectivity; Digital; Encryption; Fiber Optics; International Telecommunications; Megahertz; Mobile Communication; Modem; Network; Packet-Switching; Protocol; Regional Bell Operating Companies; Response Time; Satellite; Security; Standards; Switch; Telecommunications

UNIX UNIX is an operating system, a religion, a political movement, and a mass of committees. It has been a favorite operating system of technical experts for many years, owing to its "portability" across different operating environments and hardware, its support of "multitasking" (running a number of different programs at the same time), and its building-block philosophy of systems development (building libraries of small "blocks" from which complex systems can be built).

UNIX was developed in the early 1970s by Bell Labs, which licensed it for general use. Recently, UNIX has moved out of specialized scientific and academic environments. It has become very popular in engineering and manufacturing.

Proponents see UNIX as providing four distinctive advantages. One, it is designed for maximum practical vendor-independence and portability across machines, which makes it a potential cornerstone for truly open systems. Two, it exploits the many developments in hardware and communications that have marked the past decade better than proprietary operating systems that have had to ensure that old software could continue to run, however inefficiently, on newer hardware. Three, its strength in "multitasking," or running a number of applications concurrently at a single workstation, makes it the best available choice for
client/server computing. And four, its Lego-block philosophy of developing small units of code that can be combined and shared has resulted in the compilation of rich libraries of routines.

Although technically an "open" system, there are many varieties of UNIX, and the two leading vendor consortia trying to develop a single version are in open conflict. The UNIX International Group comprises the old guard of UNIX, developer AT&T, and the companies that have been committed to it through the 1980s. The Open Software Foundation includes recent converts to UNIX such as IBM and Digital Equipment Corporation. The core of the latter's UNIX standard includes additional features that make it essentially competitive and incompatible with the other group's standard. Novell, the leader in local area network operating systems, acquired the long-established UNIX Labs, with the announced intention of unifying the UNIX world (and striking a blow at Microsoft, its competitor, for control of the link between the desktop workstation and the enterprise network), by transferring the UNIX trademark that it had bought from AT&T in 1993 to yet another group X/open, but with strings attached in how it would be used. One computer executive commented that the UNIX community is anxious to unify UNIX, but "we are all interested in keeping our own technologies." One observer added that he was sure Bill Gates, the chairman of Microsoft, was enjoying the civil war about a supposedly open standard.

Because vendors naturally add functions to differentiate their versions, UNIX has become an example of a standard that is open in definition but, to date at least, proprietary in implementation. MS.DOS, by contrast, is proprietary in definition but open in implementation.

Many Information Services managers, for whom the commonalities in UNIX implementations far outweigh the differences, see it as the cutting edge of information technology. Others are more circumspect. A frequent criticism of UNIX is that it is basically geared to technical applications, reflecting its origins at Bell Labs and its strong history of university use and development. Skeptics,
pointing to a lack of applications and of development staff experienced in commercial applications, doubt that it will be useful or practical to move existing systems onto a UNIX platform. It will be at least five years before we know if UNIX is just another niche in the broader IT field or a key driving force.

Now that IBM has provided a powerful set of workstations based on its own version of UNIX and leading UNIX providers have developed linkages with IBM’s main operating systems and telecommunications architectures, UNIX is positioned to be part of a firm’s architecture. The religious wars can end and peaceful coexistence and exploitation of UNIX’s considerable power as a development tool and workstation environment can begin.

See also: Mainframe and Minicomputer; MS.DOS, Operating System, OS/2, Personal Computer, Workstation

User Users are an abstraction that Information Services professionals talk about either as the principal community they serve or the cross they bear. Users should be thought of as clients and colleagues. That the worlds of IS professionals and “real” people have historically been separate, both psychologically and physically, is a major impediment to doing so. Prior to the diffusion of personal computers, users had little contact with IS staff. Technical staff, hired for their aptitude and qualifications and promoted on the basis of the quality of their technical work, inhabited data centers often many miles removed from business offices.

Skilled technical people, especially in the most specialized areas of IT, still tend to be “different.” It is this difference, particularly the highly analytic and structured mode of thinking, that allows them to handle the complex and lengthy process of large-scale software development and makes them valuable to businesses. It became increasingly apparent in the early 1980s that many failures of new systems were attributable to lack of understanding of clients and their work and the absence of meaningful involvement in the design and implementation processes. Every first-rate Information Services organization began to create new
methods, groups, and services to bridge the IT-business culture divide. This has not been easy in terms of finding and building skills and developing career rewards, methods, and mutual understanding. A new style of “business analyst,” possessing hybrid skills and either strong business knowledge plus adequate technical capability, or vice-versa, has emerged in many IS groups.

It is no exaggeration to say that the effectiveness of any firm’s IT strategy is today determined more by organizational than by technical issues. IS leadership contributes most when it makes service and support a priority rather than a grudging necessity. Business managers contribute most when they assign skilled staff, not expendable mediocrities, to their IT activities and encourage real dialogue with the Information Systems unit.

See also: Data Center, End-User Computing

**User Friendly** In the IT context, user friendly is generally understood to mean that computer software or equipment is easy to use, incorporates a natural-seeming interface, and is flexible. The widespread use of the term notwithstanding, most people find computers hard to use. The more “functionality” a computer offers, in terms of range of options in use, modes of display, telecommunications, and peripheral devices, the more familiar the users have to be with the details of the operating system and hardware. True user friendliness means hiding details and handling all housekeeping and management functions so that users can concentrate on their work rather than on the computer. This is becoming a major problem in many businesses. Staff quickly learn to run, say, a spreadsheet program on a stand-alone personal computer. Later, they add a word processing package, a modem for accessing data and sending electronic mail, then a data-base management system and a laser printer. At some point the personal computer is linked to the department’s local area network. By this time, however user friendly the individual elements are, the aggregation of hardware, telecommunications facilities, and software has reached a level of complexity equivalent

*Computers are still hard to use, but they are less user hostile than last year. Every innovation that makes the user interface more “intuitive” moves the field forward.*
to that of a 1970s data processing department. Such a system must be supported by technical specialists and people who understand the details of its operation. Many Information Systems groups provide “hot lines,” which users can call with problems, and many business units are creating new support staff jobs.

Some general principles have emerged for making systems user friendly. The first, and perhaps most essential, is to eliminate the need for users to type instructions to the operating system. One way to do this is to present users with a pictorial, or graphical, choice of options. The graphical user interface (GUI) made popular by Apple’s Macintosh personal computer is an example of this. Microsoft’s Windows provides this style of user interface for IBM and IBM-compatible personal computers. The underlying principle of GUIs is to make systems use “intuitive” to users.

The second principle for increasing user friendliness is organizational. Firms standardizing on software for word processing, spreadsheets, and other widely used applications are not trying to control users or enforce uniformity, but rather to minimize problems of incompatibility between systems and make it easier to support users by enabling IS staff to move between departments without having to learn different systems.

Only users can testify that systems are user friendly. That is why they must be included in the design of any system that affects their work from the beginning of the project. No one can design a system for others without understanding how they work and think. The best way to do that is to make systems design a joint process and to use prototypes so that users can learn by using and developers by watching.

See also: End-User Computing, Prototyping, User Interface

**User Interface** User interface refers to the dialogue between a human being and a computer system. The traditional user interface is the keyboard, from which commands are typed into a computer. The innovation of the on-screen menu, which presents a selection of commands that may be invoked at any junc-
tion in an application, has saved newer users much page turning in software manuals. An evolution of the traditional menu displays options as graphical images, termed icons. This type of graphical user interface generally includes a mouse, a device attached to the personal computer that can be moved to position a pointer or cursor, over an icon. Clicking the mouse (pressing a button on the top of it) indicates that the item is to be selected.

Emerging types of user interface include tablets that may be written on with a special pen, light pens that can write directly on the computer screen, and voice commands to the computer. These are in the early stages of development; many improvements will be needed in hardware and software before they are ready for everyday use. Voice input, in which the computer recognizes spoken words, is improving rapidly and is likely to move into the mainstream of computer use during the coming decade.

See also: Bar Code, Graphical User Interface, Image Technology, MS.DOS

Value-Added Network (VAN) A value-added network, or VAN, is a network service that provides additional features to POTS, "plain old telephone service" or basic transmission links. VANs are the regulated domain of transmission suppliers and add value to ordinary transmission, including electronic data interchange services, electronic mail, and information services. They fall between the public networks that are available to any firm and the private networks leased by single companies from telecommunications suppliers.

In the international arena, VANs offer transnational firms many advantages. Because they provide "one-stop shopping," companies need not deal individually with each national PTT. Also, VANs' long-term agreements with international communications suppliers and their good working relationships with national telecommunications authorities spare users a potentially heavy burden in planning, negotiating, operating, and budgeting.

The major U.S. players in the international VAN market are
also the principal competitors in the domestic long-distance telephone market. Most entered the VAN market through acquisitions. AT&T bought the British firm Iste1 for more than $300 million. MCI acquired a position in Infonet, the fastest-growing international VAN provider (later sold off). But acquisitions work both ways, and British Telecom acquired U.S. Tymnet. VAN providers, which see the globalization of business as a tremendous opportunity and electronic data interchange as a major driver of growth, are prepared to wire the world.

*See also: International Telecommunications, Network, Telecommunications*

**VAN** See Value-Added Network

**Very Small Aperture Terminal (VSAT)** Very small aperture terminals, or VSATs, are satellite earth stations that are very small, typically five feet or less in diameter, enabling them to be located and relocated quickly, which provides opportunities for linking many locations where it would be impractical to run cables. As of 1994, a VSAT cost between $2,000 and $15,000 for the “dish” and about $60,000 for the master “hub,” which transmits and receives data.

Firms adopting VSAT technology are finding that it opens up new ways of thinking about business and organization. Imagine, for example, opening a bank of automated teller machines at a major sporting event, using a VSAT to link the ATMs to the central processing systems, or linking an oil exploration site to scientific computers for sending and analyzing seismic data. VSATs can update price lists in a retailing chain’s stores nightly, even those in rural locations. In engineering construction they can link a personal computer at a desert construction site to the head office. The Gulf War showed the importance and value of satellite communications in television reporting; CNN moved its dishes with its journalists.

VSAT is especially effective and cost efficient for organizations
that have many units—stores, branches, or offices—spread over a wide geographic area. For this reason the retailing industry has been the leader in deploying VSATs. Kmart, for instance, replaced its 29 separate telecommunications networks with a VSAT network that linked its headquarters with its 2,200 stores. The network is the firm's information highway. It handles a wide range of applications including the daily transmission of all purchasing and sales information sent to Kmart's central computers. Credit card authorizations that took from 3 to 15 minutes to process when telephone lines were jammed during the Christmas shopping period take 13 seconds with the network.

Kmart senior management is using the video capabilities of the VSAT network to repersonalize management. The firm calculates that visiting each store to meet and collect feedback from its 340,000 employees would take more than five years. The network has thus become the vehicle for these "visits." Kmart's 1988 financial results were announced by its chairman over the network, and store employees meet electronically with merchandisers.

Kmart estimates that the VSAT network is 30 percent less expensive than leased "terrestrial" lines and that the full cost of video broadcasting is a mere 50 cents per hour per store. Down-time is just half an hour per year. Kmart's figures match those of other VSAT users.

*See also:* Business Television, Distributed Systems, Mobile Communication, Satellite, Videoconferencing

**Videoconferencing** Videoconferencing uses telecommunications to bring people at physically remote locations together for meetings. Each location in a videoconferencing system needs a room equipped to send and receive video, generally via satellite. A typical room with video capability costs between $50,000 and $250,000. The cost of a one-hour California to New York City videoconference dropped from $750 in 1990 to just $250 in 1991. One maker of videoconferencing equipment now offers a complete system for less than $40,000.
Videoconferencing has been in wide use for several decades. A few companies have used it heavily throughout that time to manage projects across widely separated locations. But growth in general has been slow, partly because of cost, but more so because electronic meetings have tended to be seen as a simple substitute for travel, which is generally an inadequate justification for the capital investment required, or because people feel videoconferencing is no substitute for face-to-face meetings. Costs are now dropping rapidly, thanks largely to “codec” equipment that compresses the expensive transmission signal needed for television-quality conferencing. And in an era of VHS home cameras and video, most people are fully at ease, often to their surprise, when “on camera.” Now that PCs and local area networks can provide videoconferencing, both costs and ease of use are much more reasonable.

Videoconferencing helps organizations handle time, complexity, and distance; repersonalize leadership by enabling senior managers to meet more regularly with staff; and manage project and management review meetings and crises. Some examples of the value of videoconferencing were reported in the New York Times in early 1991. One manager described Air Products and Chemicals’ use of videoconferencing to link its Pennsylvania office to the Houston offices of Bechtel, with which it was working on a joint venture: “In some cases, we’ve cut weeks out of the whole construction process,” the manager explained; “we can get key people in two locations to sit down together, work through their problems and issues, and then go off and implement the changes without ever having been in the same room.”

Organizations that provide videoconferencing facilities that can be booked by the hour, often on one-day’s notice, span most major international cities. The cost is generally about the same as first-class airfare for one person.

Air travel is becoming more stressful, expensive, and inconvenient while business is becoming more dependent on teams working across functions, locations, countries, and even compa-
nies, and time-based competition and coordination are more of a priority. The experiences of the many firms that use videoconferencing for project and crisis management problem-solving, education, personalizing management, streamlining the bureaucracy, and eliminating delays that impede rapid coordination and decision making strongly demonstrate that business managers should examine it as a major opportunity to gain organizational advantage that can translate into competitive advantage.

See also: Business Television, Electronic Mail

**Video Dial Tone** Video dial tone refers to one of the major technical developments of the 1990s. From the perspective of your local phone company, this capability provides pay-per-view video into the home via "unshielded twisted pair"—the easily entangled phone wire that connects your telephone handset to the wall connector. Around 85 percent of the buildings in the United States have phones. Less than 40 percent have cable TV.

The phone wire has historically carried information at very slow rates, with high distortion ("noise"). By contrast, cable TV has from its inception used coaxial cable, which can carry huge amounts of information; a full-motion video carries thousands of times the amount of information per second than a phone call. Fiber optics cable has been viewed as the transmission medium of the future for cable companies. So in 1992 when TCI, the nation's largest cable firm, announced it was piloting a service that offered 500 channels on a single cable link, the industry greeted the news more with yawns than gasps of excitement.

Most commentators saw the cable industry as well positioned to offer multimedia services into the home because adding phone calls to their existing capacity would be relatively simple. But for the phone companies to add full-motion video, they would have to rebuild their infrastructures at a cost of at least $100 billion. Video dial tone changes the competitive picture and underlies much of the flurry of proposed, successful, and on-again-off-again mergers and acquisitions among cable and phone companies that
occurred in 1993 and 1994. The phone companies can be entertainment providers, too, and they have plenty of cash and access to low-cost capital.

**Videotex** Videotex is a general though obsolescent term for two-way interactive services delivered to users via personal computers or specially provided simple workstations. Videotex originated in Europe. It was expected to bring shopping, banking, newspapers, and masses of information directly into the home. With few exceptions, one being France Telecom’s famous Minitel, Videotex has been a bust. Minitel created a market by providing telephone subscribers with free terminals that were initially used for directory inquiries. Other information providers quickly added services, ranging from product information to sex clubs. Despite its widespread use, Minitel has been losing a great deal of money—an estimated $800 million in 1990.

U.S. efforts to create consumer videotex services have consistently failed, with large losses. Knight-Ridder, the newspaper chain, was able to enroll only 20,000 subscribers to its videotex service and wrote off more than $50 million. The Trintex consortium, established by Sears, IBM, and CBS, lost at least $300 million on its videotex venture, and NYNEX, a Regional Bell Operating Company, in 1991 abandoned its Info-Look Gateway Services, a collection of about 200 pay-as-you-go information services ranging from electronic bulletin boards to games to home shopping, which had managed to attract only 12,500 subscribers, fewer than 2,000 of whom used it regularly. The Prodigy service, the latest effort in this area, though it has yet to reach a break-even level of subscribers, has managed to gradually increase the number of its users over the past three years. Prodigy is a well-funded partnership of Sears and IBM that provides a wide range of services for a basic fee of $13 per month. The services include electronic mail, educational games, on-line encyclopedias, travel services (including direct use of American Airlines’ EAASY Sabre reservation system), numerous shopping opportunities (with home delivery),
film synopses and reviews, and business and financial services information, including discount security trading. The service can be accessed from any standard IBM, IBM-compatible, or Macintosh personal computer over a standard telephone line.

The principal problems with videotex have been cumbersome and slow communications and lack of consumer interest in the services being offered. Suppliers have yet to find the single self-justifying, immediate-benefit application. Cable TV companies may be able to find that application through multimedia, but the home equivalent of ATMs has yet to appear.

See also: Smart Card, Value-Added Network

**Virtual Reality (VR)** Computer folks love to use the word "virtual," which means apparent and contrasts with physical. Virtual reality creates an illusion of being in a three-dimensional world. That world is created by the computer, and viewed through a special headset that responds to your head movements, while a glove responds to hand gestures. In a virtual room, you may, for instance, move your hand up in order to fly or tap to change the color of a wall.

This is the material of science fiction, where virtual reality has been made the basis for entire new modes of living, in stories that are part of the "cyberpunk" genre of science fiction. A lot of research work is being done and prototypes are in use that are very futurist in their aims and claims, bombarding the brain with images, color, and music. Virtual reality will certainly have a major impact on entertainment, although today's systems are blurred and slow; even with expensive computers driving them, providing a clarity and speed of image that truly creates a reality is not yet possible.

That said, virtual reality is already providing benefits to a number of businesses. A Dutch system built for a construction company allows prospective buyers to "walk through" houses that have not yet been built and make changes to their design as they go; home sales immediately increased. Caterpillar uses VR for
workers to "operate" controls of a backhoe loader as if they are using the real thing. Caterpillar claims that where it previously took six months to a year to build a prototype vehicle, designers can now get one into the lab in a week. Rolls-Royce is replacing models of submarines with virtual reality systems where engineers can "enter" a virtual sub and verify design features.

Virtual reality is the next level in a well-established tradition: the use of simulation. As the Caterpillar and Rolls-Royce examples show, virtual reality replaces both physical models and designs that are displayed on a computer screen with as close to the real thing as the mind can imagine—or rather as it can be fooled into seeing. The main resistance to business use of VR is likely that it is seen as a new overhyped computer game.

**Virus** A virus is a software program that is intended to take over a computer's operation. Viruses are generally infiltrated into computers by "hackers" who understand some detail of the operating system that enables them to attach the virus to another program. At some point, often on a special date such as Christmas or April Fool's Day, the virus reveals itself, taking over and erasing files or multiplying itself and filling a computer or even a network of computers. Some viruses are harmless and merely display humorous messages, but others can create, as their name implies, a plague.

Hackers are individuals whose lives center around doing clever things with computers. Most are not computer criminals and few become involved in trying to introduce viruses into computers. But one way hackers can show off to their peers is by infiltrating supposedly secure systems. One of the best-known viruses was the work of a Cornell student who had no intention of doing damage, though his virus brought down university computers across the United States.

Viruses are a very real threat to companies. The damage they can do is literally incalculable. Many companies insist that only software bought directly from the company that developed it can
be installed on their computers. Special-purpose software programs are available that check for well-known viruses.

See also: Security

**Voice Recognition** Voice recognition refers to the ability of a computer to interpret spoken words. There are many applications in which the most efficient and simple way to communicate with computers is through speech. Air traffic controllers, bank tellers, and manufacturing production staff can use voice recognition capability to issue instructions to a computer naturally and quickly, leaving their hands free to operate other devices.

There are two aspects of voice recognition: understanding the word and understanding what it means. There has been rapid progress in the past few years in developing systems that can reliably recognize a limited vocabulary, distinguishing “one” from “three” and “nine,” for example. These systems can handle variations in voice pitch and even accent. They operate by comparing the speech input signal with stored patterns for given words and estimating the probability of match with each. This requires very large and very fast chips that can process the signals at least as fast as a person speaks.

Far more difficult is understanding the meaning of what is said. Consider the following sentence: “I want you right now to write a letter to Mr. Wright.” A prototype system developed by IBM can in fact input and display this sentence, spelled correctly, on its screen. But because the system requires massive computing power, it will be several years before systems like it are widely available to enable people to dictate memos to computers. But once a system works in the laboratory, however expensive it might be, it is almost certain to exploit the 20–30 percent annual improvement in the cost and power of computer hardware and rapidly move first to a limited system in terms of functionality and then to mass production.

**VSAT** See Very Small Aperture Terminal
Wide Area Network (WAN) A wide area network involves complex transmission facilities that link widely separated locations. In the early 1980s, high-speed transmission was pretty much limited to wide area networks. That has changed dramatically as fiber optics technology has driven rapid increases in the speed of local area networks. Local area networks, or LANs, have become the principal building block for many departmental uses of telecommunications, often with no forward planning for interconnecting separate LANs or linking them to wide area networks. LANs and WANs are based on fundamentally different technical bases.

The primary criteria for choosing a wide area network in the United States are cost and reliability. All major providers of private and public network services offer a wide range of high-speed facilities at aggressively competitive prices. Firms have four main options: (1) use the public network, which offers the most flexibility in terms of planning, since companies pay only for what they use and have access to a giant, nationwide resource; (2) contract with a transmission provider for a private, leased-line network that guarantees the firm a fixed level of capacity at a fixed price; (3) contract for a virtual private network, a technically sophisticated variant of a private network that provides greater flexibility in pricing and requires a smaller capital investment; and (4) install a VSAT private network that employs satellite transmission to connect hundreds or thousands of small earth-station “dishes.”

See also: International Telecommunications, Local Area Network, Network, Telecommunications, Transmission

Windows Microsoft’s Windows operating system has made the company the leader in the entire IT industry; Microsoft’s market value is now greater than IBM’s and it has been the target of federal antitrust investigations on the extent to which Windows drives the entire PC software industry.
Windows began as a catch-up extension of MS.DOS, the cumbersome operating system that IBM had licensed from Microsoft for its PC and that, in competition with IBM, was adopted by the masses of manufacturers that offered IBM "clones" at prices lower than IBM's. Apple's Macintosh operating system was not at all cumbersome and had set the pace for easy-to-use computing. This was built on its "graphical user interface," a visual look-and-point approach to interacting with the machine. Windows replicated it, with Apple suing for copyright infringement in a case that went on for years, with Windows selling millions of copies in the meantime. (Apple lost the case.)

The first versions of Windows were unsuccessful, but Windows 3.0 took over the PC market in the early 1990s. It was a very complex system, far more so than DOS, but with far more features. An entire industry of Windows-based applications flooded the market, including ones from Microsoft's main competitors. For instance, the ads for Lotus's SmartSuite combination of word processing, spreadsheet, graphics, data base, and groupware applications knocks Microsoft's Office equivalent but also states that it offers a "Better Vision for Windows."

In 1993, Microsoft launched its somewhat delayed NT—eNTerprise Windows and continued work on Windows 4.0, code named Cairo. NT had mixed reviews ranging from applause to downright panning. The battleground between NT, OS/2, UNIX, and Apple's next generation of PowerPC machines will be vicious. Business Week, in January 1994, commented that "competition that was merely torrid in 1993 will become cutthroat in 1994." The 1980s operating system battleground was for control of the desktop. The new one is for control of the network.

See also: Graphical User Interface, Operating System, User Interface

Word Processing Ten years ago, word processing was a major innovation. Today, it is commonplace. Then, word processors required specialized equipment. Now, word processing software packages are routinely run on personal computers. Word proc-
essing is by far the primary use of personal computers, with spreadsheet software second.

See also: Software

**Workstation** A personal computer or terminal that operates fairly continuously as part of a networked system is often called a workstation. But the term is also used more restrictively to refer to powerful, specialized microcomputers of the type used in engineering and design applications. Computer-aided engineering and computer-aided design workstations are capable of rapid simulation and calculation and have very high resolution screens that can display, refresh, and rotate images of photographic quality in full color.

See also: Personal Computer, Terminal

**WYSIWYG** Wysiwyg (pronounced wizywig) stands for “what you see is what you get.” It means that when you use a word processing or graphics software package, the reports and images will be printed exactly as they appear on the screen. That may seem like no big deal, but many early software systems displayed the “control” characters used to indicate such features as underlining, new paragraph, or italics. WYSIWYG is now well established as a general principle for designing software.

See also: Jargon and Acronyms, User Interface

**X12** X12 is the principal ANSI standard for electronic data interchange. It is a technical standard that is the basis for several business standards that define how firms can send transaction documents to and from one another’s computers without having to adopt the same form layouts.

This standard is industry-independent, but the retailing, trucking, insurance, and health care industries, among others, have used it as the base for defining subsets of X12 specific to their intercompany transactions. For example, health insurance firms worked with ANSI’s X12 committees to create the X12 835 version
of the X12 standard. This eliminates the masses of paper required to process health insurance claims and payments. Without the organizing framework of X12, it is very unlikely that any standard would have emerged. HCFA, the federal government agency that handles Medicaid and Medicare payments has already defined its own EDI standard. A firm but quiet message from the Office of Management and Budget is believed to have pushed HCFA to accept that X12 offers the maximum flexibility and breadth needed by the many organizations involved in health care transactions.

See also: ANSI, Electronic Data Interchange, Standards

X.25  The basis of the X.25 standard is packet-switching, a data transmission technique suited to high-volume "bursty" telecommunications traffic (i.e., abundant short messages typical of electronic mail, electronic data interchange, and electronic funds transfers). Packet-switching incurs substantial overhead that introduces delay in transmissions, a shortcoming being overcome by recent developments in "fast packet-switching." One breakthrough, termed "frame relay," speeds packets through an X.25 network 10 times faster.

The security limitations inherent in most X.25 networks are less a function of the standard than of the public data networks that employ it, their function being to facilitate, not constrain, access.

Inasmuch as it is the basis for so many international public data and value-added networks, X.25 is an essential part of the information architecture of a firm that must operate across borders. Yet performance and efficiency increasingly favor alternative schemes.

See also: International Telecommunications, Packet-Switching, Standards

X.400  X.400 defines the electronic equivalent of envelopes for voice mail, telex, fax, and electronic mail messages, and is independent of the type of telecommunications transmission and
receiving device. It opens up a whole new range of business opportunities related to low-cost electronic data interchange and organizationwide use of electronic mail.

X.400 is one of the many standards that interconnect previously incompatible services. Its main impact has been on electronic mail, where systems provided by AT&T (EasyLink), MCI (MCI Mail), Internet, and hundreds of other companies have allowed connections only to users of their own systems. X.400 has transformed this. In effect, it is an addressing scheme that says forward this MCI Mail message to AT&T's EasyLink system and delivers it to the specified recipient.

See also: Electronic Data Interchange, Standards
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