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Introduction

Computers and Information Systems

Computers have become a major technological tool of American society during the past quarter of a century. New developments in computer and communication technology promise within this decade an even more radical revolution in the way that information is collected, stored, used, and disseminated.

Large-scale integrated circuit technology allows hundreds of thousands of electronic components to be fabricated on a thin silicon wafer smaller than a paper clip (see fig. 1) thus providing computing capability hundreds of times less expensive, less energy-consuming, and more reliable than was available only two or three decades ago, as shown in figure 2. Because these microelectronic devices are changing the economics of computer access and use, they are dramatically

Figure 1.—The One-Chip Computer: Offspring of the Transistor

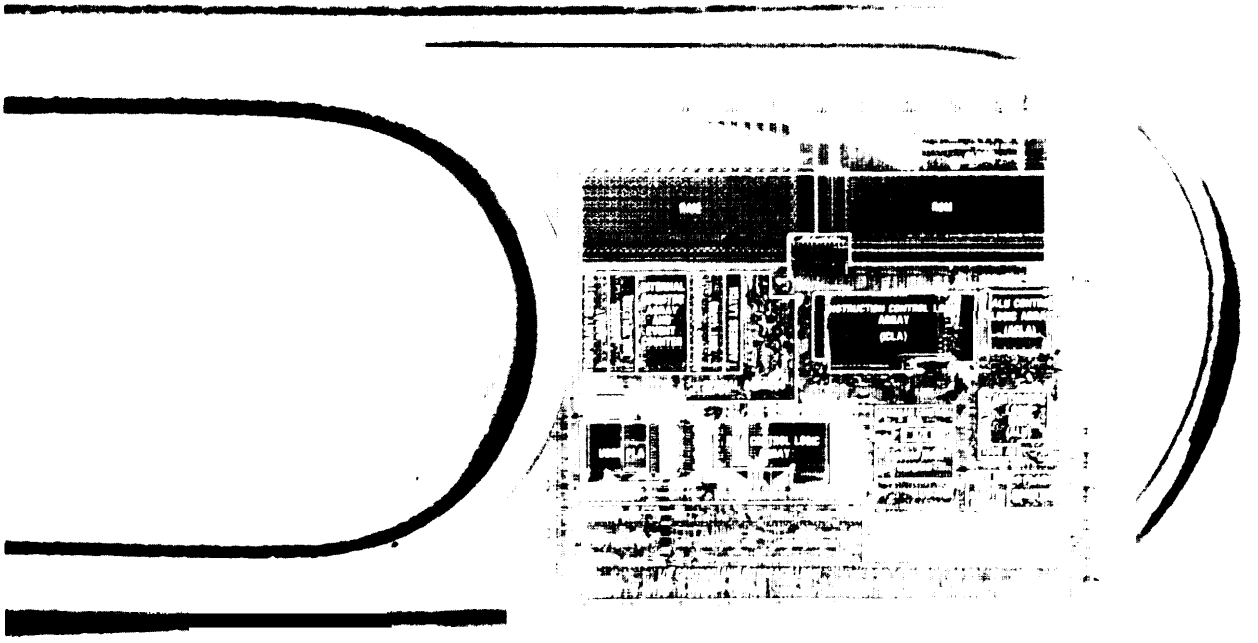
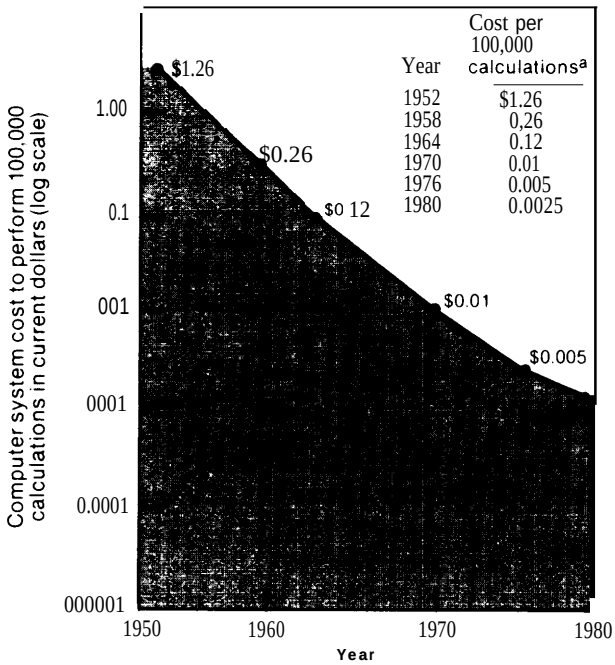


Photo credit Bell Labs

The MAC-4 one-chip computer, developed for a variety of telecommunications applications, is compared to a standard-sized paper clip. The chip's numerous functional areas are labeled

Figure 2.— Drop in Average Computer System Cost per 100,000 Calculations From 1952-80



[a]Cost per 100,000 calculations is based on data for the following IBM com puter systems (w I th year in parentheses) 701 (1952), 7090 (1958), 360/50 (1964), 370/1 66 (1970), 3033 (1976), 4300 (1980)

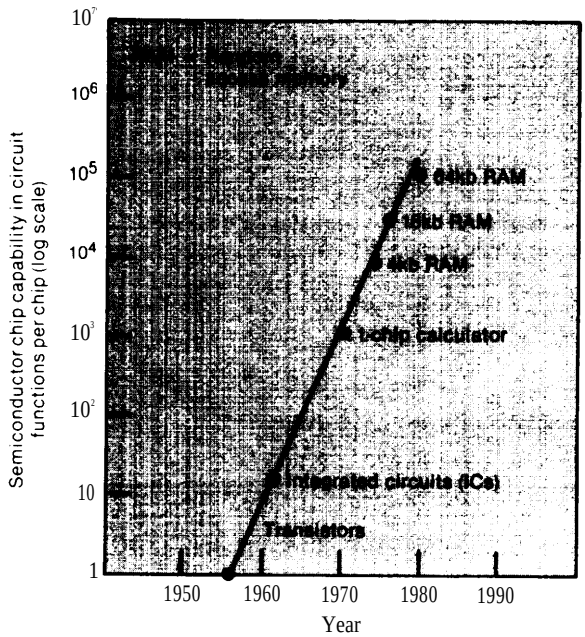
SOURCE Off Ice of Technology Assessment and President's Reorganization Project, *Federal Data Processing Reorganization Study Basic Report of the Science and Technology Team*, Washington, D C June 1978, pp 2930

affecting the ways in which computers are used, and who is using them.

This change has been accompanied by equally rapid improvement in communication technology. * New telecommunication technologies such as direct satellite broadcasting, local area distribution cables, and long-distance data communication networks allow computers to be used in ways that were unimagined a decade ago. Although initially distinctly different, computer and communication technologies are increasingly interdependent, and are being combined to form new products and services and to change the nature of information systems in several ways:

- Computers are becoming smaller and less expensive, thereby increasing their range of applications. Today, computer logic is even being built into common devices such as ovens and automobile carburetors, and complete small computer systems are being sold through consumer retail outlets at a price equivalent to a first-rate high-fidelity stereo set. At the center of this transformation is the integrated circuit chip, a tiny device capable of containing an entire computer system. The increasing capability of these circuit chips is shown in figure 3. As a result, the large computer that occupied one or several rooms in the late 1960 will soon fit in a desk drawer, and a medium-size computer will fit in a briefcase or even a coat pocket.
- Computers can be connected inexpensively to communication lines making it possible to provide access economically to large computer data bases from any-

Figure 3.— Increase in Capability of Semiconductor Chips From 1956-80



SOURCE: Institute of Electrical and Electronic Engineers, *IEEE Spectrum.* vol. 17, June 1980, p 48, and VLSI/LSI *IEEE Spectrum VOI.* 18 January 1981, pp. 57-61

*The development of communication technology is examined in detail in **the** OTA report, Telecommunication Technology and Public Policy, **in** press.

where in the country or the world. Networks of remotely sited computers provide services such as credit card and check authorization or airline scheduling to users nationwide.

c Techniques for the organization and display of information are improving as are methods of instructing the *com*-puter to perform its tasks, thus making it easier for nonexperts to obtain usable information.

• Information storage technology which is less costly and more compact makes it feasible to store large amounts of information for long periods of time in electronic form. In many cases it costs less for electronic storage than to maintain paper records, and access to specific items is faster and more accurate.

National Information Systems

The focus of this study is on national information systems that are made possible by advances in computer and communication technology.

The term "national information systems" as used here means systems that: are substantially national in geographic scope (i.e., multistate); are organized by Government or private organizations or groups to collect, store, manipulate, and disseminate information about persons and/or institutions; and are in some significant manner based on computers and related information and communication technology.

Furthermore, the focus is primarily on large, interconnected national systems where a substantial national interest is involved (e.g., in the financial, postal, military, and air traffic safety areas). Examples of such systems include:

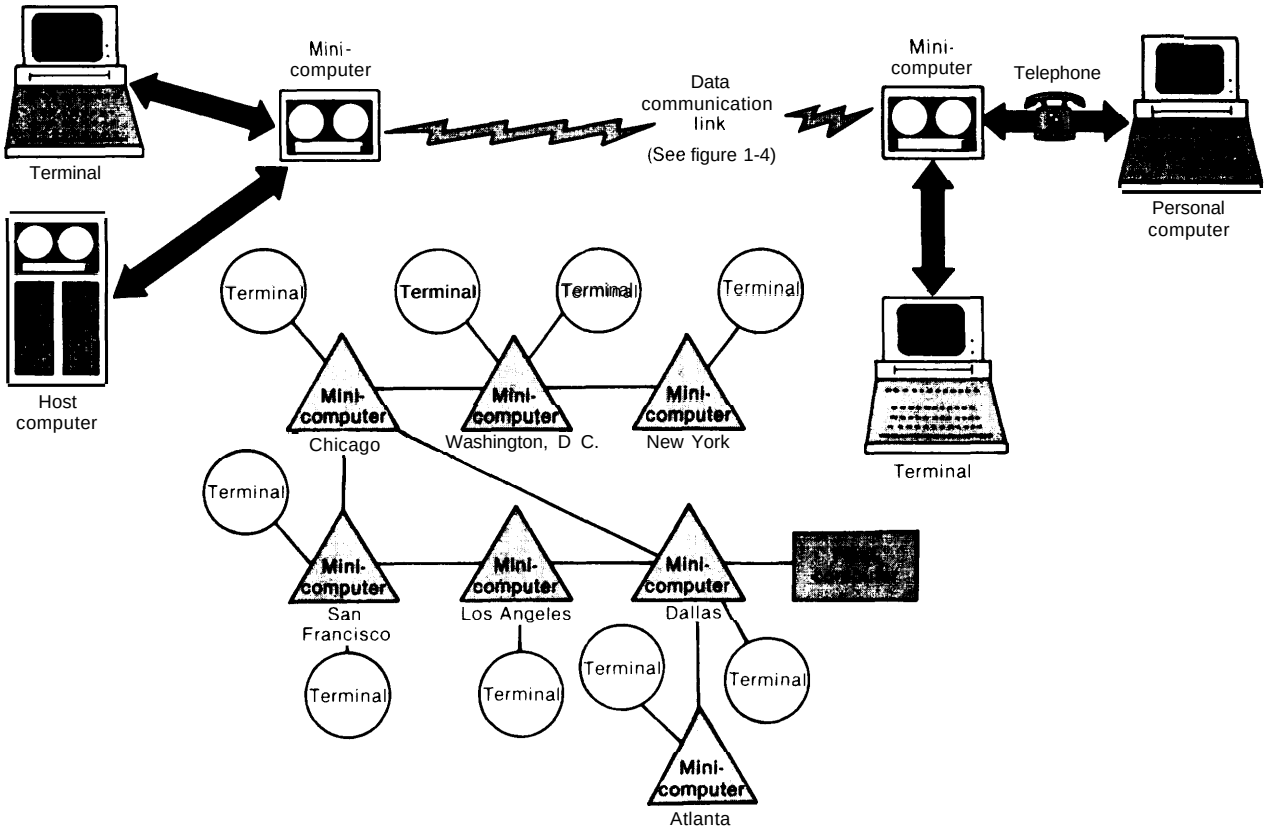
- the computer-based National Crime Information Center operated by the Federal Bureau of Investigation;
- the FEDWIRE electronic funds transfer network operated by the Federal Reserve System;
- the nationwide electronic mail services operated by several private firms and soon to involve the U.S. Postal Service;
- the nationwide computer-based credit card and check authorization services (e.g., VISA, American Express, MasterCard, Telecheck, Telecredit);
- the computerized air traffic control system operated by the Federal Aviation Administration;
- the computerized military command and control systems operated by the Department of Defense;
- the nationwide computer-based airline reservation systems operated by major air carriers (e.g., United, TWA, American); and
- the computerized automatic quotation system for obtaining over-the-counter stock prices operated by the National Association of Securities Dealers.

A secondary focus of the study is on the use of personal computers* when interconnected as part of a larger network. For example, MicroNet and The Source are new services, designed to link owners of personal computers with each other and with larger computers, data banks, and information processing services, over a nationwide network. Also, in the future, stand-alone computer games when combined, for instance, with a television set and a telephone will be able to serve as a terminal with similar access to a nationwide network.

A typical national information system is illustrated in figures 4 and 5. In the example, there are seven cities (nodes) in the network: New York, Washington, D. C., Chicago, Dallas, Atlanta, Los Angeles, and San Francisco. Information (for instance, on inventory, sales, credit transactions, and the like) is stored by the headquarters office of a national retail sales company in a central (host) computer in Dallas, as shown in figure 4. The regional offices also store information in

*Small but fully capable computers currently selling for several hundred to a few thousand dollars and designed for use by individuals in the home, business, or school.

Figure 4.—Computer Technology in a National Information System (illustrative)



SOURCE: Off Ice of Technology Assessment based on *IEEE Spectrum,* vol 17, October 1980, p 24; and ARINC Corp *Overview* 01 *Domestic Telecommunicat /ens Common Carrier Industry,* September 1979

their own minicomputers. * All terminals on the network can access the headquarters data base (in the host computer) and the regional data bases distributed around the country. The information is disseminated from one city to another via the satellite and microwave communication links illustrated in figure 5.

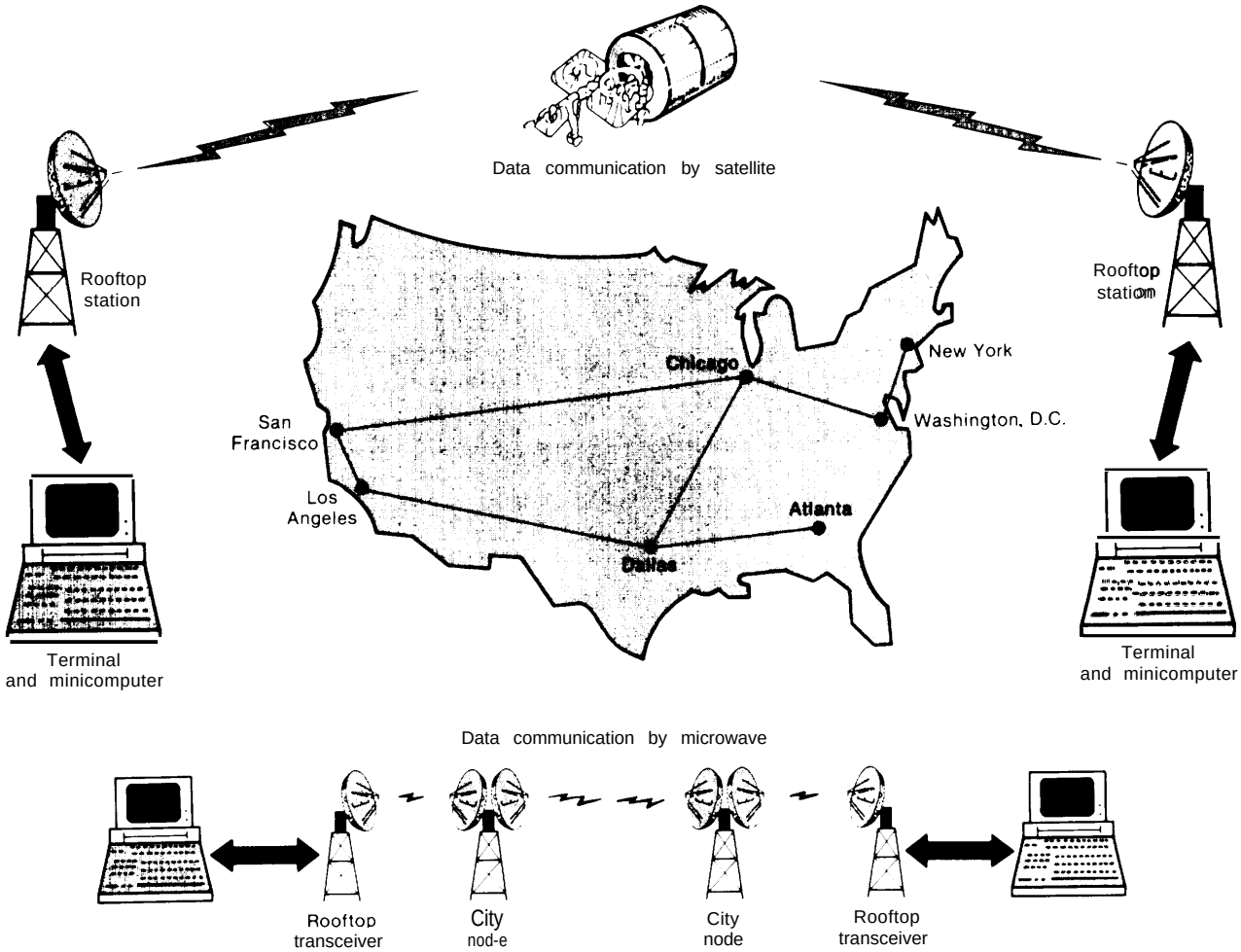
This is an example of current technology used by a growing number of private firms and some Government agencies in what is known as a "distributed data processing network. Distributed means that the data bases (and computer capability) can be in several locations (e.g., branches of a retail store as above, or regional offices of a Government agency) rather than in one central computer. Furthermore, owners of a personal computer could plug into such a network, with the appropriate code words and authorization, via a telephone line (see fig. 4) in their own home or office and actually transact business by computer.

*Small computer systems currently selling for under $50,000.

Purpose and Limitations of the Study

This overview study is intended to be a broad introductory examination of computer-based national information systems and related technology and public policy issues that Congress is likely to face over the next few years. It will also serve as a foundation for the other OTA information systems studies and for future in-depth examination

Figure 5.—Communication Technology in a National Information System (illustrative)



SOURCE Office of Technology Assessment based on *IEEE Spectrum*, VOI 17, October 1980, p 24, and ARINC Corp *Overview of Domestic Common Carrier Industry*, September 1979 *Te/ecofnrnun/caf/errs*

of particular systems and issues. It also examines the increasingly critical role that national information systems play in society.

It would not be possible for any one study to capture succinctly a single set of policy issues that would apply to all national information systems in American society. The specific system applications are too diverse, the potentials and problems too complex, and the parties-at-interest and relevant institutional and legal frameworks too disparate. Only a few of the many issues examined in this study will be important for any particular system.

Consequently, OTA is also conducting case studies of three specific national information systems:

1. an assessment of the National Crime Information Center Computerized Criminal History System;
2. a preliminary assessment of the role of the U.S. Postal Service in electronic message systems; and
3. a preliminary assessment of electronic funds transfer systems.

These case studies will provide a more detailed look at the impacts and issues associated with a specific national information system.

Computers, Information Systems, and Society

Nature of Computer-Based Information Systems

Traditionally, computers have been viewed as super calculators that automate processes that were previously performed by people sitting at mechanical adding machines. However, computers carry out a wide variety of tasks associated with processing information. It is important to understand the entire range of these capabilities in order to appreciate the nature and magnitude of the potential social impacts of this technology when used in information systems.

Computer capabilities fall into seven main categories:

1. *Data collection.* When attached to various sensing devices, computers can detect and measure such external physical phenomena as temperature, time, pressure, flow rate, or any number of other variables. Also, computers can keep a record of transactions. For example, a computerized cash register can collect and store information about a sale that includes bookkeeping entries, taxes, commissions and inventory, and can even reorder stock. Some computer-based door locks require individuals to carry magnetic identity cards. Such locks not only can control access but also can create a record of whose card was granted access, when, and for how long.

   Technological advances are beginning to provide computers with the capability to directly process visual and audio input, thus greatly increasing their applicability to data collection. Computers already have a limited ability to recognize human speech, to read directly a variety of typewritten forms and handprinted texts, and to detect patterns in video images. These functions will be improving rapidly over the next decade and will soon appear in commercial equipment.
2. *Information storage.* Computers can store large amounts of information for long periods of time in an electronically readable form that is easily and quickly recoverable. Depending on the particular application, the methods of storage vary widely, from signals in electronic circuitry, to magnetic pulses on tape, to holes in cards. New advances in memory technology eventually will allow trillions of characters of information to be stored conveniently and cheaply wherever there is even a small computer. The cost of storing information electronically will soon be substantially lower than the cost of storing the same amount of information on paper.
3. *Information organization.* Computers can be used to rearrange information so that it is more suitable for particular applications. For example, if the data in a telephone directory were stored in a computer's memory, it could be inverted to allow one to look up a telephone number that corresponds to a particular address. More generally, computers can simplify and restructure vast amounts of raw data to assist people in drawing significant meanings or conclusions.
4. *Calculations.* Computers perform arithmetic calculations millions of times faster than can human beings. They are used to make numerous simple calculations, such as those required in processing the payroll for a sizable organization; to make sophisticated statistical calculations on large amounts of data, such as those for social science research; or to perform highly complex scientific calculations, such as those needed for weather research or for modeling fusion energy systems.
5. *Communication.* Through connections over a communication system, computers can transmit data around the Nation and the world either to human users or to other computers, which per-

mits the sharing of work and data among groups of linked computers (known as computer networking). Private firms are beginning to offer special communication services to support computer networking. In addition, computers make possible the more effective use and management of the communication systems themselves.

6. *Information presentation.* Computers can put out information in a variety of forms. Through graphical display, and more recently through voice response, they can make data readily understandable and useful to nonexperts. It is possible to display data and computer schematics on screens in a multicolored, three-dimensional format for design and analytical purposes. Also, data such as numbers and statistics can be organized by the computer in an easy-to-understand tabular presentation. Much of the programing effort in developing modern management information is directed toward designing ways in which the information generated by the computer can be presented most clearly to the manager who needs it.
7. *Control.* Computers can be used to control a machine tool or a production line without human intervention. Many consumer devices—including microwave ovens, automated home thermostats, automobile engines, television sets, and telephones— incorporate computer controls using new microprocessor technology. Such uses are increasing rapidly.

Future Trends in Computer-Based Information Systems

The use of computers during the 1980's will likely follow the key trends discussed below and covered in depth in chapters 13 and 14.

- *Growth in the use of personal computers.* The small computer will become common both in the home and in business. Despite their small size, these systems will be highly capable–the equivalent of machines that sold for as much as a million dollars in the 1950's. They may appear in the guise of video games, television sets, or telephones that will also have a computer capability available for other purposes. This trend will stimulate more widespread computer literacy in society, and in turn be reinforced by the consequent increase in the ability of people to program and use computers. The first generation to grow up with computers is now reaching maturity. These "computer literate" young adults accept computers as a natural part of their world. Computer design and use will be taught more both in school and as part of adult education, and will enhance an already thriving market for specialized application programs designed for small computers.

Photo credit: Texas *Insfrurnenfs. Inc.*

INSIGHT Series 10 Personal Information Terminal. Standing only 12 i riches high with a 5¹A-inch swivel display screen

- *Expansion in the number and size of computer networks.* By the end of the decade, most computers, even small ones, will be connected to a communication network at least part of the time.

  The communication system may be dedicated to a single application in which all the machines on the network perform portions of a larger task. Public data networks, on the other hand, provide any home or business computer with access to

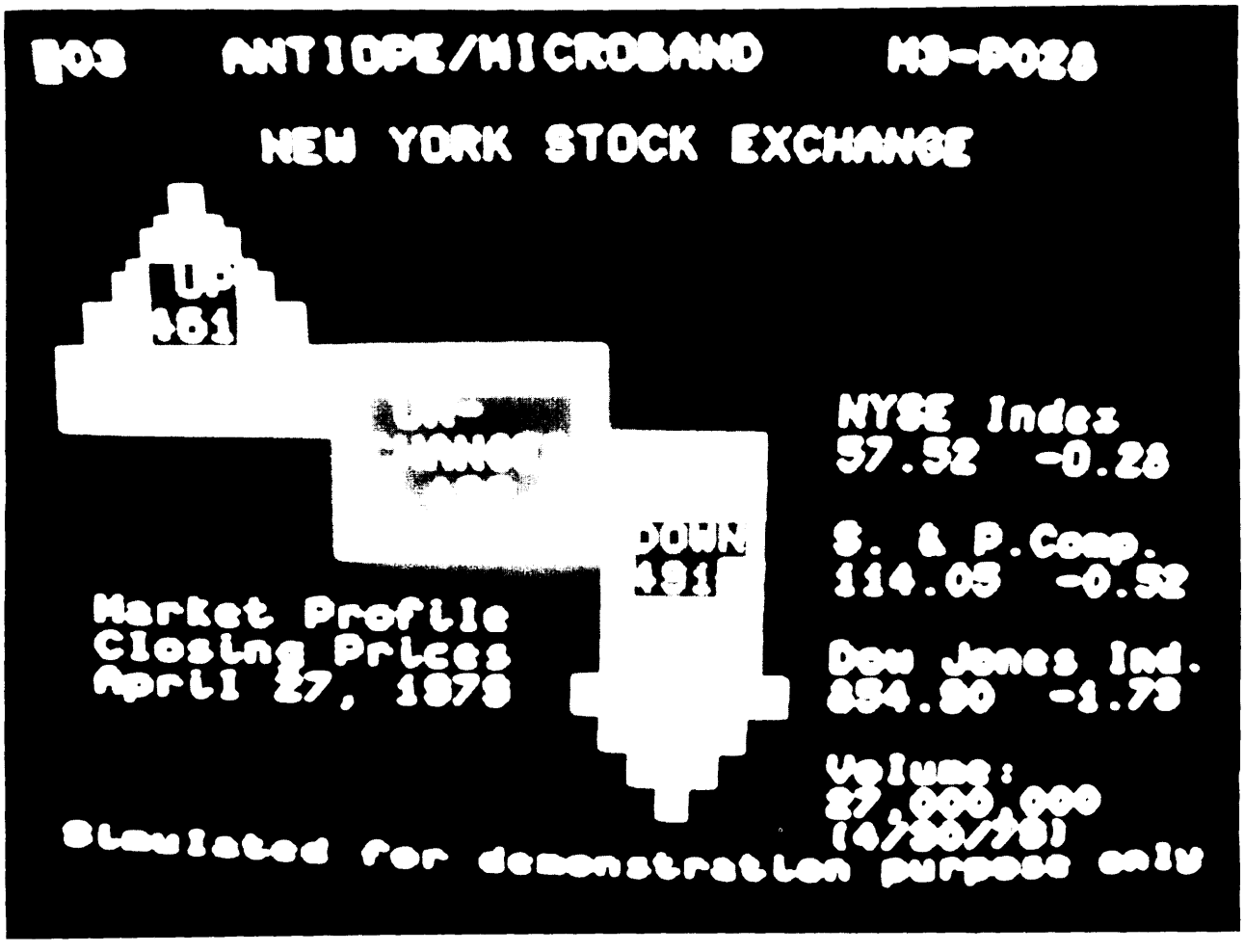
a wide range of data bases or special programs that may be wanted for occasional use. Such multiuser national networks that can be interconnected now exist, and the number of users is expected to grow at a rapid rate.

- *The trend toward information services.* The computer industry has traditionally been concerned with selling hardware (desktop, mini, and mainframe computers and related auxiliary equipment). However, current trends in both pricing and the structure of the market are driving the emphasis toward providing computer-based information services, such as bibliographic and data base searches, electronic publishing, electronic banking, and the like. A number of these services will still require that the user possess a computer. However, many will be offered over data communication lines to homes and offices, and will be accessible through a modified ("intelligent") telephone or television set. Examples include two-way cable television, videotext, and the AT&T Electronic Information Services experiment that provides an electronic telephone directory over a telephone line to a home terminal. Eventually, information services of all kinds will dominate the data processing market in terms of dollar volume.
- *The competition among giant corporations for the data communication services market.* IBM, AT&T, Exxon, and GTE, among others, are preparing to offer a variety of data communication services. Large corporations such as these have access to the capital required to install the technological base for the planned services, such as communication satellite systems and fiber optic transmission lines. A series of recent rulings by the FCC, some still under challenge, are intended to clear the way for open competition among these and other corporations to provide information services of all kinds over communication lines. Resolution of the pending challenges by the courts or by Congress will have significant implications over the long term for the data communication industry.*
- *Higher level integration of data services.* Many individual networks for servicing specific corporate and governmental needs will continue to be built. Some of these networks will become integrated. For example, most airlines, car rental agencies, and large hotel chains have their own reservation systems. It is now technically feasible to build an integrated system that would provide travel agents access to all of these reservation systems through one desktop terminal.

  Similar integrated information systems are also feasible in insurance, banking, travel, entertainment, law enforcement, commodities exchanges, medical services, and many other sectors that now use several separate information systems. However, implementation of these systems will depend on perceived need, economic viability, and other related factors.
- *The software bottleneck.* According to many computer and industry experts, the increasing capability of computer hardware is not being fully utilized due to problems encountered in creating suitable software programs for these new machines. The major problems are the relatively slow increase in the productivity of programers—their cost efficiency—compared with that of the hardware, and the difficulties encountered in managing large programing projects.

  These problems have created bottlenecks in the development of new applications. Computer programing has been relatively resistant to productivity improvement, at least when compared with corresponding improvements in hardware performance. Programing is by nature labor intensive. Its cost is rising due to the increased programing requirements of new hardware coupled with a shortage of programing personnel with the required training and experience, New mechanisms

*For a detailed discussion, see the OTA report *Telecommunication Technology and Public Policy,* in press.



u h a u d p gr m ng w b h pfu n ng n g mpu p gram and m g g h d gn d mp m a n

A h h d h a m h g m k ng p b n m n a n mp p w h ugh h a n w h dw u u m u m mpu h p T hn g kn w h w ph n h mb na n bu n h w h m a h p n a w u d ugg

E m n ng w b n k may b h k m n ng h ad n m pu h g h m ng d ad n J pan mp h wa p b m ha w b g a h gh p y h d d pm R&D n h Un d S a h ugh w d n g n ng n h m h p b m F d R&D budg mp d hn gy h d d w a m a p P ndu h u o m h ar a R p d

one-third of the research effort at Bell Labs is devoted to the software problem.

The Computer-Based Information Society

An information industry analyst recently observed that "every society is an information society."* That is, all human organizations, no matter how simple, depend for their functioning on an intangible resource called "information. In any society, information serves several purposes. It can be, for example, a commodity of commerce, an indicator of wealth or power, a basis for making decisions, or a source of entertainment.

Several key trends are transforming the United States into a computer-based information society:

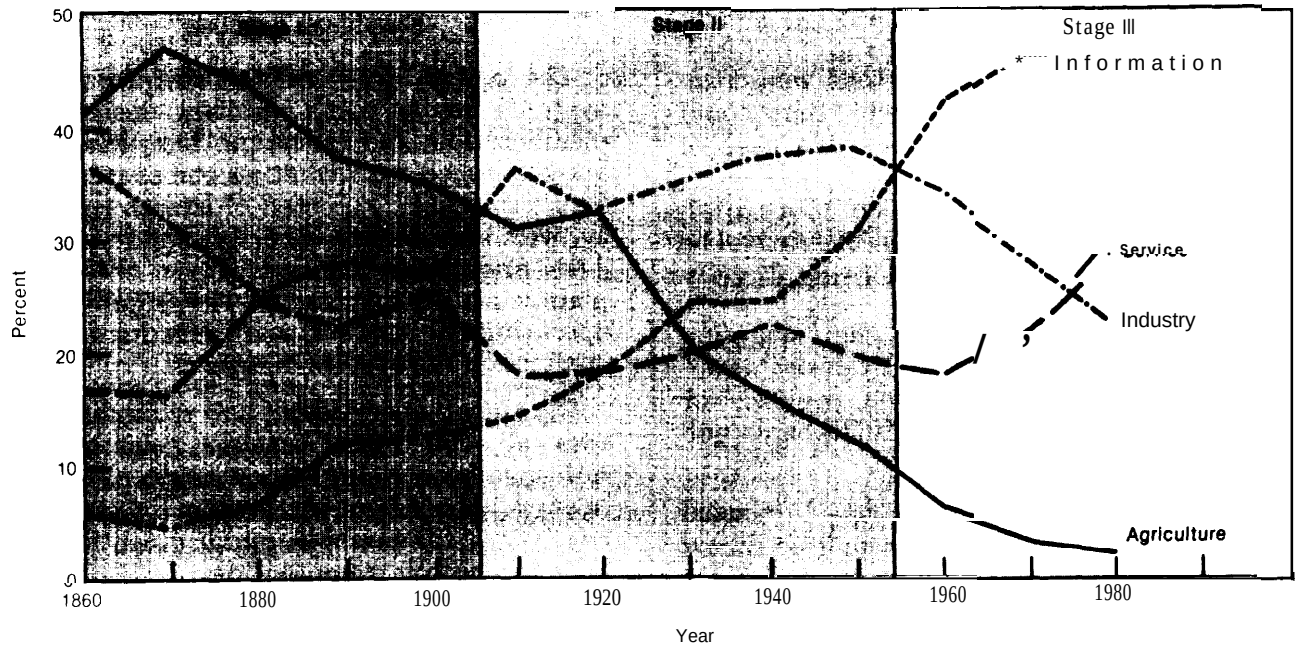
- *The tasks being undertaken by the large organizations that serve American society are growing in complexity.* The air traffic control system handles nearly 20 million flights yearly. Every year the financial system clears over 30 billion checks, the U.S. Postal Service delivers over 100 billion pieces of mail, and the Internal Revenue Service (IRS) receives more than 140 million tax returns. The use of computer-based systems is one way to cope with this vast and complex information flow.
- *The service sector of the economy is growing at a relatively faster rate than the industrial and agricultural sectors.* Many services such as medicine, law, education, and Government involve the transfer of large amounts of information. Resistance to productivity improvements in this sector, which represents a large part of the economy, has impeded overall productivity growth. Greater application of information technology has been proposed as a chief remedy. For this reason, it is highly likely that in this decade the service sector will increasingly depend on the use of computer-based information systems.
- *The information sector itself has grown to account for over half of the U.S. work force.* An examination of the trends in the work force reveals the extent to which the economy has shifted. The results shown graphically in figure 6 illustrate the transitions from an economy dominated by agriculture, to one dominated by manufacturing, to a service and information economy.

  The information sector includes those who generate and sell information as well as those who produce information technology. Included are typewriter and word processor manufacturers, newspaper publishers, and producers of films and broadway and television shows, all of whom are rapidly incorporating computer-based information systems into their operations. The information sector also covers information services and products used by any organization for its own internal purposes. Examples are internal accounting and production management, and inventory control systems, many of which are already computerized.
- *Greater international economic competition coupled with the decreasing availability of basic resources are requiring industry and Government to both improve and speed up their decisionmaking capabilities.* Computer-based information systems are growing in importance for this purpose. Decisions about design, marketing, financing, and resource allocation all require a more sophisticated approach to the collection and use of information.

*Anthony G. Oettinger, "Information Resources: Knowledge and Power in the 21st Century," Science *Magazine,* vol. 209, July 1980, p. 191.

Figure 6.— Four Sector Aggregation of the U.S. Work Force by Percent, 1860-1980

(Using median estimates of information workers)



SOURCE Marc V Porat *The In formation Economy* Stanford University Institute for Communication Research. report no 27, VOI 1, p 189, August 1976 See ch 4 for further discussion

The Structure of Information Policy Issues

Information Policy, Law, and Regulation

As these computer-based systems become more important to American society, particularly for Government administration, they create corresponding public policy issues. Current policies governing information systems are a composite of many specific regulations and laws, which are based on three main factors:

1. the areas affected or the regulatory concerns (privacy, freedom of information, etc.);
2. the affected sector of society (banking, education, Government, etc.); and
3. the lawmakers and/or rulemakers (Congress, the Federal Communications Commission (FCC), State legislatures, the Courts, etc.)

In the course of this study, OTA identified 14 major areas of law and regulation* that affect information systems or are affected by them. There are undoubtedly many others.

The analysis made by OTA has led to these findings:

- There are numerous laws and regulations, some overlapping and some potentially or actually conflicting, that directly and indirectly affect the operators and users of information systems, the consumers of information

*These areas are privacy, freedom of information, first amendment, 14th amendment, due process, communication regulation (Computer II decision of the FCC), computer crime, proprietary rights (patent, trademark, copyright), evidence, liability, antitrust, taxation, Government provision of information, and Government procurement of information systems.

services, and the' subjects of personal information data banks.

- There appears to be neither a strong trend nor sentiment at present among policymakers in favor of a uniform Federal information policy that would encompass all the problems that could arise from the many possible uses of data systems. *
- There is a lack of focus on information policy as such, and consequently the emerging issues are not being directly addressed.**
- Continuation of the present situation could inhibit many socially desirable applications of information systems or could create even more intractable policy problems in the future.

The term "information policy" as used here does not suggest that there is or should be a single uniform policy governing all the uses of information systems in both the public and private sectors. In fact, no such policy exists, nor does one appear to be likely.

"Information policy" does suggest the need for consideration of the currently confusing array of laws and regulations-and their strengths, overlaps, contradictions, and deficiencies—within some overall policy issue structure or framework. The structure developed by OTA for use in this and related studies is shown in table 1.

System Issues

The policy issues related to information systems per se focus on their design, implementation, and operation. They generally are concerned with whether the system performs the tasks expected of it with reliability, with appropriate security, and in an efficient and timely manner. These objectives mainly are of interest to the organization operating the system, and place major constraints on the system designer.

Technical, operational, and reliability factors all can have broader societal significance even though they originate in the operational goals of the system itself. In recent years, for example, public attention has been focused on areas such as:

- the safety and reliability of the air traffic control system;

Table 1.—Structure of Information Policy Issues

Level of issues	Character of issues	Example issues
System level	Relate to the design, implementation, and operation of particular in formation systems.	Government procurement policy, Efficiency and economy of operation. Security of information systems.
Information level	Relate to the handling of data: collection, storage, use, and dissemination.	Privacy (record-keeping). Freedom of information regulations. Copyright and patents as related to computer programs.
Secondary policy impacts	Exist independent of the particular information systems, but are changed in magnitude or character by use of technology.	Privacy (surveillance). First Amendment rights. Fourth Amendment rights. Social vulnerability. Federal State relations.
Long-term societal effects	Long-range societal impacts that are not currently reflected in specific policy problems, but which may ultimately affect the nature of U.S. society.	Privacy (social attitudes). Psychological self-image of humans. Educational needs. Social-political effects. Cultural impacts.

SOURCE: Office of Technology Assessment, see ch. 5

*Some recently proposed legislation would establish a comprehensive approach to certain specific problem areas, e.g., privacy and freedom of information. See H.R. 2465, 96th Cong., "Omnibus Right to Privacy Act of 1979." Also the National Telecommunications and Information Administration (NTIA) of the Department of Commerce has made an effort to formulate—or at least to develop a framework for—national information policies. See Arthur A. Bushkin and Jane H. Yurow, *The Foundations of United States Information Policy,* NTIA, Washington, D. C., June 1980, and Jane H. Yurow, et al., *Issues in Information Policy,* Helen A. Shaw (cd.), NTIA, February 1981. See also, Donald A. Dunn, "Information Resources and the New Information Technologies: Implications for Public Policy," National Science Foundation Report to the President and Members of Congress, *The Five-Year Outlook on Science and Technology, vol.* II, May 1980, pp. 493-507.

**The "paperwork Reduction Act of 1980" (Public Law 96-51 1) enacted by the 96th Congress does set out a more comprehensive policy and management approach for Federal Government information systems, The Act establishes within the Office of Management and Budget (OMB) an Office of Information and Regulatory Affairs and assigns to that Office a broad range of authorities and required actions.

- the reliability, security, and controllability of military command and control systems, existing and proposed;
- the security of large-scale electronic funds transfer systems; and
- the reliability, accuracy, and responsiveness of the social security information systems.

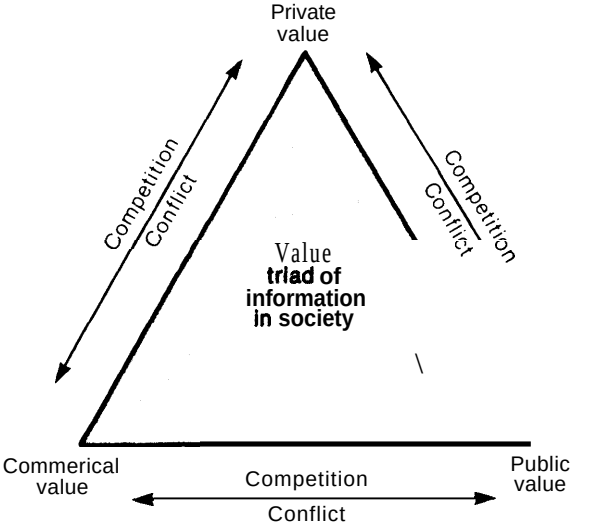
There is a strong societal interest in the proper and reliable technical operation of each of the systems cited above, and potentially high costs to society if they fail.

Information Issues

The three differing fundamental values of information shown in figure 7 motivate many of the laws and regulations affecting information. Individual regulations or laws usually address only one aspect of information. Policy issues, then, arise from the inherent tensions between the particular values reflected in different laws. Congress is called on to establish balances. These tensions are illustrated below:

- *Public v. private value.* Freedom of information laws (reflecting public value) can conflict with individual or proprietary concerns (reflecting rights to privacy). For example, in serving the public interest, Government collects an extraordinary amount of information about citizens, businesses, and other organizations. Some of this information theoretically has been available to the public by law for a long time but has been protected, in fact, by the amount of effort required to retrieve it from manual recordkeeping systems. Automated systems reduce the cost and time barriers to wider access to these public records, and thereby may accentuate the issue of the extent to which this information can and should be publicly available.
- *Commercial v. public value.* As information becomes a more valuable commercial commodity, increasing tensions are arising between those who wish to sell it through new information systerns, and those like the public librarians whose traditional role is to treat information as a public good available to all. These tensions may also stem from the competition between Government-collected data, made available through freedom of information laws, and commercial data services.
- *Commercial v. private value.* Commercially marketable information may invade privacy or proprietary rights, as in the case of computerized mailing lists

Figure 7.—Value Triad of Information: Conflict and Competition Among Private, Commercial, and Public Value



Commercial value of Information: Information has been a commodity of commerce for centuries Books and newspapers, and in this century the broadcasting Industry, all sell Information. As society becomes more dependent on Information, its value Increases. The very high growth rate of the computer-based information industry illustrates this trend.

Private value of information: In an Information society, economic competition is often based on access to special Information, such as a formula for a soft drink, an econometric projection, marketing plans, or geological data. Commercially important information is considered by organizations to be proprietary Similarly, individuals often consider Information about themselves to be private, either because damage can be done by its disclosure or simply because of desiring to be left alone.

Public value of informat/on: American society has always viewed information as having a public value, and has asserted the public interest in a free flow of information. Examples include: the public support of libraries, schools, and museums; a tradition of academic freedom and a system of open scholarly publication. the first amendment guarantees, and freedom of information laws

SOURCE Off Ice of Technology Assessment see ch. 4.

that may be compiled from third-party information sources without the knowledge or consent of the individuals involved.

Secondary Policy Impacts

Computer-based information systems, by increasing the quantity of information collected, the efficiency of its collection and dissemination, its utility, and its ease of storage can cause qualitative changes in the behavior of Government, individuals, and organizations as well as in the nature of traditional conflicts. Thus, the use of automated information systems can have secondary effects on policy problems that have existed for years and in many ways are independent of the technology. Because much more information can be obtained, handled, processed, and distributed so much faster, old problems are not merely exacerbated, but new ones are created.

For example, the increased scale and presumed efficiency of computerized criminal justice recordkeeping intensifies the tension society has always experienced between the needs of law enforcement and the individual rights of citizens. Similarly, the tendency of the technology to encourage centralized record systems creates problems of Federal-State relationships, a particularly touchy issue in law enforcement. Some experts believe this centralization trend could reverse through the use of of smaller computers with distributed data bases.

Long-Term Societal Effects

Social scientists engaged in futures studies have suggested that the information revolution, spurred both by advances in computers and communication and by the changing role of information in U.S. society, will have profound long-term effects as dramatic as those caused by the invention of the printing press.

Just as the printing press, by stimulating literacy and speeding the flow of ideas, supported the Renaissance and the transition from medieval society to the age of enlightenment, so the new information systems could profoundly transform the social and political environment of U.S. and world society. Indeed television and sophisticated computer-based polling technology have already had observable effects on the political processes in the United States. Third World leaders calling on UNESCO for a "new world information order" express the belief that information technology will have a central influence on the social and economic development of their countries as well as on international relationships.

This overview study has not attempted to address in detail these broader questions. However, given the potential for significant social change, research funded publicly, privately, or in some jointly developed projects could provide valuable insights into the long-term societal effects of computer-based information systems and related public policy choices.

Public Policy Issues

The overview study examined the national information system issues judged by OTA to be among the most important and likely to warrant congressional attention over the next few years. These issue areas include: innovation, productivity, and employment; privacy; security; Government management of data processing; society's dependence on information systems; constitutional rights; and regulatory and other issues. See chapters 6 through 12 for further discussion.

Innovation, Productivity, and Employment

Innovation, the continual generation of new technological ideas and products and services based on those ideas, is a prime req-

uisite for a healthy industry in a high technology field like computers and information systems. Innovation in information technology improves the productivity of the information industry itself and also offers the tools for improving the productivity of many other sectors of the economy.

Based on anticipated advances in artificial intelligence, robotics, computer control, and input-output technology over the next few years, computer-based factory automation will make a substantial contribution to improving manufacturing productivity. Word processing and other forms of office automation are already improving clerical productivity and may have similar potential for managerial productivity. Intelligent cash registers and automated checkout are directly improving the productivity of retail clerks and indirectly the productivity of retail management (e.g., accounting, inventory control, procurement). The full impact is yet to be felt of these and other applications that are only now starting to be installed in the manufacturing and service sectors of the economy. However, they are likely to help restore an upward trend in the Nation's productivity.

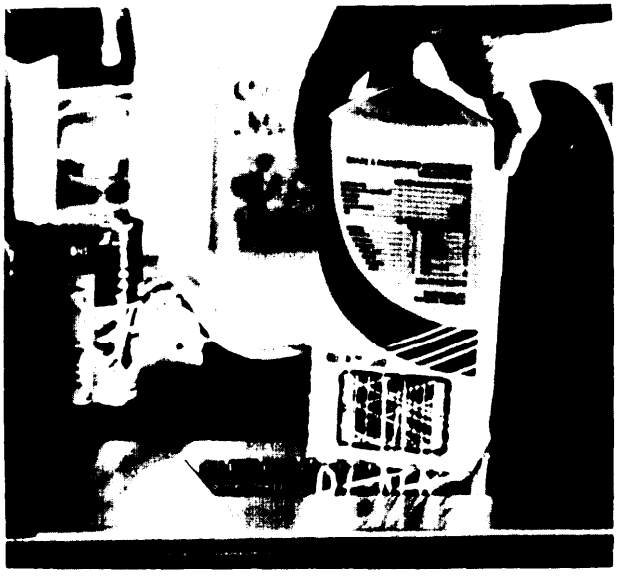


Photo credit: IBM Corp.

The I EM scanner uses holography, a technique for creating three-dimensional images, to read data on packages

From a larger societal perspective, the increased productivity brought about by advances in computer technology may be reflected not only by greater output per employee, but perhaps also in terms of better product quality, improved work environment and job satisfaction, and longer term social benefits such as improved job safety and greater opportunities for on-the-job learning and career advancement.

Congress will be confronted by a number of issues concerned with innovation in computer technology and its effects on productivity and employment:

- *R&D support.* Innovation in computer and information technology depends on continued, aggressive R&D. Many U.S. corporations in the information industry, realizing that their success depends on continued innovation, have established their own research centers. Several Federal agencies* support computer R&D, although the major part of development support comes from the Department of Defense and related agencies. An important issue is whether research in the applications of computer technology to problems in the private (civilian) sector—in such areas as education,** health, transportation, environmental quality, and job safety—is receiving adequate Federal support, given the critical nature of computer technology to the Nation's well-being.
- *Vitality of academic computer science.* Basic research in computer science is largely carried out in universities. Because of the close connection between applied technology and basic research, the vitality of the computer industry is in part dependent on the vitality of academic computer science. However, university departments of computer sciences are experiencing problems in ob-

*Including the National Science Foundation, National Aeronautics and Space Administration, and Department of Energy.

**Information Technology and Education is the subject of another OTA assessment in progress.

taining the faculty, facilities, and funds needed to do the research and to train new experts. This situation is particularly critical in systems design and software engineering.

- *Impacts on employment.* It is still uncertain whether the productivity increases brought about by computer technology will increase or decrease the overall employment level. Structural shifts in the economy are likely to occur since any innovation which creates new products and new industries will eliminate some jobs only to create others. Even if new jobs are created or old ones redefined, not all workers will find it easy or desirable to shift. Some employees may be unwilling or unable to adapt themselves to the new technology or may be untrainable in the new procedures.
- *Support for computer impact research.* The area of employment impacts is a good example of the need for computer impact research, a new field developed over the last decade by computer and social scientists. To date, however, university groups and others have experienced difficulty in securing financial support, in part because this subject does not fit comfortably into traditional scientific research programs. Computer impact research is not pure computer science; neither is it classifiable as purely social or political science. The results of such research could supply valuable input to the kinds of public policy issues identified in this overview study.
- *International competitiveness.* Computer and communication technologies are moving ahead so rapidly that products can become obsolete within a few years. Although the United States holds a substantial positive balance of trade (and employment) in certain areas of information technology, the maintenance of this balance depends in part on continued R&D and innovation and on supportive public policies. * Because of aggressive import competition from Europe, Japan, and Canada, even domestic markets are vulnerable to any faltering in the technological lead.

Privacy

Privacy-related issues dealing with the collection, dissemination, and use of personal information are likely to remain on the congressional agenda for a number of reasons:

- *An omnibus v. a selective privacy policy.* The Federal Government has deliberately chosen up to now to react to privacy issues associated with recordkeeping on a case-by-case basis rather than through omnibus legislation, which would cover all data systems both public and private in which personal information is maintained.

  With the selective approach, Congress will be considering a long series of privacy bills. To catch up with current computerized recordkeeping practices will require a substantial legislative effort. An immediate concern is to develop privacy rules for computer applications in banking, medicine, social and medical research, credit, insurance, and criminal justice. Privacy is also likely to be a major issue in the development of electronic mail.

  Congress may need to consider alternative approaches to privacy policy.
- New *technologies, new problems. New* applications for computer and communication technology, such as an automated securities exchange, in-home information services, electronic publishing, and the automated office, may create new environments for privacy

*Relevant policy instruments include taxation, antitrust, and standards, among others. U.S. industrial competitiveness in the international electronics and computer markets is the subject of another OTA assessment in progress.

policy issues to arise. As Government agencies such as the Department of Justice, IRS, or the Social Security Administration begin to use the latest generation of information technology for their recordkeeping activities, privacy problems that were not specifically addressed in previous legislation may have to be dealt with by Congress.

- *Secondary use of personal information.* A fundamental assumption underlying much of the privacy debate in the 1970's was that collecting personal information is in the nature of a transaction—the individual yields personal information in exchange for some benefit. Thus, much of the fair practice doctrine centers on the requirement that the recordkeeper abide by obligations implicit in that transaction. However, individuals will increasingly be encountering computerized systems that collect and store information about them without their knowledge or consent. Very little law exists pertaining to the ownership or disposition of such information, even when its use may be contrary to the individual's perception of his or her interests.
- *Microprocessors and surveillance.* The potential now exists for the development and marketing of a wide variety of microprocessor and computer/communication devices either specifically designed or capable of being used for the surveillance of individuals without their consent. Microprocessor-based locks can provide detailed records of the whereabouts of anyone in a building. Devices called "pen registers" provide a similar capability for monitoring telephone traffic. Abuse of this technology for illicit purposes may become a serious problem. Even seemingly legitimate applications (e.g., employer monitoring of employee phone calls to deter nonwork-related conversations) may, if abused, raise in new forms the classic issues of civil rights versus both law enforcement and the rights of employers to monitor their employees.

Security

The technology for securing computer systems from theft, sabotage, natural hazards, and the like is improving steadily, and users are becoming more aware of the need to protect information. However, the increasingly complicated computer-based information systems being designed and built make secure operation more and more difficult.

Among the several difficult issues involving computer security that are likely to confront Congress, the following appear to be the most significant:

- *Protection of Federal systems.* Federal information systems control the disbursement of an enormous amount of money. The Social Security system itself disburses over $2 billion per week. Other Federal systems contain information that could be used directly or indirectly to make profitable financial decisions, e.g., information on Federal monetary policy, on commodity markets, and on energy resource estimates. Still others contain sensitive information relating to personal privacy or national security. All would be highly attractive to theft, manipulation, or eavesdropping.

  These are not the only threats to Federal computer systems that Congress will need to consider. A more subtle threat is a system's potential diversion by the bureaucracy from its intended use; for example, the use of computerized criminal histories for employment or licensing purposes. As the Government continues to automate, problems of bureaucratic accountability and

the responsibility for oversight will confront Congress with the need to better understand and more closely monitor the use of large Federal information systems.

- *Protection of vital domestic information systems.* There is a Federal responsibility for certain information systems that, although privately operated, are fundamental to social well-being. The security and reliability of automated systems for nationwide bank check clearing, electronic message systems, and computer-based commodity trading, for example, would all be under the purview of Congress. The vulnerability of such systems is of governmental concern because of the harm that a major system failure could cause to the Nation's economy and to its citizens.
- *Development of data security and cryptographic capability.* The Federal Government, due to its traditional concern for the protection of military and diplomatic communications, has a high degree of expertise in the field of data security. For example, the National Bureau of Standards is developing computer security guidelines and standards for use by Federal agencies. The first standard to emerge from this effort is the Data Encryption* Standard (DES) for protecting data communication.

  While the DES is public, much of the Federal expertise is either classified or in the hands of highly sensitive organizations such as the National Security Agency. The appropriate role of the Federal Government has not been defined in transferring this knowledge, supporting computer security research in both the public and private sectors, setting standards for non-Federal systems, and certifying security technology.

  The lack of such policy definition is visible in the current debate over Government control of cryptographic technology. In this debate, the needs of the private sector for increased communication security, and hence for the existence of a civilian commercial cryptographic capability, are set against the perceptions of the defense community that such development threatens national security concerns by putting sensitive information in the public domain. A related issue is the desire in the academic community for the freedom to conduct research on the mathematics underlying cryptography.

*Encryption is the coding of a message so that it is only understandable to a receiver who knows the secret decoding procedure and/or key.

Government Management of Data Processing

In the early days of computing, the Federal Government as a user was a principal stimulus to the development of the field. Although a few instances of Federal expertise at the leading edge of computer applications remain, the Federal Government is rapidly falling behind the private sector in its use and management of up-to-date computer and information technology. Such a lag would penalize Government operations in two ways:

1. potentially lost opportunities to use the newest technology to improve the efficiency and effectiveness of Government programs; and
2. increased cost and decreased reliability resulting from operating systems that are becoming obsolete, from archaic management procedures, and from burdensome procurement restrictions.

Cheaper computing hardware, the emergence of data communication-based systems, and new software techniques are changing the way computers are used in industry. The next 10 years will see significant movement in the private sector toward automating the flow of information in offices, toward experimenting with new management structures based on high-volume data communication, and toward automating decision support systems for use by higher management. To the extent that these applications fulfill their promise of

improvement in both the quality and productivity of management, the Federal Government would be remiss in not making use of them where appropriate.

The most recent legislative action to address this problem is Public Law 96-511, known as the Paperwork Reduction Act of 1980, which establishes central oversight in the Office of Management and Budget of the information policies and practices of the executive branch. Perhaps most important, this Act emphasizes the basic need for restructuring the way information resources and supporting technologies are managed in the Government. This represents a new and as yet untested approach by giving management of information resources similar importance to that traditionally assigned to managing financial and personnel resources.

Many other issues and questions also need attention from this broader perspective. For example:

- *Automated bureaucracy.* There is a need to better understand the effects of large-scale information systems on the internal organization and management of Government agencies and on Federal decisionmaking. What effects do these systems have on the location of responsibility, the quality of the decisions, the nature of due process for clients affected by those decisions, and the accountability of the bureaucracy to higher-leve policymakers in the executive branch and to Congress itself?
- *Social values and goals.* The process by which appropriate social values and goals are reflected in Federal information systems design needs clarification. Major new systems will need to be evaluated for their effects on privacy, security, constitutional rights, and many other issues that are not normally the concern of the designer or operator of an information system.

  Three fundamental approaches are available to deal with social value questions:

  1. Congress could assess the potential social impacts of each new system design that is proposed on a case-by-case basis.
  2. Congress could codify a social impact policy concerning all Federal information processing systems. An appropriate agency could be designated as responsible for seeing that all new system designs are evaluated in relation to that policy.
  3. Congress could continue to examine agency proposals system by system, but would base its evaluation on a social impact framework encompassing a set of principles for the design and operation of Federal information systems.

Whatever the approach, it will be necessary for Congress to balance the need to speed up design and procurement of Federal systems, against the requirements that tax money be spent as effectively and as equitably as possible and the necessity to consider carefully the societal impacts of these systems.

Society's Dependence on Information Systems

The nature of risk is being changed by much of the new high technology on which modern society depends—jumbo commercial airlines, nuclear powerplants, oil supertankers, or large computer-based information systems. In general, because new technologies can be designed to operate more reliably than the ones replaced, the risk that any particular mechanism may fail has been reduced. However, should an accidental or deliberate disruption occur, its cost can be much larger, even catastrophic. Furthermore, when society becomes highly dependent on the reliable functioning of a single integrated technological system or small collection of such systems, the possibility of a "domino-like" collapse of several of the individual connected units could also be disastrous.

This evolution to dependency can be seen already in the reliance of safe public air

transport on the continuous operation of the computerized air traffic control system. * In the commercial sector, large stores and banks rely on the smooth uninterrupted operation of their computer systems.

Thus, as society moves toward electronic funds transfer systems, widely available electronic mail service, and other large extensively used information systems, the following factors warrant consideration:

- The ways in which public policy can help to allocate and balance the risks society may encounter from national information systems against the benefits it may receive, under conditions where failure rates appear to be low but potential losses may be high should a failure occur.
- The ability of society to retain the option to end its dependence on a particular information system if it has unanticipated undesirable effects; in other words, to avoid the possibility of becoming "locked in" to the use of certain information systems once they are installed.
- The capability of providing alternatives to persons or institutions choosing not to accept perceived risks in a new information system.
- The ways in which technology can be utilized-to reduce the risks, for example by introducing additional system redundancy (alternative paths between points in the system, distributed data bases, backup computers). The risks inherent in U.S. dependence on a nationwide, interconnected telephone system (which itself is rapidly being computerized) are minimized by the large number of circuit switching centers and parallel trunklines.

Large complex information systems contain millions of logical connections and are controlled by programs that themselves can be composed of millions of instructions. Consequently, it is difficult to calculate their reliability and to predict the failure rate of any particular part of the system, as well as the effect of a failure on the operation of the entire system. New research in risk analysis is needed to address the problem of estimating risks under these conditions.

*The airport and air traffic control system is the subject of another OTA assessment.

Constitutional Rights

Little legal precedent exists, in many cases, for applying constitutional law to the issues raised by computer-based information systems. This overview study identified several areas of constitutional rights that may be affected by information systems, as illustrated below:

The *first amendment* guarantees freedom of religion, speech, the press, peaceable assembly, and the right to petition for redress of grievances.

- A principal first amendment issue facing the Government may be how to encourage the maximum freedom of expression–fostering the "marketplace of ideas' '—in new electronic media that have been tightly regulated in more traditional forms. For example, the scarcity of frequency spectrum and channel capacity that provided a basis for regulation of broadcast television may not apply to new versions of TV such as cable, direct-to-home satellite, and videotext.
- Another first amendment issue may be generated by extensive data collection and possibly surveillance by Government and private organizations that could, in fact, suppress or "chill" freedoms of speech, assembly, and even religion by the implicit threats contained in such collection or surveillance. These threats might be directed as much at the "listener" as the "speaker." Clearly, automated information delivery systems possess a much greater capability for recording, storing, and analyzing in detail the flow of information from all sources into homes and offices, than do manual systems

such as bookstores, newspapers, and the like.

The *fourth amendment* protects the persons, houses, papers, and effects of individuals against unreasonable searches and seizures by the Federal Government.

- Fourth amendment issues may develop from:
  - —the use of personal and statistical data contained in automated information systems as a justification for search and seizure;
  - —the search and seizure of information per se as personal property, particularly in electronic form; and
  - —the use of automated information systems as a tool for search and seizure operations.

An electronic mail cover illustrates the latter type of fourth amendment issue. A nonelectronic mail cover requires approval by the Postal Inspection Service but not a search warrant because only the outside of an envelope is examined. In an electronic mail system, however, no distinction may exist between the "outside" (or address) and the "inside" (or contents) of a message. Therefore, it maybe difficult to distinguish a mail cover from a wiretap, which would require a warrant issued by a court upon probable cause, unless some form of coding was used to "seal" an electronic message as an envelope seals a physical one.

The *fifth amendment* guarantees that a person may not be compelled to be a witness against himself or be deprived of life, liberty, or property without due process of law.

- A fifth amendment issue could arise from the use of personal or corporate computer data that have been collected by the Government for one purpose as evidentiary material in unrelated criminal or regulatory cases.
- Another fifth amendment issue could develop from the delivery of Government services by computer-based information systems. For example, very large systems that "mass produce" decisions in such areas as health benefits, student loans, or tax returns may have subtle biases "built in" to the program or code of the computer. These systems may react quickly to what the computer recognizes as "normal" applications, but reject "unusual" claims. If, as a consequence, citizens are subjected to an unacceptable amount of hassle, delay and/or error, the program or code used by the computer to define "normal" or the entire information system may become subject to due process challenge.

The *sixth amendment* guarantees, among other things, the right of a speedy and public trial by an impartial jury.

- A sixth amendment issue may be raised by the growing use of computerized dossiers of potential jurors along with computer models for predicting juror behavior. At this time, computer-based jury selection is very expensive and its value is controversial. However, future computer technology and social scientific techniques may make this application cheap and improve its effectiveness. If so, the entire concept of an "impartial" jury may be challenged.

The *14th amendment* guarantees that a State cannot deprive any person of life, liberty, or property without due process of law nor deny any person within its jurisdiction the equal protection of the laws.

- Fifth and 14th amendment issues may develop from a similar application of computer-based social science and statistical models to predicting criminal behavior and to aid in such tasks as approving credit, determining insurability, or hiring and promoting employees. Essentially, individuals may be denied rights, privileges, and benefits based, not on past performance, but on a prediction of future tendencies. For example, society cannot imprison a person that a computer model predicts may someday rob a bank. But should that knowledge be "probable cause" to

monitor such a person closely or deny employment?

Regulatory Boundaries

As computer-based information systems evolve, they challenge traditional concepts of boundaries—physical or social—that are reflected in the law and regulatory policy. The integration of computer and communication technologies creates systems that cross boundaries between nations, States, and organizations. The issue of transborder data flow discussed in chapter 12 exemplifies the kinds of international problems created. Others include the following:

- *Interstate conflict of laws:* When States have conflicting laws involving information or information processing, for example, property laws that cover computer data bases, an integrated data system that exists in a number of different States can raise difficult questions of legal jurisdiction.
- *Federalism:* Linking Federal data systems with State and local systems complicates problems even further. Issues of federalism could arise with systems containing data on criminal history, taxation, welfare, education, medical care, and drug abuse, among others.
- *Antitrust:* Policy issues may arise with respect to whether large integrated data systems using shared facilities create monopolistic barriers to new entrants or are mechanisms for control of the market, or whether they encourage competition by reducing the cost of access for smaller firms.

Information technology is changing form so fast that it is tending to outstrip the working definitions of devices and services that serve as the basis for law and regulation. These definitional problems relate both to the technology itself, and to the products and services that depend on it.

- *Computers or communication:* The best known example is the continuing attempt by the Federal Communications Commission to establish what services and what technologies are already "communications, thus regulated, and what are "computer' services and technologies, thus not regulatable. Their second inquiry on these questions, which began in 1976, only recently resulted in an opinion that is now under court challenge. Even if the definition is accepted, there is no reason to believe that the problem has been permanently resolved.
- *Branch banking:* Many States have laws that either prohibit or tightly regulate branch banks. An issue that has been widely debated is whether the automated extensions of banking (e.g., automatic teller machines or pay-by-phone services) constitute "branches" in the usual meaning of the law.
- *The status of electronic mail:* Electronic data transmission has opened a major policy question about the definition of mail. As with the computer/communication issue above, this definition is significant because it places a class of services under one or another set of regulations. Unlike many other countries that have combined postal and telecommunication services under one national agency, the United States has pursued completely different approaches to regulating each service category. Electronic mail, in its various forms, provides a new service with features of both manual delivery and telecommunication, and may pose new and difficult regulatory questions.

Other Issues

Four other issue areas were identified as important although not analyzed in great detail:

1. *Computer crime:* Crime directed against computer-based information systems or in which these systems are used as tools for criminal activity.

2. *Transborder data flow:* Problems that arise from differing national attitudes and laws regarding the increasing flow of data and interconnection of information systems across national boundaries.
3. *Information gap:* The possibility that some individuals or groups would be denied access to information services vital to their survival in an information society because of technological illiteracy, lack of economic resources, or other reasons.
4, *Computer software protection:* The concern that continuing uncertainty about copyright and patent protection for computer software is significantly impairing software R&D and innovation.