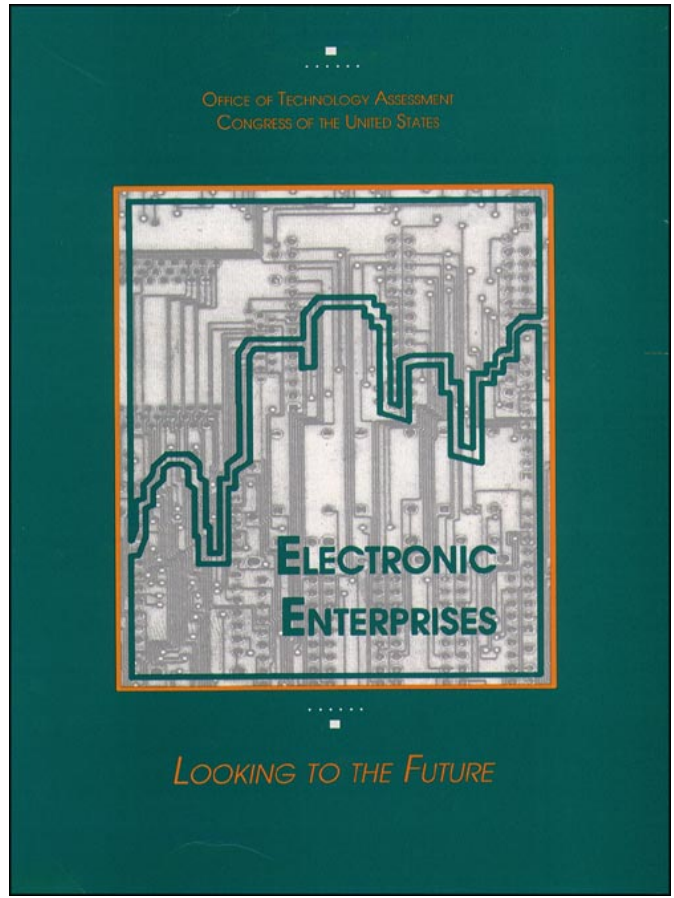
Electronic Enterprises: Looking to the Future

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Foreword

Electronic Enterprises: Looking to the Future takes a strategic look at the development of electronic commerce and identifies the characteristics of the infrastructure that will be required to support it. The report found that, in an electronically networked economy, the design and underlying architecture of the global information infrastructure will have a major impact on national economic growth and development. The Senate Committee on Commerce, Science, and Transportation and the House Committee on Science, Space, and Technology requested the report.

To support U.S. business performance and to ensure a competitive economic playing field, the information infrastructure will need to be flexible and open, seamless and interoperable, and evenly and ubiquitous y deployed. How well the infrastructure meets these criteria will depend on factors such as the degree of competitiveness in the communication and information networking industries; the rules governing access and interconnection; and the availability of standards and software applications to support electronic commerce.

The government can adopt a number of strategies to promote a network architecture that meets these requirements. Several strategies are discussed in the report. Complementary actions to support business and the workforce in the effective use of networking technologies are also identified. If American businesses are to benefit fully from electronic commerce. infrastructure policy cannot be developed in a vacuum; adequate attention must also be given to the social and economic factors that govern the use of networking technologies as Congress develops a national infrastructure policy.

OTA appreciates the assistance of the project advisory panelists, workshop participants, and the interested business, labor, consumer, and other private sector groups and individuals who participated in the study. OTA values their perspectives and comments; the report is, however, solely the responsibility of OTA.



ROGER C. HERDMAN
Director

Advisory Panel

Daniel Bell
Panel Chairperson
Scholar-in-Residence
American Academy of Arts and Sciences

Marietta Baba
Professor
Department of Anthropology
Wayne State University

James Beatty
President
National Consulting Systems, Inc.

Jim Berm
Executive Director
Federation for Industrial Retention and Renewal

Kathleen Bernard
Director, External Programs
North Carolina Supercomputer Center

Willard R. Bishop, Jr.
President
Willard Bishop Consulting, Ltd.

Fred Block
Chairman
Department of Sociology
University of California at Davis

Bernard W. Campbell
Vice President, Corporate Information Services
Sonoco Products Co.

Carl Cargill
Standards Strategist
Sun Microsystems, Inc.

William Cunningham
Founder and Director
Focus: HOPE

Irwin Dorros
Executive Vice President, Technical Services
Bell Communications Research

Frank Emspak
Professor
University of Wisconsin, Madison
School for Workers

Sara Kiesler
Professor
Department of Social and Decision Sciences
Carnegie Mellon University

James L. Koontz
Chief Executive Officer
Kingsbury Corp.

Donald R. Lasher
President
Information Services Division
United States Automobile Association

Scott Loftesness
Group Vice President
Visa International

Glenn Smith
Manager
Strategic Technology Planning
United Parcel Service

Paul Vetter
Director, Information Services
Cone Mills Corp.

Mark Weiser
Chief Scientist and Manager
Computer Science Laboratory
Xerox Palo Alto Research Center

John Wohlstetter
Director, Technology Affairs
GTE Corp.

John Zysman
Professor
Department of Political Science
University of California, Berkeley

/k)&: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

Project Staff

Peter Blair
Assistant Director
OTA Industry, Commerce, and International Security Division

James W. Curlin
Program Director
OTA Telecommunication and Computing Technologies Program

PRINCIPAL STAFF

D. LINDA GARCIA
Project Director

Stephanie Gajar
Analyst

Sunil Paul
Analyst*

Jean Smith
Project Editor

Mark Young
Contractor

OTA REVIEWERS
John Alic
Rob Atkinson
Mark Boroush
Alan Buzacott
Vary Coates
Betsy Gunn
Todd LaPorte
Joan Winston
David Wye

ADMINISTRATIVE STAFF

Liz Emanuel
Office Administrator

Michelle Smith
Secretary

Karolyn St. Clair
PC Specialist

CONTRACTORS

Richard Bishop
Richard Bishop Consulting Ltd.

Timothy J. Brennan
University of Maryland Baltimore County

Robert Mittman
Institute for the Future

Abbe Mowshowitz
Rotterdam School of Management
Erasmus University, Rotterdam

Paul E. Teske
State University of New York at Stony Brook

*Until January 1994

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Executive Summary

Electronic transactions are now commonplace in the U.S. business environment. Consumers use electronic technologies daily to transfer funds, make credit card purchases, buy stock, and browse electronic catalogues. Businesses, too, rely heavily on electronic technology for record-keeping, accounting, inventory control, production management, and purchasing and sales. This use of networked information technology barely hints, however, at its full potential for improving U.S. economic performance in the future.

Competition from abroad has forced American businesses to seek new, more productive ways to organize their operations and carry out their work. These innovative methods include total quality control, customer-driven planning, lean production, agile manufacturing, just-in-time manufacturing, and electronic integrated enterprises. An advanced communication and information infrastructure, such as that embodied in the concept of a National Information Infrastructure (NII), could greatl y enhance these new management and production tools and improve overall U.S. economic performance.

This report identifies and frames the technological, economic, and social issues related to the use of electronic networks for business and commerce. It focuses on the features that must become part of an NII, as well as the social and economic conditions needed to support it. In an electronically networked economy, the design and underlying architecture of the global information infrastructure will have a major impact on national economic growth and development. However, if all American businesses—large and small, national and multinational, service and manufacturing—are to fully benefit from electronic commerce, national

Information technologies will need to be varied, flexible, open, and easily interconnected if they are to serve business and the nation's needs.

infrastructure policy must also consider the social and economic factors associated with its use.

POTENTIAL IMPACTS OF ELECTRONIC NETWORKS

Changes in the world economy and the global business environment require American businesses to adapt through innovation. These changes include: 1) the emergence of a highly competitive global economy in which multinational corporations play a greater role; 2) the growing importance of information as an economic resource and basis for competitive advantage; and 3) a shift from mass production to a system of customized, flexible production.

Information and communication technologies are driving and facilitating the adaptation of American businesses to these changes. Businesses are now using these technologies in nearly all of their operations: from recruiting to downsizing, from ordering materials to manufacturing products, from analyzing markets to developing strategic plans, and from inventing technologies to designing new uses for them. Early users of these technologies gain a strategic advantage; latecomers must eventually adopt them just to survive,

Networked information technologies are especially useful in helping firms to restructure and reengineer their operations to become more competitive. Businesses are using these technologies to reorganize their activities into more versatile and flexible networks and teams. Some businesses, for example, are using networking technologies to build long-term, integrated business relationships with their customers and suppliers. Others are teaming up with outside firms for specific, short-term ventures. Some of these business relationships, operating through electronic networks, cross national as well as organizational boundaries. Networking technologies such as wide area networks (WANs), videoconferencing, computer-integrated engineering and manufacturing, and electronic data interchange (EDI) are necessary to support these flexible business arrangements.

While information and communication technologies have an impact on how firms conduct their business, they will also affect the size, structure, and openness of markets. As these technologies are integrated into reliable commercial networks, more trade will take place in electronic markets, online. How these electronic markets evolve and the form they take will have significant consequences for the functioning of the economy as a whole. Electronic markets can reduce the net costs of doing business, and thus improve overall efficiency and expand trade. However, if these networks fail to interconnect, or are unevenly deployed, they could create technological barriers to trade and restrict competition.

TECHNICAL CRITERIA FOR SUCCESS

The “architecture” of electronic networks will be critical in determining the impacts of electronic commerce. Like a sculpture that is fashioned from Tinker Toys, a network’s structure is determined by the connections and linkages that give it shape. How these networks are formed and joined together in a national infrastructure will determine the size and scope of markets, as well as the gains in trade, the distribution of costs and benefits throughout the economy, the nature of work, and the quality of jobs.

Information networking technologies will need to be varied, flexible, open, and easily interconnected if they are to serve business and the nation’s needs. Flexibility and choice allow businesses to move quickly and strategically to respond to changing circumstances and market demand, and to mix and match network components to develop new products and services. Open, interoperable systems, which can be easily interconnected, reduce business transaction costs and barriers to market entry. Technology diffusion will also occur faster and more broadly because interoperable components are cheaper and easier to use. In addition, interoperable systems provide a standard platform for the innovation and development of new components and applications.

If everyone is to share the benefits of electronic networks, the technology must also be widely deployed. The first developer of a commerce network can gain a significant competitive advantage, if investment costs are high and the market is limited. Potential competitors may be unable to attract enough users to justify the cost of establishing additional networks. Latecomers in the business network game will also be disadvantaged because they lack the hands-on experience needed for network development and operation. Although the profits gained from an early competitive advantage may stimulate further network investment, this competitive advantage could lead to anticompetitive behavior if too many newcomers are discouraged or locked out of the market.

TECHNOLOGY ALONE IS NOT ENOUGH

The most sophisticated technology and the best designed network architecture will not achieve their potential payoff unless businesses change their attitudes and business procedures. Fortunatel y, new communication and information technologies are subversive; they can serve as agents Of change, helping firms to make the necessary adjustments. In a networked business environment, cooperation among firms can prove more rewarding than unbridled competition, and in formation-sharing more fruitful than information control. Moreover, with the rapid social, economic, and technology changes taking place, the most successful businesses will 1ikely be those that use information technologies to adapt to their changing environment. rather than to control situat i ons and events.

The workplace environment will be critically important. The shift from mass production to customized, flexible production will require a highly skillcd and flexible workforce. Information technologies can affect the workplace in one of two entirely different ways. Management can use technology counterproductive y to monitor workers, reduce skill levels, or replace permanent workers with contingent labor-. Or these same technologies can be used beneficially to improve workers skil1s, integrate employees into the decision process, and encourage team participation. If the benefits of electronic commerce are to be realized, business strategies will need to foster job quality, wages to support a high living standard, and a collaborative work environment.

IMPLICATIONS OF INFORMATION TECHNOLOGY CHOICES

The age-old adage that “knowledge is power” is nowhere more applicable than in a knowledge-based society. Whether in work relationships within a firm, competition in the marketplace. or trading relations among nations, having access to information and the ability to use it are the keys to success or failure.

This has always been the case, of course. What is different today is the extent to which knowledge is now embedded in information and communication technologies. As a result, choices about the design, architecture and structure, or the rules and regulations of network technologies will be irreversible in the short- to medium-term. Once technological decisions are made, technology develops along a given path. This is particular] y true for networked information technologies, which require huge amounts of sunk capital and social investment. Thus, this period of rapid technological advancement provides a rare opportunist y to assess and direct technological developments and the economic and social relationships associated with them. With the stakes high, and the potential for winners and losers, care must be given not onl y to the choice of technologies. but also to the participants in the decisionmaking process.

POTENTIAL ROLES FOR GOVERNMENT

With major changes in the world economy, all nations are rethinking their government’s responsibility for maintaining their economies. Russia and the Republics of the former Soviet Union and Eastern Bloc are undergoing the most dramatic readjustment to free markets. Europe is struggling with the transition to a single, unified market where national governments play a lesser role. Japan is experiencing similar doubts and reservations about its economic future, while trying to

sort out its government's role in pulling the country out of a severe recession.

The United States faces its own global readjustment. This will require that the nation move beyond the unproductive debate about whether the nation should have an "industrial policy" and begin to identify the joint interests of business and government and how they can mutually support one another. Government has always had a role—and cannot avoid its involvement—in structuring economic relations and outcomes.

In the context of the National Information Infrastructure, the private sector clearly has the primary role for developing, deploying, and operating the NH. For the most part, industry will develop the technology, provide bandwidth, offer connectivity, and ensure the availability of services and products in the pursuit of profit. Government, however, cannot stand idly by. In its various roles as regulator, broker, promoter, educator, and institution-builder, the government must establish the rules of the game and the incentive structure that will help determine private sector choices.

The same is true for electronic commerce. In government's role as regulator, it will need to ensure that electronic markets are evenly deployed, open, and accessible on an equitable basis. Acting as a broker, the government can bring together potential, but disparate, network users, thereby helping to generate a critical mass. As a promoter, the government can take steps to overcome market failures. As an educator, the government can promote electronic commerce by fostering demand through the effective use of networking technologies. Finally, and most importantly, the government can create an institutional environment that strives to assure that electronic commerce is conducted in a manner consistent with the nation's overall social and economic objectives.

Introduction 1

Few businessmen in the late 19th century were aware of how fundamentally machinery, transportation, electricity y, and communications technologies would change their lives. Most people could not foresee the profound social changes that these technologies would bring—the shift from an agricultural to an industrial-based economy; the exodus of people from rural communities to urban areas; the transformation of work from craft production to mass production; and the decl ine of small, proprietary business in favor of large, vertically integrated firms. Although revolutionary in their ultimate effect, the changes wrought by new technologies took place in an evolutionary fashion. Moreover, these impacts were both positive and negative, requiring considerable time and social and economic restructuring before they could be fully absorbed.

The United States is currently in the midst of a similar transition created in part by advances in communication and information technologies. These technologies have already transformed the structure, the markets, and the regulation of the communication industry, altering the ways that information is created, processed, transmitted, and delivered to consumers. Similar changes are taking place throughout the world. New communication and information technologies are making information products and services more available across national borders, wearing away the lines of demarcation between markets and communication systems that are considered domestic and those that are considered foreign.

These technological developments are radically altering the U.S. economy and changing the way that business is conducted. Markets are expanding globally; business organizations are streamlining: what we normally think of as a firm is becoming

Information and communication technologies will not only affect the nature of business organizations; they will also have considerable impact on the size, structure, and openness of markets.

blurred; some worker skills are becoming obsolete, requiring workers to be retrained; and production is being carried out "just-in-time" on a flexible schedule, rather than being mass-produced. These changes are fundamental and far--reaching. They challenge some traditional economic notions and definitions of terms such as the firm, competitive advantage, productivity, and economic performance.

The implications of these developments for business and the economy—as well as society as a whole—may only be fully appreciated by a few at this time. However, business leaders who take advantage of what these technologies have to offer will gain competitive advantages, while those who fail to recognize their potential will likely experience decline. To the extent that policy makers and businesses grasp the implications of these developments, they can make knowledgeable choices about how the nation will deal with them and take steps to offset their negative consequences. Unlike the lawmakers and businessmen at the turn of the century, who only reacted after new technologies had restructured their society, citizens today have an opportunity to comprehend and prepare for the radical changes taking place.

PURPOSE AND SCOPE OF THE STUDY

The study was requested by the Senate Committee on Science and Transportation and the House Committee on Science, Space, and Technology. The report identifies and frames the technological, economic, and societal issues related to the use of electronic networks for business and commerce. It provides neither cookbook solutions nor simple fixes for the complex problems raised by rapidly expanding uses of communication and information technologies by business and industry. The report is intended to contribute to the discussion and debate that will take place as the concept of a National Information Infrastructure (NII) moves from vision to reality.

This report describes and analyzes how advances in communication and information technologies will likely affect the future of American business and the national economy. It identifies the new opportunities that these technologies afford, as well as the technological, social, and economic conditions needed to take advantage of them. In addition, it describes and assesses the policy implications raised by electronic business networks; identifies where tradeoffs among values and stakeholders will need to be made; develops a framework and strategy that can be used to advance the debate; and suggests criteria for judging the options that Congress might consider.

This report is the latest in a series of OTA reports that address many of the technical, regulatory, and economic issues that communication and information technologies have raised. Prior OTA reports have addressed:

1. network and personal privacy;
2. electronic dissemination of government information;
3. delivering government services electronically;
4. managing radio frequencies for wireless communications;
5. protecting intellectual property in electronic environments;
6. the technology of advanced network design; and
7. the development of technical standards.]

In addition, OTA has several studies currently underway that address the use of the National Information Infrastructure for improving health care

[1] See the following publications from U.S. Congress, Office of Technology Assessment (Washington, DC: U.S. Government Printing Office): *Informing the Nation: Federal information Dissemination in an Electronic Age* (OTA-CIT-396, *1988); Critical Connections: Communications for the Future* (OTA-CIT-407, 1990); *Electronic Bulls and Bears: Securities Markets and Information Technology* (OTA-CIT-469, *1990); Global Standards: Building Blocks for the Future* (OTA-TCT-5 *12, 1992); Finding a Balance: Computer Software, intellectual Property, and the Challenge of Technological Change (OTA-TCT-527, 1992); The 1992 World Administrative Radio Conference: Technology and Policy Implications* (OTA-TCT-549, 1993); *Advanced Network Technology,* (OTA-BP-TCT-101), 1993; *Protecting Privacy in Computerized Medical Information (OTA-TCT-576, 1993);* and *Making Government Work: Electronic Delivery of Federal Services* (OTA-TCT-578, *1994).*

delivery, the role of wireless technology in the NII, and maintaining security and ensuring privacy within the NH environment.

This report, the prior OTA reports mentioned above, and those to be released later in the 103d and 104th Congresses will provide Congress with information and policy choices about technologies, problems, barriers, and economic implications of the development and deployment of a National Information Infrastructure.

NATIONAL INFORMATION INFRASTRUCTURE INITIATIVE

In September 1993, the Clinton Administration announced an initiative to promote the development of a National Information Infrastructure (NII):

> . . .that would create a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips. . ..[That] can help unleash an information revolution that will change forever the way people live, work, and interact with each other.[2]

The initiative relies on the private sector to innovate and aggressively pursue the deployment of these technologies. But certain problems in the deployment of the NH will persist that only the government can address.

The guiding principles for creating the NII include:

1. promotion of private sector investment;
2. extension of universal service at affordable prices;
3. promotion of technological innovations and new applications;
4. promotion of interactive, user-driven operation of the NII;
5. ensuring information security and network reliability;
6. improving the management of the radio frequency spectrum;
7. protection of intellectual property;
8. coordination within government agencies and with other countries; and
9. providing access to government information and improving government procurement.

This report focuses on the implications of the NII for business applications, and addresses many other issues related to the broader social and economic issues of the NII.

FACTORS DEFINING ECONOMIC PERFORMANCE

U.S. businesses are seeking new and more productive ways to organize their functions and activities in the face of increased competition from abroad. The new approaches have labels such as total quality control, customer-driven planning, lean production, just-in-time manufacturing, agile manufacturing, and electronically y integrated enterprises. Many of these ideas are inspired by innovations in foreign countries, some of which have been successful. An advanced communication and information infrastructure could make these tools even more effective for American business (see box 1 -1).

These new approaches are based on assumptions about the critical factors driving economic performance in today's global economy and about what constitutes *economic* success. Some, for example, stress the importance of national industrial policies; others emphasize the organizational cultures and structure of group relationships within the firm; still others focus on the use of technology to improve performance and eliminate unnecessary jobs and activities. But seldom are these factors considered in their entirety or as they relate to each other. Nor do they spell out in detail how, and under what circumstances, the communication infrastructure will likely contribute to economic success.

To ensure that the important factors are taken into account, it is necessary to consider how

[2]Information Infrastructure Task Force, "The National Information Infrastructure: Agenda for Action," Sept. 15, 1993.

BOX 1-1: Some Examples of How Businesses Are Using Information Networks

- Boeing Corp. has used networking technologies to reduce administrative overhead, speed production, and enhance product quality. Except for a few critical parts, most of Boeing's production is now being outsourced to suppliers throughout the world. Networked together using seven mainframe computers and 2,800 workstations, these suppliers have designed and preassembled the entire new Boeing *777* jet airliner. The company expects that this networked effort-the largest computer-aided design and computer-aided manufacturing project yet undertaken—will eliminate 20 percent of the project's total cost.
- Nike, Inc uses information networking technologies to reduce costs and achieve greater flexibility and responsiveness in an Industry that is subject to rapidly changing, global demand. Nike is the ultimate in "flattened" organizations. It "outsources" 100 percent of its athletic footwear production to suppliers. Having no production facilities of its own, it orchestrates the overall process, focusing on areas in which it has the greatest strength—research, design, and manufacturing.
- The discount retailer Wal-Mart uses networked point-of-sale technologies and reformation network tech nologies to Implement a quick response system with its vendors, Cash register data are collected, analyzed, and shared using electronic data interchange (ED I). This system has Improved Wal-Mart's efficiency, and many of its vendors have benefited from greater efficiency and increases in sales of up to 30 percent
- Computer use in financial markets was first initiated by the National Association of Securities Dealers Automated Quotations (NASDAQ) when it began in 1971 to provide computer listings of primary information for several thousand companies. A decade later, it developed a system to provide information as sales were completed. More recently, it has developed the PORTAL system, which provides the cross-listing of securities together with an automated trading system. Linked electronically with both the London and the Singapore exchanges, NASDAQ has become an important foreign exchange security market with trade totaling $6 billion in 1991,
- Networked services need not be high-tech for businesses to benefit. For example, toll-free services linked to the public switched network not only enhance business performance; they can also lower barriers to market entry. For example, 1-800 numbers can give small businesses access to a national, and even international, market. Many entrepreneurs, operating on a very small scale, are finding creative ways to take advantage of this opportunity John M Shanahan, for example, the founder and CEO of Gateway Educational Products, Ltd , used the toll-free number 1 -800-ABCDEFG to nationally market a musical phonics product, Hooked on Phonics, which he had originally developed for personal use to help teach his son to read. After *4* years, Shanahan's annual sales totaled $85 million, and he is now developing a follow-on educational math program. Shanahan attributes much of his success to his toll free "ABCDEFG" phone number,

SOURCE Off Ice of Technology Assessment, 1994

economic performance is defined and the conditions that foster high performance. It is then possible to examine the role of business as it relates to these factors. Economic performance entails three essential elements: 1) an increase in the average standard of living; 2) sustainable growth; and 3) greater sharing among all groups of the benefits of growth.[3]

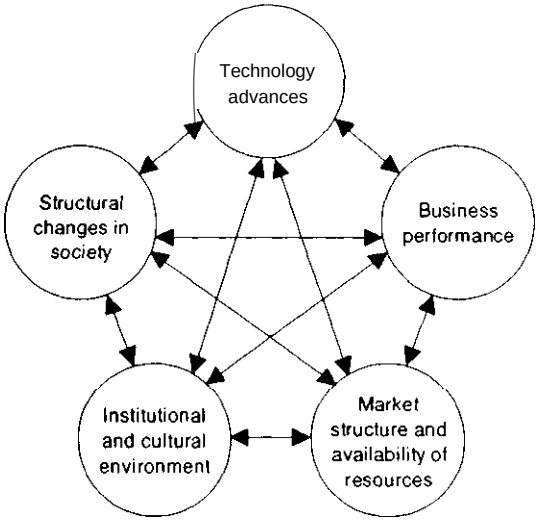
[3] As described by Rivlin: "There is no obvious single measure of how well the economy is performing in the long run, and there is lots Of room for argument about what aspects are important and how m measure them. At a minimum, Americans ought to want three things from their economy: the average standard of living should be rising; the improving level of living should be shared by all groups; and the rising standard should be sustainable. All three elements of this definition are important." Alice Rivlin, Reviving (he Americans *Dream: The Economy, the States, and the Federal Government* (Washington, DC: The Brookings Institution, 1992, p. 35).

The factors that determine economic performance, as defined here, include:

1. major structural changes in society that create new business opportunities or pose new constraints;
2. technological advances that create new possibilities and potential problems;
3. the ability of business and industry to seize these opportunities and adapt to their changing environment;
4. the impact of business decisions on market structure, factor resources, and other economic actors; and
5. the role of government and other institutions that support or inhibit business activities and determine the rules of operation for business and the marketplace (see figure 1-1).

These factors are interrelated and, over time, account for changes in economic performance. Technological advances, for example, are a major source of social and economic change. In economic relationships, technology developments will affect economies of scale, the availability of product substitutes, the cost of production, and the structure of the market.[4] Work relationships are influenced by technological advances, as the history of automation clearly attests.[5] New technologies also create new potential and new opportunities that change ideas about what is possible and what is not. By challenging conventional ways of thinking, technological advances also provide an opportunity to reassess and reconsider basic socioeconomic values, goals, and choices.[6]

FIGURE 1-1: Factors Determining Economic Performance



Economic performance is defined as growth sustainable over time including an Increase m the average standard of living for all groups Economic performance is a function of a complex Interrelationship of factors

SOURCE Off Ice of Technology Assessment 1994

Although sweeping in their impacts, technological advances are not without limits. New technologies are subject to social choice; they are also regulated by the institutional, cultural, and organizational environments in which they evolve. Businesses rarely adopt technological innovations in their original form; rather, they redesign and adapt them to meet their specific needs

[4]As Porter has described: "Technological change is one of the principal drivers of competition. It plays a major role in industry structural change. as well as m creating new industries. It is also a great equalizer, eroding the competitive advantage of even well-entrenched firms and propelling others to the forefront. Many of today's great firms grew out of technological changes that they were able to exploit. of all the things that can change the rules of competition, technological change is among the most prominent. " Michael Porter, *Competitive Advantage: Creating and Sustaining Superior Performance (New* York, NY: The Free Press, 1985), p. 164.

[5]See, for instance, David Noble, *Forces of Production: A Social History of Industrial Automation (New* York, NY: Oxford University Press, 1984).

[6]Emmanuel G. Mesthane, "The Role of Technology in Society," in Albert H. Teich (cd.), *Technology and Man's Future (New* York, NY: St. Martin's Press, 1981); and Langdon Winner, Autonomous *Technology: Techniques Out of Control as a Theme in Political Thought* (Cambridge, MA MIT Press, 1977).

and to conform to their organizational cultures.[7] Businesses that can take advantage of these technological developments to reduce costs, increase efficiency, extend markets, develop new products, or otherwise gain a competitive advantage will prosper-others will not.

Technologies tend to embody social values and forms of social organization; thus, their impacts are felt far beyond the realm of business itself.[8] Technology will also have an impact on the nation's competitiveness, the structure of the marketplace, workplace skills, values, tastes and preferences, and the quality of the environment. Moreover, if the nation's economy is to perform well, it will need to create an environment in which businesses can be flexible in adapting to changes in the competitive environment. To do so, government will need to support the acquisitions of knowledge and learning, induce innovation, foster risk-taking and creative activity of all sorts, and help resolve problems and bottlenecks as they arise.[9] The communication and information infrastructure supporting these efforts will need to be widely accessible and flexible.

THE CHANGING BUSINESS ENVIRONMENT

Today, American businesses and the U.S. economy as a whole are confronted by a number of changes that require an innovative response (see box 1 -2). Among these are: 1) the emergence of a high] y competitive global economy in which multinational corporations play a greater role; 2) the growing importance of information as an economic resource and basis for competitive advantage; and 3) the shift from mass production to a system of customized, flexible production.

| Emergence of a Competitive Global Economy

The integration of the international economy has been facilitated and fostered by a number of developments. These include:

- the increasing similarity among countries with respect to tastes, infrastructure, distribution channels, and marketing approaches;
- the emergence of a global capital market, as witnessed by the large flow of funds between countries;
- declining tariff barriers and the establishment of regional trading agreements;
- shifting opportunities for competitive advantage due to technology restructuring;
- the integrating role of advanced information and communication technologies;
- slow and uneven world economic growth that has fanned the flames of international competitiveness; and
- the emergence of new global competitors, prin - cipally from East Asia. [10]

Together, these developments have given rise to a global economy in which patterns of international trade primarily reflect patterns of international production, Specialization takes place on the basis of parts and specialized components, rather than on the exchange of finished products as in the past. Thus, inter-firm and intrafirm trade is steadily replacing interindustry trade. [11] Today, for example, Japan provides approximately 40 per-

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[7] See, for instance, Philip Anderson and Michael L. Tushman, "Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change," *Administrative Science Quarterly, vol. 35, 1990,* pp. 604-633; and Wesley M. Cohen and Daniel A. Levinthal, "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly,* vol. 35, 1990, pp. 128-152.

[8] Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch (eds.), *The Social Construction o/ Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: The MIT Press, 1987).

[9] Douglas North, *Institutions, Institutional Change and Economic Performance* (Cambridge, England Cambridge University Press, 1990).

[10] Michael Porter (ed), *Competition in Global Industries* (Boston, MA: Harvard Business School Press, 1986), pp. 408-409.

[11] Robert Gilpin, *The Political Economy of International Relations* (Princeton, NJ: Princeton University press, 1987), p. 238. See also Jack N. Behrman, *Industrial Policies: International Restructuring and Transnationals* (Lexington, MA: Lexington Books, 1984).

BOX 1-2 The Economic Environment

Business environments change over time because of technology advances, major social and economic events, new ways of thinking about business and evaluating performance, and changes in the institutional norms and government rules that determine economic behavior These changes may be abrupt and revolutionary, as in the case of war, famine, and natural disaster More often than not, however, structural changes take place Incrementally, having a cumulative effect over time Even changes as significant as the demise of the feudal system or the Industrial revolution occurred not at one stroke, but in an evolutionary fashion as a result of a number of small but Interrelated events [1]

Structural changes create both new economic opportunities and new constraints The American Civil War, for example, gave rise to both It not only ended slavery, and thereby greatly constrained the mode of cotton production in the South, it also created new opportunities for textile manufacturing [2] More recently, a vast array of new market opportunities have been created with the sudden collapse of the governments of the Eastern European bloc

Over the long run, business performance depends on how well businesses react to such changes Those that respond creatively can gain advantage, while those that fail to adapt will likely experience decline [3] The railroad industry is an example In the fifties, when U S railroad companies were confronted by trucking and the airlines, they disregarded them They did not see these technologies as a threat because they thought of themselves as being in the railroad business rather than the transportation business This misperception was costly, the railroad companies were soon superseded by the emerging trucking and airline industries

National economies are also subject to such ebbs and flows This rise and fall occurs because the conditions for success—or competitive advantage—vary according to circumstances What works well in one case will not necessarily succeed in another [4] Thus, for example the U S economy gained advantage over many European economies during the Industrial era because mass production required a large market which existed only in the United States [5] Similarly, although the British economy was successful in the 19th century, it declined in the 20th in part because, unlike the Germans and others who invested in science and education, the British failed to anticipate the emergence of new markets and the growing Importance of knowledge resources [6]

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[1] As North notes with respect to the feudal structure "The Important point is that the changes were an aggregation of literally thousands of specific small alterations in agreements between lords and serfs, which in total made for fundamental institutional change Douglas North *Institutions Institutional Change and Economic Performance* (Cambridge UK Cambridge University Press, 1990) p 89 Braudel describes the industrial revolution in similar terms "When one is talking about social phenomena rapid and slow change are inseparable For no society exists which is not constantly torn between the forces working to preserve it and the subversive forces—whether perceived as such or not—working to undermine it Revolutionary explosions are but the sudden and short-lived volcanic eruption of this latent and long term conflict " See Fernand Braudel *Civilization and Capitalism 15th - 18th Century The Perspective of the World* vol III (Berkeley CA University of California Press 1992) pp 537-538

[2] See Brodus Mitchel *The Rise of Cotton Mills m the South* (Baltimore MD The Johns Hopkins Press, 1921) As the author points out the availability of slave labor tended to discourage the development of manufacturing in the South until after the Civil War when the textile industry began to flourish

[3] Andrew Schotter *The Theory of Social Institutions* (Cambridge, UK Cambridge University Press, 1981) pp 1-2

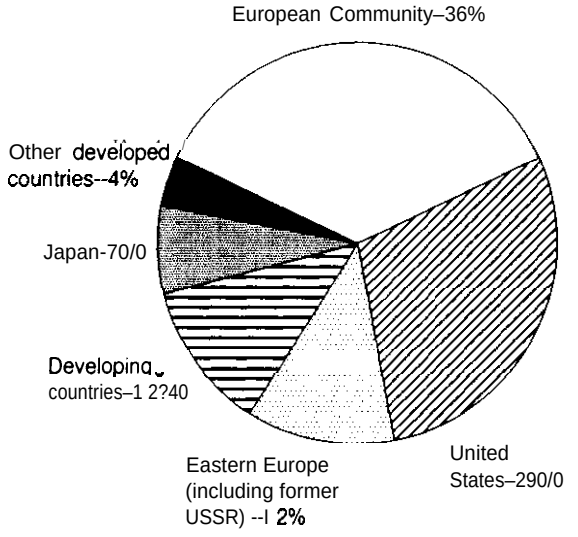
[4] As Karl Polanyi notes "A nation may be handicapped in its struggle for survival by the fact that Its institutions, or some of them, belong to a type that happens to be on the down grade—the gold standard in World War II was an instance of such an antiquated outfit Countries on the other hand which for reasons of their own are opposed to the *status quo* would be quick to discover the weaknesses of the existing institutional order and to anticipate the creation of institutions better adapted to their interests See Karl Polanyi, *The Great Transformation The Political and Economic Or/gins of Our Time* (Boston, MA Beacon Press 1957) p 28

[5] For a discussion of these factors in mass production see Harold Williamson (ed), *The Growth of the American Economy (New* York NY Prentice Hall 1951) pp 721-722

[6] See James Beckford ' Great Britain Voluntarism and Sectional Interests in Robert Wuthrow (ed) *Between States and Markets The Voluntary Sector in Comparative Perspective* (Princeton NJ Princeton University Press 1991) p 33

SOURCE Off Ice of Technology Assessment, 1994

FIGURE 1-2: Share of Major International Joint Ventures (Announced August-December 1992)



SOURCE Institute for the Future, "The Electronic Enterprise," contractor report prepared for the Off Ice of Technology Assessment, May 1993

cent of U.S. component parts in electronics and automobiles. [12]

Patterns of direct investment abroad also highlight this trend toward global economic integration and interdependence. Between 1960 and 1988, for example, direct investment abroad by all firms in all nations increased by over 10 percent per year to more than $1.1 trillion. This trend is especially pronounced in the United States where foreign direct investment increased during the same period faster than the world average—from $9.9 billion to $328.9 billion, or 18 percent per year. Moreover, foreign direct investment accounted for 3.4 percent of Gross National Product (GNP) in 1978, compared with 1.8 percent a decade earlier. ' [14]

Multinational corporations are also driving the trend toward globalization. To compete in today's global economy, companies must integrate their activities on a worldwide basis, allocating activities among a number of countries to gain the greatest advantage. [15] Depending on the particular case, it might be best for a firm to disperse its production facilities—such as design modification, fabrication, and assembly—to foreign countries, and to focus its own domestic production on the fabrication of key components. [16] or, alternatively, a firm might decide to manufacture a product domestically, but transfer abroad such downstream activities as distribution, sales, marketing, and service. When not fully integrated into multinational corporations, these firms are networking their activities across global boundaries through a variety of arrangements such as cross-1icensing of technology, joint ventures, orderly marketing agreements, offshore production of components, secondary sourcing, and crosscutting equity ownership [17] (see figure 1 -2).

[12] Porter, op. cit., footnote 10, p. 225.

[13] John W. Rutter, "Direct Investment Update: Trends in International Direct Investment," U.S. Department of Commerce, International Trade Administration, September 1989. The stock investment given here is the position of foreign direct investors, or the value of the foreign investors' equity in and loans to offshore affiliates. For the United States, a foreign direct investor is one that owns or controls at least 10 percent of a company's voting stock (or equivalent amount in an unincorporated enterprise)

[14] Ibid.

[15] See Porter, op. cit., footnote 10.

[16] Ibid.

[17] Gilpin, op. Cit., footnote 11. See also Peter Cowhey and John Aronson, *Managing the World Economy: The Consequences of Corporate Alliances* (New York, NY: Council on Foreign Relations, 1993). Once generally associated with U.S. industries, multinationals are, themselves, increasingly becoming global in nature. For example, globally networked Japanese and European firms, while differing somewhat in style from U.S. firms, have significantly grown in number in the course of the past decade. See Bruce Kogut, Weijian Shari, and Gordon Walter, "Knowledge in the Network and the Network as Knowledge," in Gernot Grabher, *The Embedded Firm: On the Socioeconomic's of Industrial Net\\orks* (London, UK: Routledge, 1992), p. 90.

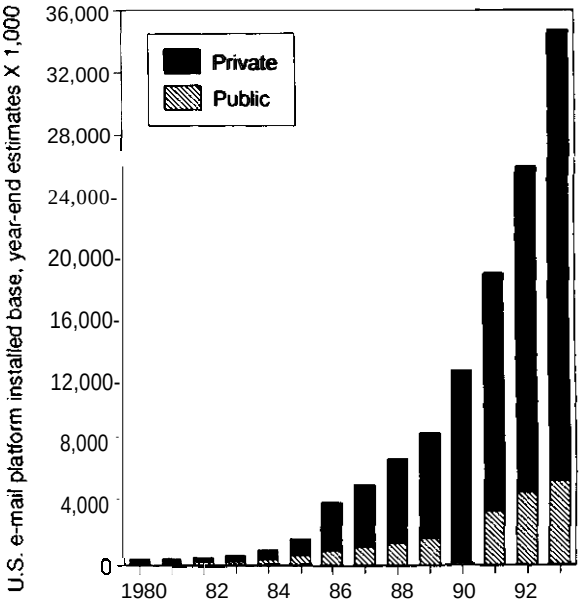
I Trend Toward an Information-Based Economy

There is an interrelated trend toward an information-based, network economy. Increasingly, information serves as a primary resource, a key factor of production. Information is becoming a prerequisite to the development and allocation of other resources. As such, it is treated less and less as a free good and more and more as a commodity to be bought and sold in the marketplace. As the economic value of information increases, the economic rewards of those who have greatest access to it grow as well. [18]

The trend toward an information-based economy results, in part, from the development and widespread deployment of information and communication technologies. The emergence of these technologies has increased: 1) the speed at which information can be communicated; 2) the quantity of information that can be collected, stored, manipulated, and transmitted; and the access to information (see figure 1-3).

These technologies provide numerous ways to improve efficiency and increase productivity, and thus engender growth. Information is, for example, reusable. Unlike capital resources such as steel and iron, it requires very few physical resources to produce and distribute it. Information can be used to substitute more efficiently for labor and to improve the overall efficiency of the productive process itself. As productive processes become increasingly complex, the largest reserve of economic opportunities will be in organizing and coordinating productivity activity through the process of information-handling [19] (see figures 1-4 and 1 -5).

FIGURE 1-3: Growth of Private and Public Electronic Mail Networks



NOTE The online computer version of mail, "electronic mail" (e-ma(l), is perhaps the most used and most basic computer network application Simpler to use than writing and mailing a letter, e-mail is installed on virtually every networked computer and the total number of e-mail addresses (mailboxes) is growing exponentially As depicted above, e-mail addresses installed by the private sector (corporations, nonprofit associations, and universities) have grown much faster than their public counterparts

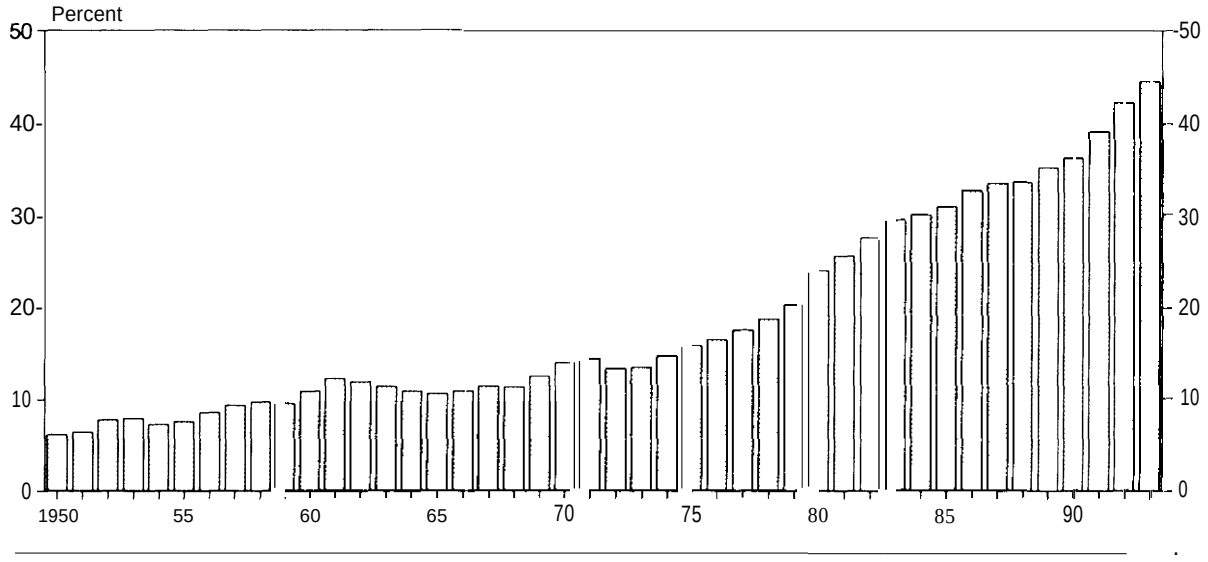
SOURCE Electronic Mail and Micro Systems Jan 1 1994, PP 1-10 (year-end 1993 figures revised April 1994)

Technology advances have also given rise to new businesses that specifically cater to business information needs. Information can now be processed in a variety of new ways, adding to its value from the point at which it is created or composed

[18] As noted by Merrifield "Wealth will no longer be measured primarily in terms of ownership of fixed physical assets, but rather in terms of time-critical access to needed resources; and to knowledge-intensive value-added operations. The value-added dimension, moreover, will be the deciding source of the comparative advantage required for industrial competitiveness. This shift in the basis of wealth formation is a major break with the past, a discontinuity that is driven by accelerating forces of change. One of these factors involves an explosion of technology that has created about 90 percent of all scientific knowledge over just the last 30 years. Moreover, this knowledge basis is likely to double again in the next 15 years." D. Bruce Merrifield, "Global Strategic Alliances Among Firms," *International Journal of Technology Management, Special Issue on Strengthening Corporate and National Competitiveness Through Technology*, vol. 7, 1992, p. 77.

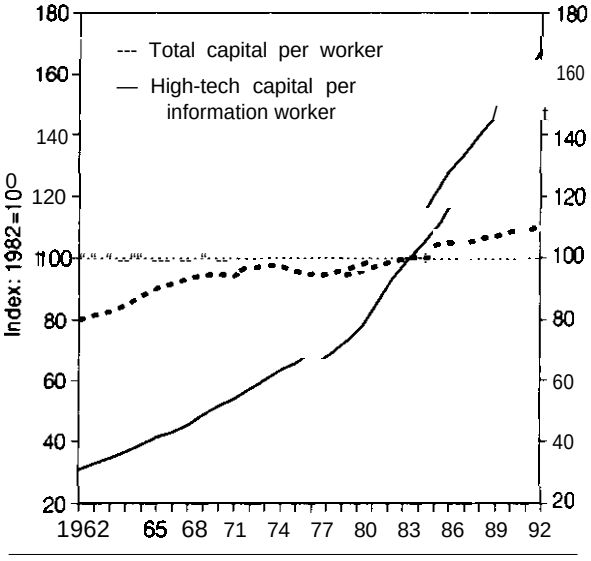
[19] Charles Jonshur, "Information Resources and Economic Productivity," *Information Economics and Policy* / (North Holland: Elsevier Science Publishers. 1983), pp. 13-35.

FIGURE 1-4: Information Technology as a Share of Total Investment in Producers' Durable Equipment



SOURCE Morgan Stanley Economics, 1994

FIGURE 1-5: Capital Endowment in the Service Sector



SOURCE Morgan Stanley Economics, 1994

to the point at which it is assimilated or used. As the opportunities for creating new information products and services have increased, so too have the number of commercial providers. Responding to the increased demand for information, the new technologies have spawned a rapidly growing industry. For example, in 1992, the worldwide market for online services totaled $10.1 billion, a 9.2 percent increase from $9.3 billion in 199120 (see box 1-3).

Shift to Flexible, Decentralized Production

To gain competitive advantage in a knowledge-based, global economy, firms must adopt new ways of doing business. Customers are now more diverse and sophisticated, and new, highly skilled competitors use communication networks to access foreign markets. Success in the global economy no longer depends only on achieving efficien-

[20] *Online Services: 1993, Review*, Trends & *Forecast* (Wilton, CT: SIMBA/Communications Trends, 1993), p. 11.

cy and cost reduction.[21] Increasingly, it depends on the effectiveness of businesses—their ability to innovate, respond just-in-time, focus on quality, and establish more cooperative interfirm and intrafirm relationships. To enhance their effectiveness, businesses are taking advantage of more timely and appropriately packaged information to help them shift from business models based on mass production to those that center around the concept of flexible, decentralized production[22] (see table l-l).

The system of mass production that developed in the United States was extremely efficient for its time. Because it eliminated variability, it greatly reduced the need for information. With lower information costs, firms could handle greater volume and reap even greater efficiency gains through economies of scale and scope, The system was self-reinforcing. Given lower costs, volume was sustained through price reduction and the generation of a mass market.[23] However, this system of mass production, which took the form of the assembly-line process, hinged on maintaining constancy. As a result, everything-parts, processes, tools, products, workers, and tasks—had to be standardized.[24] In addition, this system required a rigid, hierarchical business structure that would provide adequate control .[25] Equally important, it necessitated a tradeoff in favor of efficiency over diversity.[26]

Such a tradeoff is neither necessary nor appropriate today when diversity is at a premium. Flexible, decentralized production systems (also referred to as mass customization) allow businesses to customize production without sacrificing economies of scope. Using such an approach, businesses seek to control a particular market niche rather than maximize market size. As a result, scale economies are no longer such an important factor for success .27

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[21] As noted by Gehani: "For many years, the delay and the cost ..in the development of new products did not hurt most companies' bottom line very much. The customers generally waited patiently for new products to appear in the market. With few new organizations entering an oligopolistic and mainly domestic U.S. economy, [here was no significant erosion in (he customer base of an organization due to such delays. But with globalization of competition in the l 980s and ease of transcontinental movements of goods, money, and information, foreign competitors started entering as soon as some gaps appeared in the highly valued U.S. or European markets. " R. Ray Gehani, '"Concurrent Product Development for Fast Track Corporations, " *Long Range P/arming,* vol. *25,* No. 6, pp. *40-47, 1992.*

[22] As Stinchcombe points out: "'Structures of organizations, and of parts of organizations, vary according to the sorts of uncertainties the) confront, and according to what sources of information they depend on and to how that information is best got to the dec I sion-making un Its. " Arthur L. Stinchcombe, *Information and Organizations* (Berkeley, CA: University of California Press, 1990), p.3.

[23] As Williamson notes: "Mass production was the main support as it was the prerequisite of mass production. . . . The American home market, in the words of Andrew Carnegie, is a 'vast homogeneous market, and this factor too was a major influence affecting the evolution of mass production. Across the horizontal plane and its great geographical extend, as well as up and down the vertical social scale, the A merican market place underwent a standardization of taste and consumption that bore profound psychological and economic significance.' '" Harold WI II iamson (ed.), *The Growth of the American Economy (New* York, NY: Prentice Hail, 1957), pp. 721-722.

[24] Ibid. See also James P. Womack, Daniel T. Jones, and Daniel Roos, *The Machine 7-hat Changed The 14'orld: The Story of Lean Production (New* York, NY Harper Perennial, 1990), p. 27.

[25] James Beniger, *The Control Revolution: Technology and the Economic Origins of the Information Society* (Princeton, NJ Princeton University Press, I 986).

[26] As pointed out by Boynton et al.: "Change in either process or product works against the mass- -production formula. Changes m product make reach inery obsolete, force costly changeover and reduce managerial control. Changes in process complicate ind i vidual jobs, raise waste and error, and increase unit costs. Thus a mass production organization is intended to respond to and initiate as little change as possible. This design for stability requires limiting product variety as well as process innovation. '" A.C. Boynton, B. Victor, B.J. Pine II, "New Competitive Strategies. Challenges to Organizations and Information Technology," *IBM* Systems *Journal,* vol. 1, 1994, pp. 43-44.

[27] According to Ayres: "The key to the suggested "new paradigm" for economic grow [h is that increasing flexibility progressively reduces the cost d] fferential between customized and standardized products. The smaller this differential, the greater the demand for diversity and, hence, flex ibility. But this process, in turn, leads to further improvements in the manufacturing process , generating savings in both labor and capital, and in effect, restraining the traditional cost-driven engine of growth." R.U. Ayres, "CIM A Challenge to Technology Management," *International Journal of Technology Management,* December 1992, p. 21.

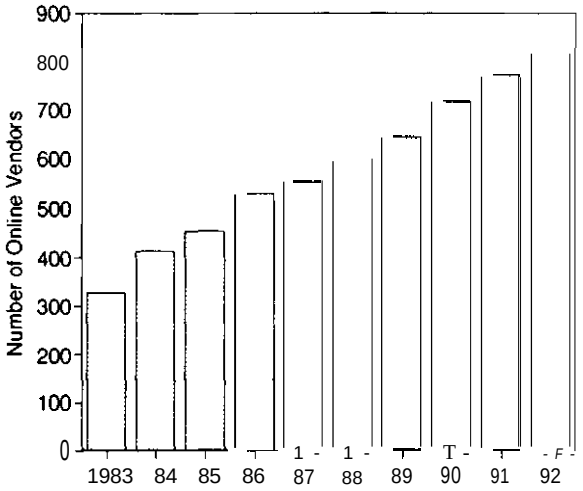
BOX 1-3: Online Information and Services Market

Online Information—facts, figures, pictures, numbers, and words traveling through telephone and computer networks, and stored and retrieved from computers—is prevalent and growing throughout the American economy Businesses and consumers are using this method of information-gathering and exchange to supplement telephone conversations, face-to-face conversations, and paper-based information sources While the most basic services only allow for information retrieval from a database, others allow communications such as electronic mail (E-mail), electronic bulletin board services (BBSs), and online chat sessions similar to telephone conference calls.

Looking back in time, the first online service was computer time-sharing that gave businesses access to a central computer from a dumb terminal at a remote site Computer time-sharing allowed companies that could not afford in-house systems to benefit from computing After computer time-sharing took hold, publishers realized the benefits of distributing information as well as computing resources through similar shared network arrangements Today, online information and communications are generally accessed through personal computers instead of dumb terminals The installed base of personal computers is expected to number about 57 million in the United States and 148 million worldwide by 1994 [1]

SIMBA Information Inc , a market analyst, divides the online services market according to whether businesses or individuals are the customer. The services offered to businesses and consumers, however, may be similar as individuals demand business-oriented services, such as for professional correspondence or individual investing More specifically, the business services market includes brokerage, credit, financial news/research, legal/regulatory, and professional/library services, whereas the consumer services market includes general interest, individual investing, and gateways to more than one service provider

FIGURE 1-6: Annual Online Vendor Growth 1983-92



SOURCE Gale Directory of Databases, Volume 1Online Databases Gale Research, Detroit, MI, 1993

(continued)

[1] Dataquest Inc , San Jose, CA, as cited in Online *Services 1993 Review,* Trends&Forecast (Wilton, CT SIMBA/Communications Trends, 1993)

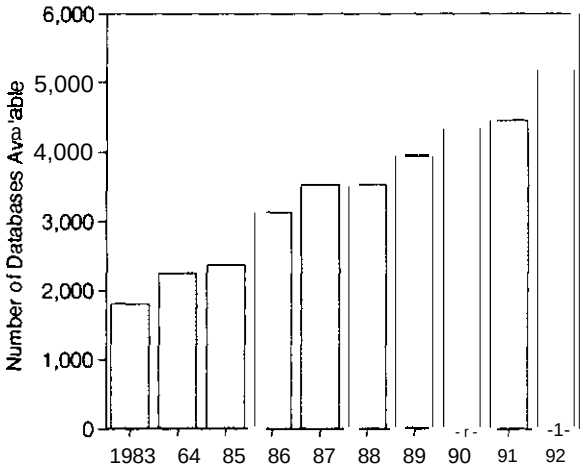
BOX 1-3: Online Information and Services Market (cont'd).

Brokerage services distribute real-time market information to banks and financial institutions Credit services collect and sell payment histories to credit grantors Financial news/research services provide news and decision support services for investors Legal/ regulatory services provide access to government information such as laws, corporate records and real estate transaction histories Marketing services sell targeted mailing lists and other market Information Professlonal/li - brary services sell scientific, medical, and technical Information Individual investor services give Information such as stock quotes and some permit Investors to initiate trades Gateways are telephone company services that provide links to many online services

The online services market IS growing rapidly Worldwide sales in 1992 topped $101 billion Of this amount, North American-based companies accounted for 60 percent and European-based companies accounted for 32 percent Annual sales growth was 92 percent in 1992 and averaged 91 percent between 1988 and 1992 Figures 1-6 1-7, and 1-8 depict the growth between 1983 and 1992 in the numbers of databases, database producers and online services (vendors who distribute database information) While these numbers are large, they are only a subset of a much larger information market that Includes the sale of information and services over private networks, electronic data interchange (EDI), networking offered by value-added networks (VANS), airline customer reservation systems (CRSs), real-estate multiple-l listing services (MLSs), electronic funds transfers (EFTs) and automated teller machines (ATMs)

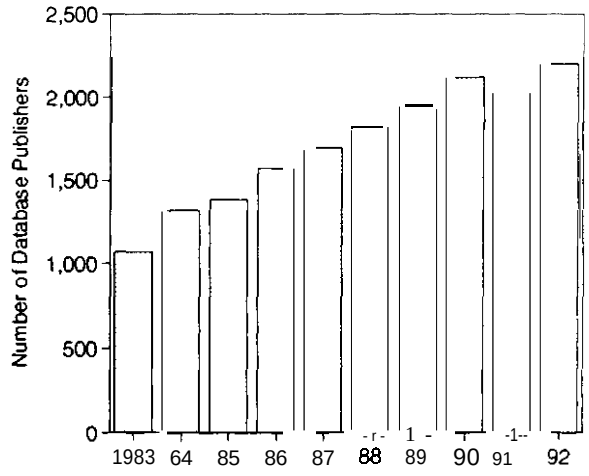
SOURCE *On/me Services 1993 Review Trends & Forecast* (Wilton CT SIMBA Communications Trends 1993)

FIGURE 1-7: Annual Online Database Growth 1983-92



SOURCE Gale Directory of Databases, Volume 1 Online Databases Gale Research, Detroit, MI, 1993

FIGURE 1-8: Annual Database Publisher Growth 1983-92



SOURCE Gale Directory of Databases, Volume 1 Online Databases Gale Research, Detroit, MI, 1993

TABLE 1-1: Changing Organizational Patterns in U.S. Industry

Old model	New model
Mass production, 1950s and 1960s	**Flexible decentralization, 1980s and beyond**
Overall strategy	
* Low cost through vertical integration, mass production, scale economies, long production runs. * Centralized corporate planning, rigid managerial hierarchies. * International sales primarily through exporting and direct Investment	* Low cost with no sacrifice of quality, coupled with substantial flexibility, through partial vertical disintegration, greater reliance on purchased components and services, ‘ Multimode International operation, including minority joint ventures and nonequity strategic alliances
Product design and development	
* Internal and hierarchical, m the extreme, a linear pipeline from central corporate research laboratory to development of manufacturing engineering. * Breakthrough innovation the ideal goal	* Decentralization, with carefully managed division of responsibility among R&D and engineering groups, simultaneous product and process development where possible, greater reliance on suppliers and contract engineering firms. * Incremental innovation and continuous improvement values.
Production	
* Fixed or hard automation * Cost control focuses on direct labor * Outside purchases based on arm’s length, price-based competition, many suppliers • Off-line or end-of-line quality control. * Fragmentation of individual tasks, each supplied in detail, many jobs classifications • Shopfloor authority vested ■ first-line supervisors, sharp separation between labor and management.	• Flexible automation, * With direct costs low, reductions of Indirect cost become critical * Outside purchasing based on price, quality, delivery, technology, fewer suppliers. * Real-time, on-line quality control. * Selective use of work groups; multitasking, job rotation, few job classifications * Delegation, within limits, of shopfloor responsibility and authority to individuals and groups, blurring of boundaries between labor and management encouraged
Hiring and human relations practices	
* Workforce mostly full-time, semi-skilled * Minimal qualiflcations accepted * Layoffs and turnover a primary source of flexibility, workers, in the extreme, viewed as variable csst	‘ Smaller core of full-time employees, supplemented with contingent (part-time, temporary, and contract) workers. who can be easily brought in or let go, as a major source of flexibility * Careful screening of prospective employees for basic and social skills, and trainability • Core workforce viewed as an investment, management attention to quality-of-workmg life as a means to reducing turnover
Job ladders	
• Internal labor market, advancement through the ranks via senlority and informal on-the-lob training	* Limited internal labor market, entry or advancement may depend on credentials earned outside the workplace
Governing metaphors	
* Supervisors as policemen, organization as army	* Supervisors as coaches or trainers, organization as athletic team (The Japanese metaphor organization as family.)
Training	
* Minimal for production workers, except for Informal on-the-job training. * Specialized training (including apprenticeships) for grey-collar craft and technical workers	* Short training sessions as needed for core workforce, sometimes motivational, sometimes intended to improve quality control practices or smooth the way for new technology * Broader skills sought for both blue- and grey-collar workers

SOURCE Off Ice of Technology Assessment, September 1990

Flexible, decentralized systems use information and networking to integrate and compress the time from product innovation to marketing to drive demand and to maximize customer responsiveness.[28] With a variable organizational structure, firms can rearrange their activities around teams and networks that bring together everyone who is involved in the life cycle of a product. Working together and sharing the same information, all processes can be carried out in parallel .29 This kind of structure reduces the time involved in product development and the likelihood of waste. It also leads to fewer defects and higher quality products. This is a major benefit because, as production processes become more complex, the cost of error detection and correction is rising as a fraction of total cost.'[30] Moreover, flexible teams are advantageous because they can be reconfigured to respond quickly to changing demand.[31]

POTENTIAL FOR BUSINESS

| Impact of Technology on Businesses

Information and communication technologies are both driving and facilitating the adaptation of business to structural changes in the economy. Businesses are now applying computer technology to almost all of their activities—from recruiting to laying off workers, from ordering raw materials to manufacturing products, from analyzing markets to performing strategic planning, and from inventing new technologies to designing applications for their use. Not only are these technologies being applied to traditional tasks; they are also being used to reconfigure the nature of the business process itself. While early innovators and adopters have often used these technologies to gain strategic advantage, businesses must take advantage of them over the long term for the sake of survival alone.

Conducting business on *a global scale,* for example, creates many new challenges and opportunities.[32] To fully benefit from the availability of worldwide resources and markets, businesses must have a truly translational perspective that harmonizes operations in the service of a single corporate strategy. Translational corporations must be able to balance their global operations with the requirements of local markets—such as the need to establish special sales channels, service contracts, and work relationships. In addition, as companies spread their corporate boundaries, they will need to make decisions that are far more complex based on information and data that

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[28]As noted by Bessen: "The phrase 'getting close to the customer' now has a definite high-tech ring. Farsighted companies like American Airlines and R.J. Reynolds have gained a decisive competitive edge by building powerful customer information systems. Through such systems, these companies not (rely understand individual consumers better but also employ information to develop and market new products." Jim Bessen, "Riding the Marketing Information Wave," *Harvard Business Review,* September/October, 1993, p. *150.*

[29]As Gehani points out, if such teams are to he effective: "'the organization human resources may have to be trained to share, communicate, and exchange Ideas with team members from other parts of the organization in a non-confrontory manner. In a traditional 'serial organization, product and process innovations may emerge independently in different parts of the organization. On the other hand, in an integrated "parallel organization, the product and process innovations in different parts of an organization develop and grow concurrently in a sharing and 'systemic' manner." op. cit., footnote 21.

[30]Ayres, op. cit., footnote 27, p. I 8.

[31]As noted by Gehani ". . .an accelerated product development process produces both internal as well as external benefits to an organization. The external or competitive benefits include market penetration due to faster customer responsiveness, premium pricing, precise flow of market research information, and ability to incorporate latest technology into a product." Op. cit., f(wtnote21. See also, Boynton et al, op. cit., footnote 26.

[32]See, for instance, Robert Mittman, "The Electronic Enterprise," contractor report prepared for the Office of Technology Assessment, May 1993. See also Stephen H, Rhinesmith, John N. Williamson, David M. Ehlen, and Denise S. Matwell, *Training and Development ./et/rfra/,* April 1989, pp. 25-34.

reflect cultural and political disparities.[33] Worldwide networks that can support group decision-making and information-sharing will be critical for operating in such a fashion.

If available to them, networked technologies will also allow small and rural businesses to participate more fully in the global economy .34 For example, a small business that serves only a single niche market may be able to greatly expand its operations by using technology to enter similar niche markets on a worldwide basis. Small companies may be able to link up with translational corporations as suppliers, value-added providers, or other market intermediaries. In addition, technology enables groups of small businesses to operate as if they were much larger entities, much like consortia, enabling them to compete with large businesses on a more equal footing. When working with translational corporations, however, small businesses may require high-capacity/high-quality networking systems comparable to those used by larger businesses, as well as the skills and expertise necessary to integrate them.

The international communication marketplace is rapidly responding to this demand for seamless, worldwide telecommunications services.[35] According to one account, in 1990, 16.3 percent of worldwide value-added service revenue was derived from international offerings. Estimates are that this figure will increase to 28 percent by 1996.[36] To provide service, a full range of providers are engaging in a variety of new cooperative arrangements-global partnerships, consortia, joint ventures, and foreign investments.[37]

The need to apply information and knowledge to an ever-growing number of complex business problems—as well as to share and leverage these resources both within and across organizational boundaries-will also increase business requirements for advanced applications and networking technologies, such as wide area networks, databases for information management, groupware, and electronic data interchange (EDI).[38] Sharing information and data permits businesses to employ production processes that shorten product cycles and adopt marketing strategies that are highly responsive to customers needs. For example, computer-integrated manufacturing (CIM) improves efficiency and product quality because the data describing the engineering parameters of a product, once created and stored electronically, can be retrieved by any member of a project team in a form most appropriate for his or her needs (see boxes 1-4 and 1 -5). Redundancies and discrepancies are avoided because everyone uses the same information.[39] Similarly, businesses can greatly improve customer service by employing distributed computing systems and relational databases

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33 Cresiencia Torres and Mary Bruxelles, "Capitalizing on Global Diversity," *HR Magazine,* December 1992, pp. 30-33.

34 See J.E. Butler and G.S. Hansen, "Network Evolution, Entrepreneurial Success and Regional Development," *Entrepreneurship and Economic Development, vol. 3, 1991,* pp. 1- 16; Andrea Larsen, "Partner Networks: Leveraging External Ties to Improve Entrepreneurial Performance," *Journal of Business Venturing, vol. 6, 1991,* pp. 173- 188; and Torn Peters, "Rethinking Scale," *California Management Review,* fall 1992, pp. *7-29. See* also U.S. Congress, Office of Technology Assessment, *Rural America at the Crossroads: Networking for the Future,* OTA-TCT-471 (Washington, DC: U.S. Government Printing Office, 1992).

35 See U.S. Congress, Office Of Technology Assessment, *Telecommunications Services In European Markets,* OTA-TCT-548 (Washington, DC: U.S. Government Printing Office, August 1993); and Carol Wilson, "Global Economy, Changing Political Scene Play Havoc With Spending," *Telephony,* Jan. 6, 1992, pp. *21-26.*

36 Karyn Lynch, "Global Service Showdown: Communication and Computer Companies Jockey To Redefine Themselves as International Service Providers," *Communications Week International,* May 11, 1992, p. 22.

37 Cowhey and Aronson, 0p. cit., footnote 17.

38 See Berm R. Konsynski and F. Warren McFarlan, "Information Partnerships-Shared Data, Shared Scale," *Harvard Business Review,* September-October 1990, pp. I 14- 120; and Max Munday, "Buyer-Supplier Partnerships and Cost Data Disclosure," *Management Accounting, 1992, pp. 28-29.*

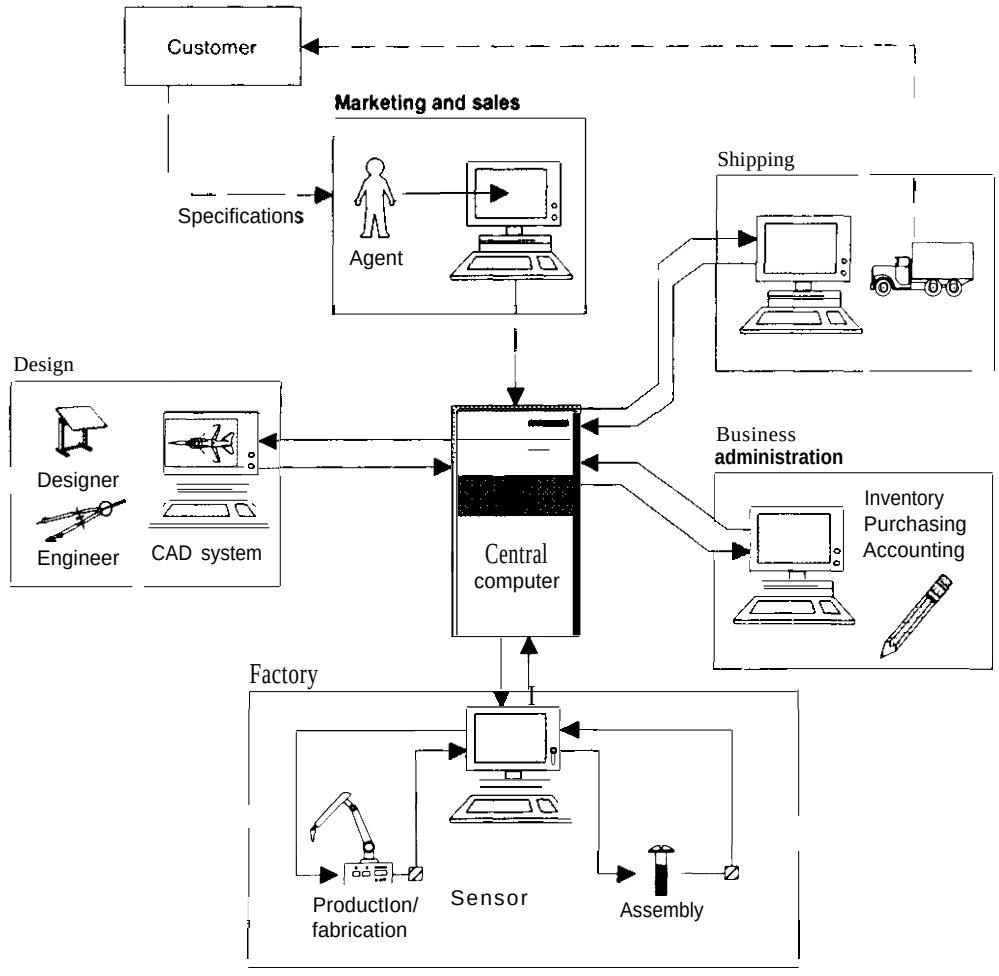
39 See Kevin Parker, "Reengineering the Auto Industry," *Manufacturing Systems,* January 1993, pp. 40-44; and Laura De Nardis and Marvin Chartoff, "CIM Users' Group Need for Flexible Net Underpinnings,. ' *Network World,* Mar. 16, 1992, pp. 1, 29-33, 38-40.

BOX 1-4: Enterprise Integration

The intensely competitive business environment has drastically shortened time-to-market, Product innovations must occur much more rapidly (see figure 1-9). Shorter life cycles mean that manufacturers need to be flexible and prolific, efficiently churning out higher quality products at much faster rates Competing effectively in this environment means that businesses must operate on a "just-in-time bass, " producing goods on demand and in response to specific customer needs, To reduce production time, many firms are Integrating their business functions around processes such as concurrent engineering and computer-integrated manufacturing (CIM) With concurrent engineering, process-oriented teams manage the engineering and production processes simultaneously, This kind of reorganization reduces costs in two ways it speeds up the production process itself; it also allows engineers to design for manufacturability. With computer-Integrated manufacturing and design, manufacturing and resource planning are not only Integrated, they occur online with the use of shared Information systems. CIM permits rapid prototyping enhances quality control, and greatly reduces waste.

SOURCE Off Ice of Technology Assessment, 1994

FIGURE 1-9: Enterprise-Wide Computer Network



SOURCE Off Ice of Technology Assessment, 1994

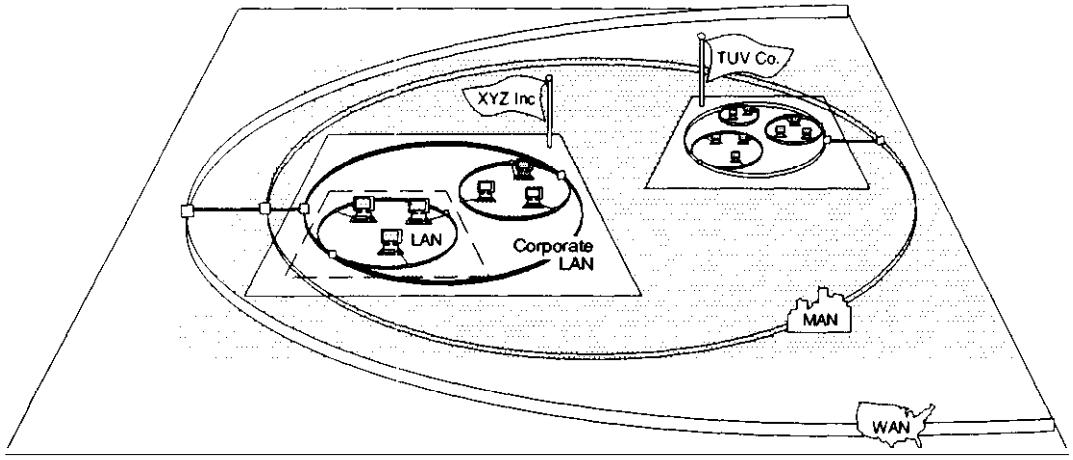
BOX 1-5: Shared Information System

Enterprise integration is greatly facilitated by the use of shared information systems, across groups and facilities, so that teams can leverage the Information resources of others, wherever they may be To support enterprise integration, communication must be seamless and reliable so information can be relayed in a timely manner and without errors

There are a number of technologies that support shared information systems Networking options include Local Area Networks (LANs), Wide Area Networks (WANs), and Metropolitan Area Networks (MANs), supported by a vast array of transmission and networking technologies, including Asynchronous Transfer Mode (ATM), Integrated Services Digital Network (ISDN), fiber optics, satellite, and many radio-based technologies (see figure 1-10) Open systems architecture and object-oriented programming environments wiII enable systems to be built more efficiently and effectively to facilitate information-sharing Client-server architectures that distribute data over a network of desktop workstations (as opposed to having the data reside in a central mainframe computer) wiII allow departments to own their own data and make it available to the people who need it Software such as groupware and distributed databases will provide the ability to store, search, and refine disparate pieces of Information

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FIGURE 1-10: Network of Networks



This figure Illustrates how the data communications portion of the information superhighwayis composed of a complex network of interconnected networks A firms internal computer network typically consists of several smaller, linked local area networks (LANs), which in turn are Interconnected to increasingly wider networks, MANs and WANs

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to integrate, update, and deliver relevant customer information on demand at the point of sale or point of customer inquiry. [40]

Systematic and creative ways of providing information will also be required to support the growing number of knowledge-workers across all sectors of the firm. [41] Fixed, controlled procedures are being superseded by team-based flexible processes that require discretionary and diverse sets of capabilities. By learning and generating knowledge on the job, workers will be valued more for their cognitive than their manual skills .42 With the blurring of boundaries across hierarchies and organizations, decisionmaking will be distributed both downward and outward: managers will spend less time directly supervising, and more time making strategic choices and orchestrating and evaluating overall enterprise activities. [43] To enhance their capabilities and maximize their effectiveness, workers and managers will not only need access to information itself, but also to the technologies that can help them filter, process, apply. distribute, and further generate it.

Networked information technologies will also be a prerequisite for enterprise restructuring and reengineering. [44] Seeking new ways to improve quality. enhance efficiency, gain strategic advantage. and acquire greater knowledge and expertise, many businesses are rearranging their activities to carry them out in networks and teams (see box 1-6). Some businesses, for example, are entering into highly integrated, long-term relationships with customers and suppliers; others are setting up short-term, ad hoc alliances to address a particular problem at hand. Many of these networks transcend national as well as organizational boundaries. [45] *Technologies such as* wide area networks. v ideoconferenc ing, computer-integrated engineering and manufacturing, and electronic data interchange are necessary not only to support such activities; they also serve as a catalyst for organizational change (see box 1 -7).

| The Impact of Technology on Markets

Information and communication technologics will not only affect the nature of business organizations; they will also have considerable impact on the size, structure, and openness of markets. Networking technologies can greatly reduce the costs entailed in exchange transactions. As these costs decline, many business activities previously carried out within vertically integrated firms will likely be shifted to the marketplace. In addition, because exchange transactions will increasingly be carried out electronically and online. the network will in many instances serve as the mar-

[40]Robert Janson, "How Reengineering Transforms Organizations To Satisfy Their Customers," *National Productivity Review*, winter 1992/1993, pp. 45-53; and Regis McKenna, "Marketing Is Everything," *Harvard Business Review*, January-February 1991, pp. 65-79.

[41]See Ikuyiro Nonaka, "The Knowledge Creating Company," *Harvard Business Review*, November-December 1991, pp. 96-104. See also, Alan M. Weber, "What's So New About the New Economy," *Harvard Business Review*, vol. 71, No. 1, January/February 1993; and Kathryn Rudie Harrigan and Gaurov Dalmia, "Knowledge Workers: The Last Bastion of Competitive Advantage," *Planning Review*, November/December 1991, pp. 9, 48.

[42]Fred Porter and Jan Beanen, "The Power of Empowered Teams," *Mortgage Banking*, August 1992, pp. 22-26; Alan H. Magaziner, "Human Resources: Restoring the Competitive Edge," *Small Business Reports*, November 1989, pp. 25-28; and William Wiggenhorn, "Motorola U: When Training Becomes an Education," *Harvard Business Review*, July-August 1990, pp. 71-83.

[43]Howard E. Dolenga, "Management Paradigms and Practices for the Information Age," *SAM Advanced Management Journal*, winter 1992, pp. 25-29; L. Applegate, J.I. Cash, and D. T. Mills, "Information Technology and Tomorrow's Managers," *Harvard Business Review*, vol. 66, No. 6, November-December 1988, pp. 128-136; and Charles C. Snow, Raymond E. Miles, and Henry J. Coleman, Jr., "Managing 21st Century Network Organizations," *Organizational Dynamics*, vol. 20, winter 1992, pp. 5-19.

[44]On the need for reengineering, see Michael Hammer, "Reengineering Work: Don't Automate, Obliterate," *Harvard Business Review*, July/August 1990, pp. 104-112.

[45]See B.R. Konsynski, "Strategic Control in the Extended Enterprise," *IBM Systems Journal*, vol. 32, No. 1, 1993; John R. Rockart and James E. Short, "The Networked Organization and the Management of Interdependence," Michael Scott Morton (ed.), *The Corporation of the 1990s: Information Technology and Organizational Transformation* (New York, NY: Oxford University Press, 1991).

BOX 1-6: Networking for Economic Advantage

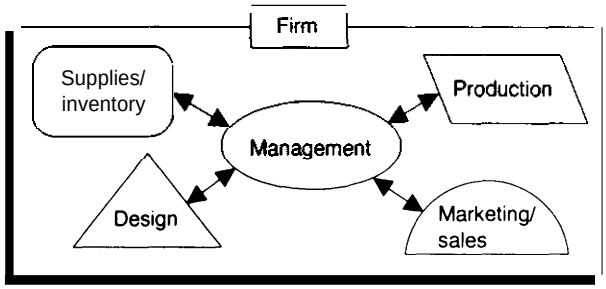
Networking provides new opportunities for businesses to enter new markets, gain strategic advantage, and reduce transaction costs These networks are effective because they cut across traditional organizational boundaries, either within or across firms

Business networks come in a number of varieties As depicted in section A of figure 1-11, some networks are internal to the firm They generally cut across traditional business functions, allowing firms to reorganize around processes that support team-based work for total quality control and just-in-time delivery A wide range of groupware applications are being developed to support such networks Businesses may also set up networks to create new interorganizational connections, as can be seen in section B An electronic data Interchange (EDI) network might be used, for example, to connect a firm to its suppliers Networking can also be used to support virtual corporations and agile manufacturing, as Illustrated in section C

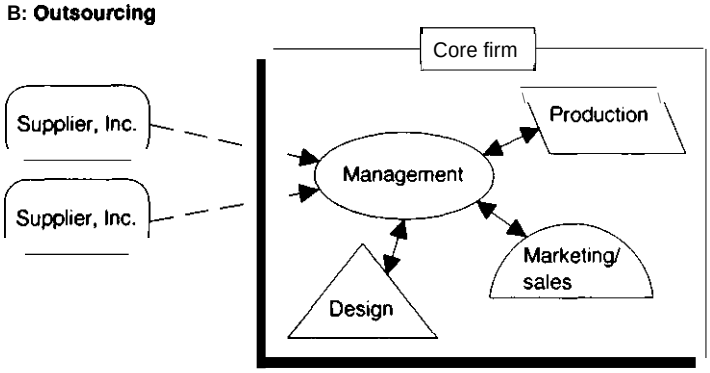
SOURCE Off Ice of Technology Assessment, 1994

FIGURE 1-11: Networking for Economic Advantage

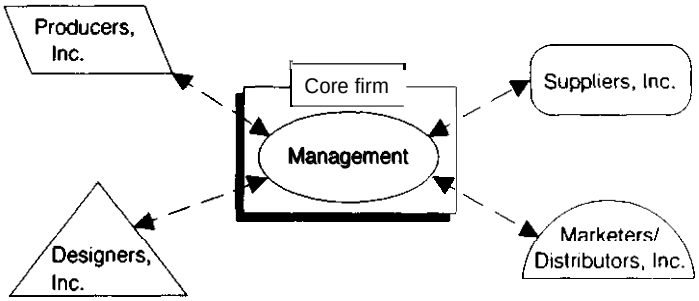
A: Fully-integrated firm



B: Outsourcing



C: Virtual corporation



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BOX 1-7: Technology Applications To Support Organizational Change

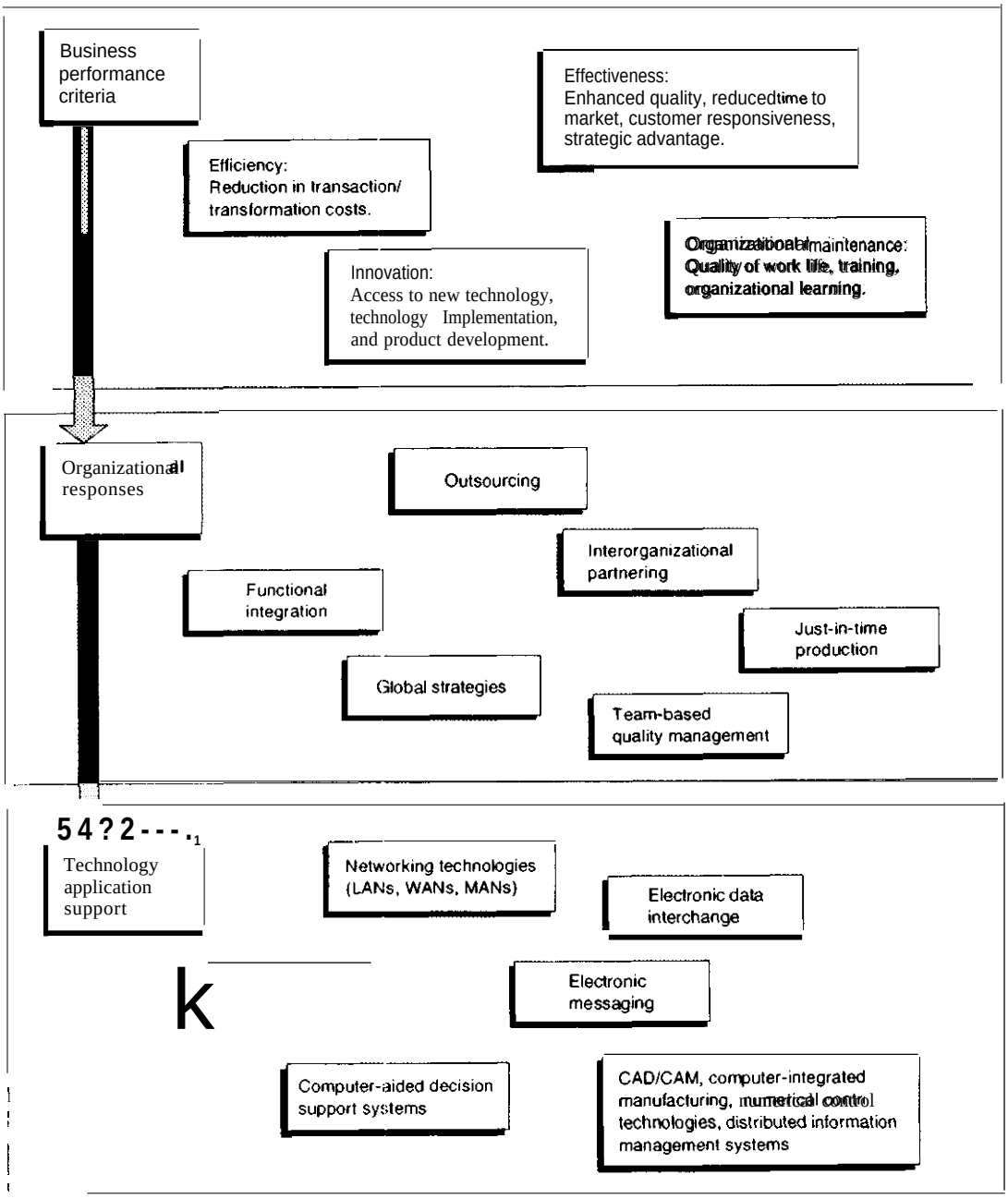
- Technology can help businesses reorganize to achieve greater efficiency, effectiveness, and innovation However, the benefits stem from the organizational change, not from the technology itself Some examples can serve to Illustrate (see figure 1-1 2),
- Mercedes Benz takes advantage of its computer-based communication network to differentiate and enhance its product It not only provides car owners with a toll-free 800 number to call for service, it also helps drivers locate a service provider, wherever they may be. Networked mobile phone and paging services also Improve service delivery by linking repair personnel to their offices while they are on the road With continual access, management can easily learn about schedule changes and hear directly from clients Improvements of this kind make firms more competitive
- The national drug company, McKesson Corp., used its networked Information systems to develop new products It offered its pharmacy customers a detailed analysis of their sales, including the profitability and turnover ratios of different items based on their orders over a period of time. The company also offered to print price labels for pharmacies.
- The OTIS elevator company uses its computer-based communication network to provide more efficient centrally coordinated repair activities, When clients call, they report their problem to a highly trained operator who records the information in a computer and dispatches repair personnel via a telephone/beeper system When the repair IS made, the information IS again stored in the computer so senior management can track repair efforts and deal with special problems as they arise Moreover, the recorded fault data, which are also immediately available online to the company's engineers and designers, can be analyzed by management to identify any recurring problems that might require more general corrective action
- In some companies, research data are now being integrated into other corporate information systems allowing for their more effective use throughout an entire organization For example, the Integration of systems at Marion Laboratories Inc allows the R&D department to send the formula for a new drug along with the engineering process control data, directly to the manufacturing department This same information IS sent to the sales and marketing department where it IS used to create educational materials for physicians to use when testing the drug.
- Using sophisticated databases that track consumer behavior, companies can refine their marketing campaigns Donnally Marketing in Stamford, CT, for example, specializes in providing this kind of service It gathers and correlates the responses to questionnaires that are mailed to consumers along with shopper coupons, and then stores the Information in a large-scale database where it can be reprocessed and retrieved as needed With this system, the company can track the purchasing patterns of more than 90 million households

(continued)

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BOX 1-7: Technology Applications To Support Organizational Change (cont'd).

FIGURE 1-12: Performance Criteria, Organizational Responses, and Technology Support



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ket. Where this occurs, market structure will depend as much on network characteristics, and the economies of networks, as it does on relationships among firms.

The rise of vertically integrated firms at the end of the 19th century was facilitated by the transportation, communication, and information technologies of the day—the railroads, the telegraph, and the telephone. By increasing the speed and control with which goods could be moved, processed, and distributed, these technologies made it possible to coordinate and manage production on a very large scale.

A reverse trend is occurring today[46] (see box 1-8). In a highly complex and rapidly changing global economy, vertical bureaucracies are pushed to their limits. Businesses everywhere are increasing their flexibility by downsizing and outsourcing.[47] They are increasingly purchasing in the market what they need, whether preassembled parts, logistical support systems, customized communication services, or packaged business information. At the same time, a multitude of new enterprises, structured to serve a particular business need, are appearing to provide these services.

This shift toward greater market reliance is being facilitated and fostered, as in the past, by technological advances. However, unlike earlier technologies that diminished the costs associated with large-scale organizations, today computer-based communication networks and shared information systems are reducing the costs of carrying out market activities.[48] These include, for example, the costs of searching for the right products and best deals, executing transactions, and monitoring and enforcing the terms of the trade. Taking advantage of electronic data interchange, for example, buyers can place orders with appropriate suppliers, execute exchanges, transfer funds, and update inventories, all automatically and online (see box 1 -9). Similarly, global corporations such as Chrysler Corp. can outsource the production and assembly of many parts to a number of suppliers located in different countries, knowing that these pieces, having been joint] y engineered and developed through computer-integrated engineering systems, will all fit together.

A growing number of technology applications are designed to facilitate and support various aspects of market exchange (see box 1-1 O). These include, for example: 1) search tools such as audiotext and videotext, online databases, electronic catalogs, and multiple-listing services; 2) exchange mechanisms such as 1-800 numbers; credit, debit, and smart cards; EDI; automated teller machines; and computer reservation systems; and 3) electronic monitoring and enforcement systems such as electronic data capture, credit card authorization, electronic funds transfer, and automated clearinghouses.

As these technologies and their various functions are brought together into integrated and interactive networks, more and more trade will take place electronically, online. How these electronic markets evolve, and the actual form they take, w ill have significant consequences for competition and the functioning of the economy as a whole. Because electronic markets can reduce the overall costs of doing business, they can greatly enhance efficiency and lead to expanded trade. This may

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[46] See Tom Malond, Yates, and R. I Benjamin, "Electronic Markets and Electronic Hierarchies: Effects of Information Technology on Market Structure and Corporate Strategies," *Communications of the ACM, vol.* 30, No. *6,* June 1987, pp. *484-497.* See also, Ajit Kambil, "Information Technology and Vertical Integration Evidence from the Manufacturing Sector"; in Steve S. Wildman and Margaret Guerin-Calvert, *Electronic Services Networks: A Business and Public Policy Challenge (New* York, NY: Praeger, 1991); and Stuart Smith, David Transfield, John Bessant, Paul Levy, and Clive Ley, "Factory 2000: Design for the Factory of the Future," *International Studies of Management and Organization,* vol. 22, No. 4, pp. 6 1 -68.

[47] See Gadi Kaplan, "Manufacturing A La Carte: Agile Assembly Lines, Faster Development Cycles. " *IEEE Spectrum,* September I 993, pp 24-27; and Gary Hamel, "The Core Competence of a Corporation," *Harvard Business Review,* May/June 1992, pp. 79-91,

[48] See J. Yannio Bakos, "A Strategic Analysis of Electronic Marketplaces," *MIS Quarterly,* September 1991, pp. *295-309.* See also Chris Holland, Geoff Lockett, and Ian Blackman, "Planning for Electronic Data Interchange," *Strategic Management Journal,* vol. 13, *1992,* pp. 539-550.

BOX 1-8: Markets, Firms, and Networks: Their Relationship to Information Technology

Information is required for all economic activity The exchange of information is at the heart of the market system A market economy relies on the communication of information to identify buyers and sellers, allocate resources, and establish prices Within firms, the availability of timely and accurate information is key to decisions about whether to enter or exit markets, how to finance, how to organize working relationships, and how to distribute and market goods. Where adequate reformation is not available, markets will fail and economic performance will suffer because of higher business costs

Information and communication technologies are critical in determining the nature of firms and the structure of markets These technologies reduce the costs of doing business, and can increase economic activity and foster economic growth in several ways To understand the Implications of newly developing reformation and communication technologies for the future organization of business and markets, they must be considered from a historical perspective

Once markets were face-to-face exchanges. Commerce took place in town centers where people congregated to exchange and trade goods. The costs of doing business were small, buyers, sellers, and the intermediaries who provided capital, credit, and brokered information were all present As transportation improved, local markets gave way to regional fairs, and later, with the development of sailing and navigational technologies, to port cities such as Lisbon, Genoa, Venice, Antwerp and Amsterdam [1] But, until the development of the telegraph m the last half of the 19th century, the size of markets, as well as the extent of trade, were constrained by the slow pace at which goods and market information could be transported [2]

Communication and information technologies also affect how businesses are organized When transportation and communication over long distances was difficult and slow, merchants had Insufficient information on which to base sales Prices differed significantly from market to market, so most merchants avoided long-distance trading, When they traded, they relied on merchants in distant trading centers to sell their goods for a commission To reduce and spread the risks Involved in distant trading, they sold a variety of products and avoided single product specialization

With the development of the railroads in the 1830s and the telegraph in 1844, the speed and control needed for specialization and large scale production was in place The speed of communication and the range of control afforded by the railroad, the telegraph, and later the telephone enabled the growth of large organizations with modern management structures, a first step in the centralization of production and distribution [3]

The impacts of these technologies were cumulative Trade gave rise to more trade As markets expanded, the number of merchant exchange networks using communication technologies and the amount of available market information increased As a result, distribution costs declined, and merchants were further encouraged to engage in trade Moreover, with larger markets and better information, businessmen faced fewer risks, and they were able to specialize in importing, wholesaling, retailing, or exporting Increased specialization led, in turn, to better coordination of markets and reduced costs, making trade even more attractive. The information-based networking technologies being developed today will have an equal, if not greater, effect on economic performance

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[1] Fernand Braudel, *The Perspective of the World, Civilization and Capitalism 15th-18th* Century, vol 3 (Berkeley, CA University 01 California Press, 1992), pp 118-119

[2] James Beniger, *The Control Revolution Technology and the Economic Origins of the Information Society* (Princeton, NJ Princeton University Press, 1986)

[3] Alfred D Chandler, *The Visible Hand* (Cambridge, MA Harvard University Press, 1977)

SOURCE Off Ice of Technology Assessment, 1994

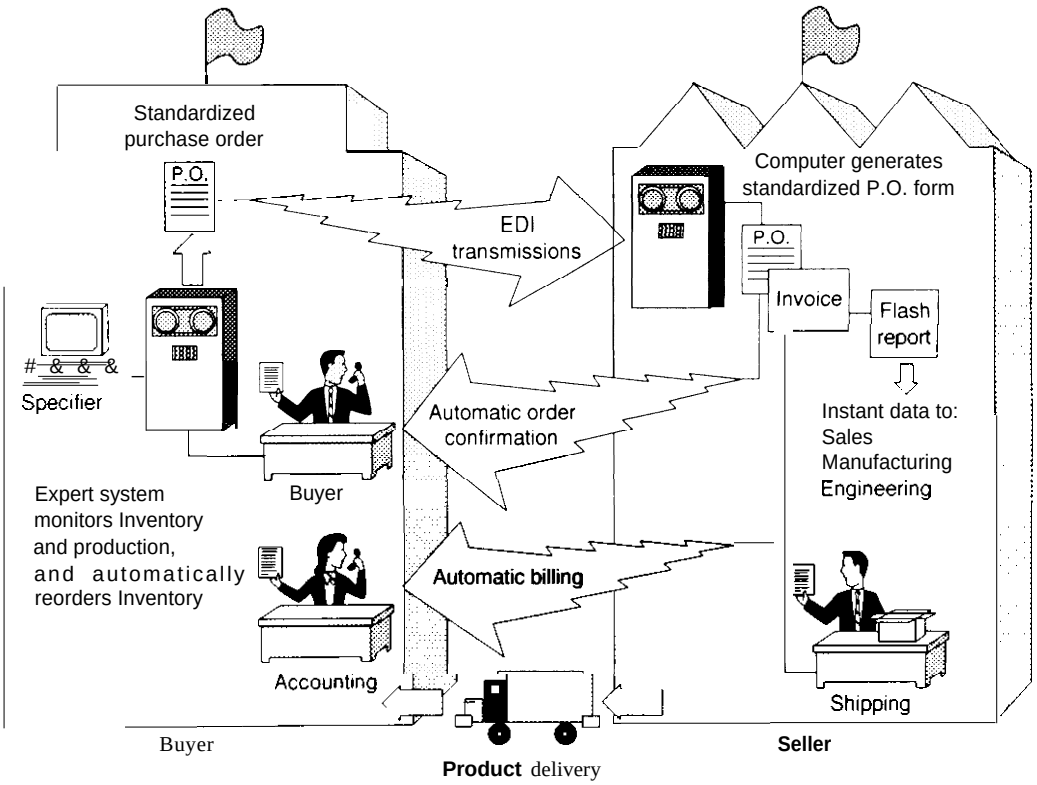
BOX 1-9: Electronic Data Interchange (EDI)

Electronic data interchange (EDI) is a notable example of how information and communication technologies are emerging as Important strategic tools for efficient and effective business operations EDI is essentially the modern, computer-based method by which companies order, invoice, and bill their products and services Such common transaction functions as invoices, shipping notices, and bills which traditionally have entailed the transfer and processing of paper documents, are replaced by electronic transfers between the businesses' computers (see figure 1-1 3)

EDI improves the efficiency and effectiveness of operations by enabling businesses to purchase supplies and to produce and distribute products precisely when and where they are needed The company's computer system, for example, wiII initiate a purchase order and execute the purchasing transaction when an item is requested and removed from the inventory The price, terms, and conditions of the contract are all stored in the computer In addition to the considerable savings gained as Inventory costs are reduced, EDI also minimizes human clerical error and the considerable processing costs involved with paper transactions By reducing or eliminating the prolonged and often error-plagued paper trail large retailers and manufacturers are able to gain a competitive advantage by streamlining transactions with their suppliers and buyers

SOURCE Off Ice of Technology Assessment, 1994

FIGURE 1-13: Electronic Data Interchange



SOURCE Reprinted from Datamation Mar 15 1988

BOX 1-10: Electronic Commerce Matrix

Markets can be viewed as the web of relationships between buyers, sellers, and products that are revolved in an exchange While only two basic roles—that of consumer and producer—are essential for an exchange to take place, more often than not others act as intermediaries facilitating transactions These might include advertisers, retailers, financiers, bankers, and brokers

There are a number of economic ("transaction") costs entailed in market operations These include the cost of searching for products, buyers, and sellers, the cost of arranging and carrying out the exchange, and the cost of ensuring that the terms of the trade have been met

Each of these transactions occurs through some form, or pattern, of communication interaction 1) a one-to-one connection—as in the case of two parties meeting face-to-face or connected by telephone, 2) a broadcast, or one-to-many connection—as in the cases of the fishmonger, the floor trader, or TV shopping channel; and 3) many-to-many connections, as in the cases of bazaars, regional fairs, or an electronic trading market

As depicted in the matrix, (see figure 1-14), communication and Information technologies can be arranged in each of these three ways to support each of these types of economic transaction In the past, when such technologies were not available, human Intermediaries carried out these roles For example, before the advent of the telegraph, it was the "jobber" who personally earned market Information relating to southern cotton to Manhattan where he sought buyers who would match the price The jobber's role was "to make the market " On the floor of the stock market, the broker (often referred to as a jobber) similarly "makes the market "

Many of the same technologies can be used to support different kinds of communication patterns and activities, and thus they appear within more than one box in the matrix The Important thing to note IS that, the more that these technologies can be linked together to provide more services to more users, the greater the savings in transactions costs and the closer the electronic network approximates true electronic markets

(continued)

SOURCE Off Ice of Technology Assessment, 1994

not occur, however, if electronic markets fail to interconnect for lack of standards, or if large businesses are overly successful in developing dominant, proprietary networks that are used to create new barriers to market entry.[49]

KEY FINDINGS AND POLICY IMPLICATIONS

| Transaction Costs in Determining Economic Performance

A major part of the cost of business is gathering, exchanging, and using information.[50] Information exchange is the essence of markets. Markets function through interactions among trading partners, suppliers, producers, vendors, brokers, and consumers. In this sense, information is the most valuable commodity in an economy.

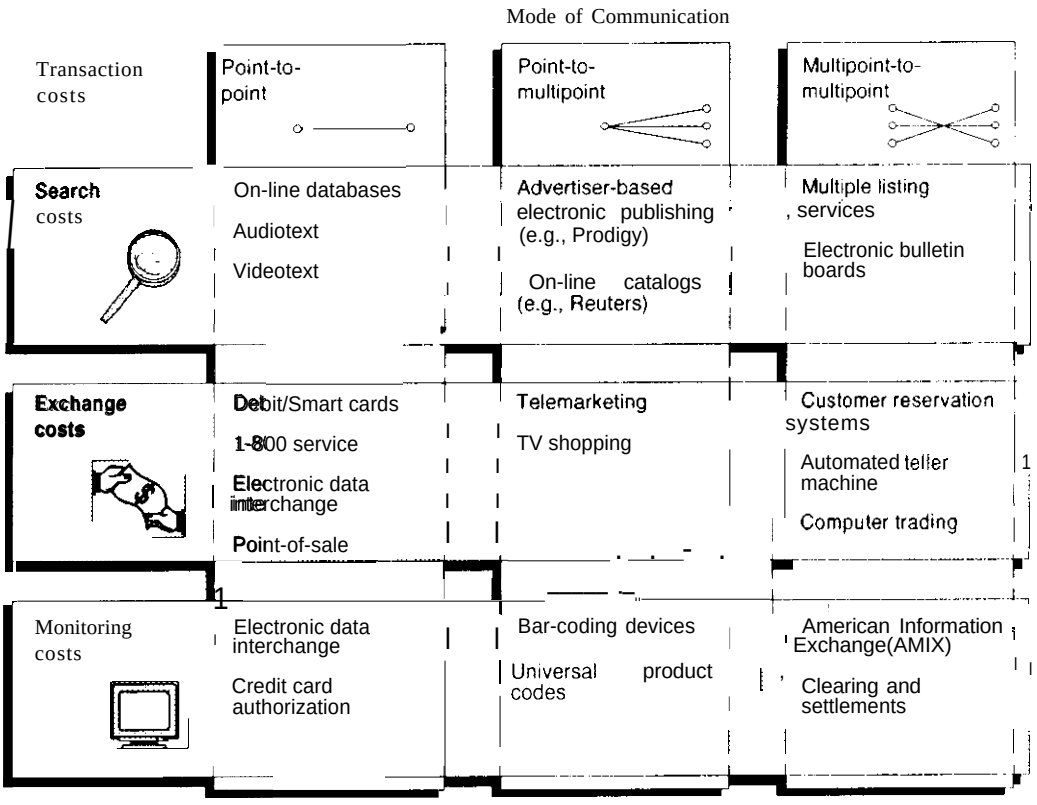
Consider markets in the context of a consumer buying a high-end stereo system. The buyer mulls over the features that are most important—wattage, audio performance, appearance, size, speakers, CD player, tape deck, and cost. There may be hundreds of dealers to choose from. The consumer reads catalogs, compares specifications, consults Consumer Reports, calls for price information,

[49] Ibid. see also Kogut et al op cit footnote 17; Robin Mansell, "Information, organization, and Competitiveness: Networking Strategies in the 1990s,"' in Cristiano Antonelli (cd.), The *Economics of Information Networks* (Amsterdam, The Netherlands: North Holland, 1992), pp. 217-227; and Stuart Macdonald, "Information Networks and Information Exchange, " in ibid.

[50] See O]iver E, Williamson, *The Economic Institutions of Capitalism (New* York, NY: The Free Press, 1985).

BOX 1-10: Electronic Commerce Matrix (cont'd).

FIGURE 1-14: Electronic Commerce Matrix



SOURCE: Office of Technology Assessment, 1994

and visits dealers to compare models and prices. The search can take hours, days, or weeks. The time spent in research, comparative shopping, and making the deal are "transaction costs, " as are the expenses for fuel, wear and tear on the automobile, magazine and catalog purchases, and telephone charges.

Manufacturers are also faced with transaction costs. First. a manufacturer has to read the market for signals about the size and specific nature of demand. Then he must find the necessary materials and contract with suppliers; search for the most suitable workers and managers: negotiate their wages and salaries: and perhaps even provide on-the-job training. Assembling people and materials in the right place at the right time, and coordinating and monitoring the actual production process. is also costly in terms of time and effort. So, too, is the task of sett ing up distribution channels or dealerships. To stimulate future demand, the manufacturer will also have to promote his product among potential customers, track customer behavior, and invest in advertising.

These kinds of transaction costs are on the rise in today global, knowledge-based economy comprised of many more players and fewer standardized, mass-produced products. Now buyers and sellers must explore a multitude of options and be able to compare costs and values acrossf languages and cultures and on the basis of differ-

ent currencies. When laws and institutions differ, special arrangements are required to guarantee contracts, warranties, and standards. Many American businesses wanting to trade in Europe have had to make costly arrangements to certify that their products meet European standards.[51]

As transaction costs begin to constitute a greater proportion of the total costs of production and exchange, a firm economic performance, as well as a nation's competitiveness, will increasingly rest on its ability to efficiently process and distribute business-related information. When businesses can access the best available information at the most appropriate moment in time, they can reduce their costs and enhance their productivity. Similarly, when buyers and sellers can easily locate one another, and have a good idea of what they can expect in terms of quality and price, they are more 1ikely to engage in trade. The result will be greater economic growth and development.

| Using Networking To Reduce Transaction Costs

Economic activities are all based on some level of "social" networks. Doing business is a social activity.[52] Trust, respect, knowledge, and even friendship are part of any business transaction. This subtlety is often obscured by one of the myths of American business—that deals are based on impersonal, fact-based, hard-nosed business decisions. In other countries with different cultures the connection between family position, castes, and friendship and business dealings are more obvious. The "Kerietsu" of Japan, the "Impannatore" of Italy, and the familial nexus of businesses in Taiwan are al1 examples of the commingling of business and personal networks.

These social networks are extremely efficient because much of the information that is usually transferred in the course of doing business is already accepted as a given .53 Thus, transaction costs are very low. Buyers and sellers are well known to one another. Shared expectations and an established level of trust reduces the need to haggle over prices and wages. In addition, the existence of social sanctions reduces the need to monitor performance and assure that the terms of business transactions have been adequately met.[54] The benefits of social networks are, however, generally limited in scope. When extended to global markets, for example, time, space, culture, language, and different legal traditions will likely undercut the basis for a common understanding.

Today, communication and information technologies can be used to conquer time and space. With advanced networking technologies and the growing number of business applications they can support, buyers and sellers—regardless of their geographic locations-can interact online in a virtual, electronic space. Under such circumstances, the network will, in effect, become the marketplace. Linking buyers and sellers directly, the need for information—as well as for costly intermediaries to transport, process, and interpret it—will be significantly reduced.

For example, electronic data interchange (EDI) is a computer-based system that allows companies to order, invoice, and bill their products and services electronically. Common transactions such as invoicing, shipping and billing—which traditionally have entailed human interaction and the transfer and processing of paper documents—are replaced by automatic electronic transfers between business computers. Prices, terms, and the conditions of a contract are all stored electronically. Electronic data interchange networks that allow businesses to operate on the basis of a shared information system can greatly improve efficien-

[51]Amy Zuckerman, *ISO 9000 Made Easy: A Self-Help Guide to Certification* (Amherst, MA: INEX, Information Export, 1993).

[52]Mark Granovetter and Richard Swedberg (eds.), *The Sociology of Economic Life* (Boulder, CO: Westview Press, 1992).

[53]North, op. cit., footnote 9.

[54]Robert Axelrod, *The Evolution of Cooperation* (New York, NY: Basic Books, 1984).

cy, triggering purchasing and distribution just when and where they are needed.

To some extent, communication and information technologies can substitute for some of the social and cultural "glue" that welds social networks together, giving rise to a number of efficiencies. Reducing transaction costs, they can improve productivity, greatly extend markets, and thereby generate wealth. Nonetheless, technology is the medium, not the end in itself. The social and cultural relationships-the trust, dependability, and honesty-of those who do business over the electronic business network will spell its success or failure in serving American business and the nation's economy.

| Designing Networks To Meet Business Goals

The "architecture" of electronic business networks is critical in determining their economic impacts. Like a sculpture that is fashioned from Tinker Toys, a network's structure is determined by the connections and 1inkages that give it shape. How these networks are formed and ultimately joined together to comprise a national infrastructure will influence the cost of doing business. Their design will also affect the overall efficiency of the economy, the size and scope of markets and the ability to conduct trade, the distribution of economic costs and benefits throughout the economy, and the nature of work and the quality of jobs.

To serve business and the nation's needs, the network architecture will need to be flexible and open, Without such versatility, businesses will be unable to rapidly reconfigure their networks to respond to changing circumstances and market demand. Nor will they have the leeway needed to customize applications and networks to support changing business processes and flexible working relationships. Moreover, with the freedom to mix and match a wide variety of network components, businesses can use technology to add value and develop new products and services.

To fully reap the benefits of communication and information technologies, networks and network components will also need to be interoperable and open for interconnection. Open, interoperable systems reduce transaction costs. Proprietary systems with closed standards both increase the cost of doing business and create significant barriers to market entry, Interoperable components provide greater network flexibility. greater ease of use, and reduced network costs. Technology diffusion will occur faster and more broadly, and equity of access will be encouraged as a result. Interoperable systems also provide a standard platform for the innovation of new components and applications.

In addition. if the economic benefits of networking are to be broadly shared. technology must be evenly and widely deployed. BUsiness networks may allow the first developer of a network to gain a significant competitive advantage. Networks benefit from economies of scale and scope; therefore latecomers may be at a disadvantage in attracting users and providing services. Latecomers might also be disadvantaged because business networking requires not only extensive expertise, but it also requires considerable "learn - ing by doing. " Although the profits derived from gaining a competitive advantage will likely stimulate network development, if all potential newcomers are locked out of the marketplace, anti - competitive behavior may result.

| Requirements for Access

The requirements for access will need to be recon - sidered with the advent of electronic commerce. To operate on a level playing field in such an envi - ronment, a business will need to be able to access the electronic network that serves as the market.

Today, a manufacturer who does not have outlets of his own must find a retailer to sell his products, This is generally not a problem; in any given geographic area—with the exception of rural areas—there are a considerable number of retailers who are willing to provide the manufacturer with shelf space. Bringing buyers arid sellers together, the retailer in effect "makes the market," and is thus paid for reducing everone's transaction costs.

In the case of electronic commerce, the situation is 1ikely to be much more complex. Electronic markets can be costly to establish with respect to both financial investment and expertise. Thus, they may be much less ubiquitous than today's retail outlet, at least initially. Unlike the local grocer, the profits to be gained from establishing electronic markets depend to some extent on their exclusivity. As a result, electronic markets may become more restrictive than retail stores in terms of access.

These differences stem from the incentive structure that is associated with the economics of networking.[55] If a network vendor decides to establish an electronic market, he must first generate a critical mass of users. Unless there is sufficient demand, the vendor will be inclined, at least at the outset, to pursue an open network strategy. However, given a critical mass, the vendor might choose an alternative strategy. Under such circumstances, the return on investment will likely be greater if he adopts a restrictive approach. Users would probably be willing to pay a premium for exclusive network access to gain in two important ways. First, they will have greater control over their customers or suppliers, as well as privileged access to market information. Secondly, they will benefit from the "economies of aggregation"[56] (see figure 3-3 in ch. 3) that stem from a significant reduction in transaction costs. Moreover, the benefits of reduced transaction costs will become increasingly important with the proliferation of independent electronic markets, as products become more customized and complex and markets are extended further across time and space.

Organizational Change Within Firms

New communication and information technologies are, to some extent, subversive; to be effective, they require organizational change. The most sophisticated technology and the best designed network architecture will not be effective without concurrent changes in business attitudes and procedures. Technology can, however, serve as a catalyst, helping businesses make the necessary adjustments to their changing environment.

In the new business environment, cooperation may prove more rewarding than competition, and information-sharing more fruitful than information control. Equally important, given the rapid pace of social, economic, and technological change, the most successful businesses will be those that employ information technologies not to control situation and events, but rather to enhance their ability to adapt to take advantage of them.

The workplace environment will be of critical importance. The overall shift in the structure of the economy from one dominated by mass production to one that is more flexible and centered on services will require a workforce that is similarly flexible and increasingly skilled. However, information technology can provide flexibility in one of two diametrically opposed ways. For example, shifting the burden of uncertainty onto the labor force, information technologies can be used to foster worker monitoring and a greater reliance on contingent labor. On the other hand, the same technology can be used to enhance worker skills and encourage team participation. If the benefits of electronic commerce are to be widely shared, strategies will be needed that foster quality jobs, high standards of living, and collaborative work environments.

The Government Role

As the world moves toward a global economy, the role of government will necessarily change. All major industrial nations are being forced to rethink their government's responsibility towards the maintenance of their economies in this era of rapid change. Russia and the republics of the for-

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[55] See, for discussions, Steve S. Wildman and Margaret Guerin-Calvert, *Electronic Services Networks: A Business and Public Policy Challenge* (New York, NY: Praeger, 199 *I*), Bakos, op. cit., footnote 48; and Antonelli (ed.), op. cit., footnote 49.

[56] Sometimes referred to as "economies of aggregation."

mer Soviet Union and Eastern Bloc are undergoing the most dramatic readjustment to free markets. Europe is struggling with the transition to a single, unified market where national governments play a lesser role. Japan is experiencing similar doubts and reservations, while trying to sort out its government's role in pulling the country out of a severe recession.

The United States faces its own global readjustment, which will require moving from an unproductive ideological debate misdirected at whether the nation should have an "industrial policy." This kind of dialogue obscures the fact that government has always played—and, in fact, cannot avoid playing—a role in structuring economic relations and outcomes.

Take, for instance, the case of the National Information Infrastructure. The private sector clearly has the primary role for developing, deploying, and operating the NII. Similarly, for the most part, industry will develop the technology. provide the bandwidth, offer connectivity, and ensure the availability of services and products in the pursuit of profit, Government, however, cannot stand idly by. In its various roles as regulator. broker, promoter. educator, and institutional builder, the government must establish the rules of the game and the incentive structure that will help determine private sector choices.

The same is true of electronic commerce. In its role as regulator, the government will need to ensure that electronic networks and markets are evenly deployed, open, and accessible on an equitable basis. Acting as a broker, the government can bring together potential, but disparate, network users, thereby helping to generate a critical mass. Serving in the role of promoter, the government can take steps to overcome specific market failures with respect to advanced research, development, and/or technology deployment. As an educator, it can promote electronic commerce by fostering demand and the effective use of networking technologies. Finally, and perhaps most importantly, the government can create an institutional environment that strives to assure that electronic commerce is conducted in a manner consistent with the nation overall social and economic object ives.

| Impact of Information Technology Choices

The age-old adage that "knowledge is power" applies to a knowledge-based society. Whether referring to work relationships in a firm, competition in the marketplace, or trading relations among nations, having access to information and the ability to package it for a particular use is a key determinant of success or failure.

Clearly this was always the case. What is different today is the extent to which knowledge is now actually embedded in information and communication technologies. As a result, choices about these technologies-their design, architecture, and structure, or the rules and regulations governing their availability and use—will have far--reaching social and economic consequences.

Equally important, many of these choices will be irreversible, at least in the short and medium terms. Once a decision is made. technology tends to become firmly established along a given path. This pattern is especially evident with networked information technologies, which require vast amounts of sunk capital and social investment. Thus, periods of rapid technological advance provide a rare opportunity to reassess and redirect both the nature of a particular technology itself. and the economic and social relationships that are structured around it. Given the significance of the moment, and the potential consequences for winners and losers, care should be given not only to what technology choices are being made, but also to the process of how, and by whom, they are made.

Issues in Electronic Commerce 2

Recognizing the increased importance of computers and communication technologies for economic growth and development, many countries have taken steps to assure that their businesses have access to these technologies and the skills and other requirements needed to benefit from them. In contrast, in the United States, there have been fewer focused efforts of this kind. In assessing what kind of role the government might play in the future, OTA found that information and communications will clearly be critical factors in determining business success. However, if American businesses are to take advantage of new technologies to the benefit of the entire nation, a number of issues will need to be addressed.

THE TECHNOLOGY TO SUPPORT BUSINESS NEEDS

Because advanced information and communication technologies can reap considerable benefits for both business and the economy as a whole, the question arises as to whether enough is being done to assure that these technologies will be available in an appropriate, timely, and equitable fashion. OTA found that technology, per se. is not likely to be a major barrier to the success of electronic enterprises. Although there is a continued need for investment in research and development, there is no lack of state-of-the-art technology. And, with the important exception of software, much of the technology required for the electronic enterprise or for use in electronic markets either exists or is in the making, and its cost is falling precipitously as its capabilities continue to rise. Reaping the benefits of an increasingly competitive environment, American businesses have access to a wide variety of product offerings, which will 1ikely increase in the future given industry's repositioning and realignment to develop new products based on tech-

Technology alone is not enough. If the nation economy is to benefit from advanced networking technologies, a number of technological, organizational, and institutional criteria must be met.

nology convergence. Despite such advantages, the actual diffusion of technology, and more importantly its implementation in economic settings, has been quite uneven. It has also been limited, to a significant degree, to high-tech businesses that are geographically well positioned.

Electronic commerce can only occur when the communication and information networks to support it are widely available. [1]Technology diffusion, however, is typically a long-term and uneven process that depends on a number of factors, making it very difficult to assess its likely evolution in any particular situation. [2] As a general rule, the diffusion of new technologies takes the form of an S-shaped curve. This pattern reflects the forces of supply and demand, and the way in which users respond to new technologies. Vendors market new technologies slowly at first because investment and product development costs are high, while demand and profitability are low. As costs and prices fall and demand and profits rise sharply, vendors will greatly increase their supply.[3] Users reinforce this pattern. Their initial reaction to new technologies is very cautious, but their demand will eventually quicken and reach a critical mass as prices fall, knowledge of and familiarity with the technology spreads, and applications multiply and are adapted and readapted to new and different tasks.[4]

Achieving a critical mass is especially important in the case of networks, which are comprised of a number of interdependent parts.[5] Because these networks represent a large installed base, users are generally reluctant to purchase incompatible components. Instead, they may postpone the adoption of new, superior technologies until their entire network can be written off.[6] On the other hand, once there is a critical mass, users will likely "jump on the bandwagon." This happens because network users and network services are, like network components, also interdependent. The value that users attach to a network will generally increase in proportion to the number of users it has and the services it can support. Thus, when a critical mass of users adopts a new technology, others are quick to follow, fearing they will be left behind.[7]

Even after a critical mass has been achieved, however, diffusion will continue to be patchy. In the case of the telephone, for example, the pattern followed a sequence of connecting ever lower order cities: major trunks linked Northeastern cities first, followed by lines to smaller towns in their immediate hinterlands, then connections to major Midwestern cities, and so forth. Although the tele-

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[1] See Robin Mansell, "Rethinking the Telecommunications Infrastructure: The New 'Black Box,' " *Research Policy,* vol. *19, 1990,* pp. 501-515.

[2] For a cross-cultural and cross+ sectoral analysis, see Fabio Arcageli, Giovanni Dosi, and Massimo Moddi, "Patterns of Diffusion of Electronic Technologies: An international Comparison With Special Reference to the Italian Case," *Research Policy,* vol. *20,* 1991, pp. 515-129.

[3] Christopher Freeman, *The Economics of Industrial Innovation* (Cambridge, MA: MIT Press, 1982); and Edwin Mansfield, "The Diffusion of Eight Major Industrial Innovations," N.E. Terleckjy (ed.), *The State of Science and Research: Some New Indicators* (Boulder, CO: Westview Press, I 977).

[4] Everett M. Rogers, *Communication Technology: The New Media in Society (New* York, NY: The Free Press, 1986), pp. 116-149; and Ronald Rice and Everett Rogers, "Reinvention in the Innovation Process," *Knowledge: Creation, Diffusion, Utilization, vol. 1,* No. *4,* June 1980, pp. 499-5 14; see also Paul Attewell, "Technology Diffusion and Organizational l-earning: The Case of Business Computing," *Organizational Science.* vol. 3, No. *1,* February 1992, pp. 1-19.

[5] See Cristiano Antonelli, "The Economic Theory of Information Networks," in Cristiano Antonelli (cd.), *The Economics of Information Networks (The* Netherlands: North Holland, 1992).

[6] Joseph Farrell and Garth Saloner, "Horses, Penguins and Lemmings," H. Landis Gabel (cd)., *Product Standardization and Competitive Strategy* (North Holland: Elsevier Science Publishing Co., 1987); and Paul A. David, "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox ," *American Economic Papers and Proceedings,* May 1990, pp. 355-361.

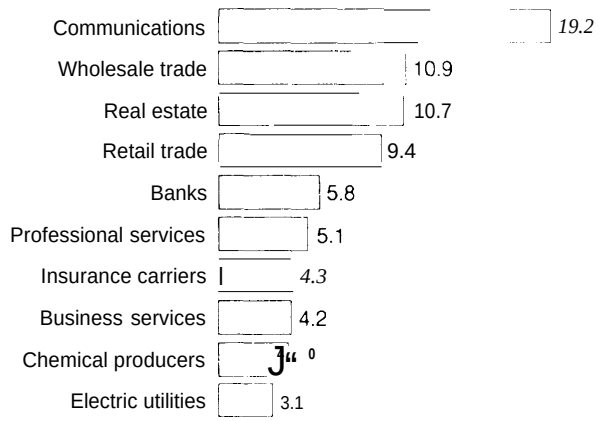
[7] Ibid,

phone was patented in 1876, it did not reach Chicago until 12 years later, and transcontinental service was not inaugurated until 1915. For rural areas the situation was even worse. As late as 1949, many of these areas were still without service. As a result, favorably situated businesses in the Northeast enjoyed a headstart of several decades in utilizing regional and inter-regional telephony.[8]

With deregulation and a highly competitive industry environment, it is unlikely that the deployment of new, information-age technologies will deviate greatly from this earlier pattern.[9] In a competitive, market-driven environment, deployment will mirror the state of demand. Today, the demand centers around large businesses that have the financial resources and expertise required to monitor technological developments, integrate disparate systems and technologies, and provide ongoing maintenance and support. These firms also have a clear strategic vision of the role of technology, and their organizational structures are generally directly linked to its use. Most of them are highly information intensive (see figure 2-1). Employing technology in a strategic fashion, these businesses gain valuable know-how, which can provide them with both a competitive advantage and the wherewithal to develop and deploy new technology applications.

In contrast, most small and medium-sized businesses have yet to realize these kinds of technology benefits. Some are simply unaware of them.

FIGURE 2-1: America's Leading High-Tech Users (Shares of High-Technology Capital Stock: 1992)



SOURCE Morgan Stanley Economics1994

Others lack the resources and expertise required to match their organizational needs to what may be an overwhelming variety of technology choices. Businesses need to decide whether to purchase technology; outsource to a third-party prov ider; or lease a hybrid, virtual private network. Technology and service vendors also need to be selected. and network architectures and standards options need to be worked out as well. More difficult still. all of these choices need to be evaluated and decisions made on the basis of an accurate detemination of the firm's specific needs for speed, capac -

[8]Richard Kielbowicz "The Role of Communication in Building Communities and MarLets," contractor report prepared for the Office of Technology Assessment, November 1987.

[9]As attested to by Noam "But it will be impossible to maintain the old traditional redistributive system of generating subsidies and transferring them internally within the same carriers from one category of users to another category. Several things will disrupt this arrangement. in a network of competing carriers, an internal redistribution is not sustainable once other carriers without redistributive burdens forget the users whose price is above cost as the most likely customer." Eli M. Noam, "Industry Structure in 2000: From the Network of Networks to the System of Systems."' Presented to the National Association of State Utility Consumer Advocates, "Telecommunications 2000 What's at Stake for Consumers in the Next Century," Apr. 17, 199.3, p. 9.

[10]See Stephen Davies, *The Diffusion of Process Innovations* (Cambridge. UK: Cambridge University Press, 1979), and John Kimberly and Michael E\anisko, '"Organizational Innovation: The Influence of Individual, organ] zational, and Contextual Factors on Hospital Adoption of Technological and Administrative Innovations," *Academy of Management Journal*, vol.124, No. 4, pp. 689-713.

[11]Stephen Roach, "America's Technology Dilemma. A Profile of the Information Economy," A Special Economic Report, Morgan Stanley Economics, New York, NY, Apr. 22, 1987.

ity, reliability, and security. Such decisions take time, expertise, and financial resources, which many businesses either lack or are unwilling to expend without further assurance of the benefits. Thus, when small businesses invest in systems such as electronic data interchange and computer-integrated manufacturing, it is generally not in response to their own business needs, but rather at the request of their larger trading partners. Although technology transfer can occur under such circumstances-especially given a trading partner support—all too often technology remains at the periphery of the smaller firm's activities, and additional learning, innovation, and diffusion fail to take place.

Interoperability and Standards

Interoperability and standards area matter of considerable importance in any networked environment. However, their role will likely loom even larger in the future, as networks come to provide the basic underpinnings for many economic activities. Under such circumstances, standards and interoperability will affect the cost and technical characteristics of networks. More importantly, they will influence the overall efficiency and competitiveness of the economy; the cost, quality, and availability of products and services; and market structure. A lack of standards and appropriate levels of interoperability is also likely to be a formidable barrier to businesses seeking to use networks as a basis for extending their operations globally, improving their productivity, creating new value--added products, and linking up more effectively with their suppliers and customers. Given the slow pace of development of standards and open systems, the failure to achieve interoperability will likely present a major obstacle to attaining these ends.

Standards were essential to the success of mass production, and will likely be critical for the development of new, more flexible production processes. However, whereas mass production required standardized components to meet the demand for standard processes and standardized products, flexible production calls for standardized networks that provide the essential platform for carrying out small-batch production needed to satisfy a more customized demand.

A case in point is just-in-time production, which for many industries is rapidly becoming the norm. [12] Quick response production requires a communication network that allows for information-sharing and continual feedback and interaction among manufacturers, suppliers, retailers, and consumers. To ensure effective communication, however, the partners to such an arrangement will need to adopt standards for universal product codes, electronic data interchange, shipping container bar codes, and point-of-sale technologies. [13] These standards are extremely difficult to develop, requiring agreement on technical interfaces and terminology as well as business processes themselves. Because the stakes are so high, many businesses are reluctant to adopt standards. At the same time, opportunities are lost for failing to do so. Estimates are, for example, that the apparel industry can save $12 billion a year by implementing quick-response systems.

Agile manufacturing, so often touted as the paradigm of the future, also requires interoperable systems. [15] With agile manufacturing, firms estab-

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[12] Janice H Hammond, "Quick Response in Retail/Manufacturing Channels," Stephen P. Bradley, Jerry A. Hausman, Richard L. Nolan (eds.), *Globalization. Technology, and Competition: The Fusion of Compilers and Telecommunications in the 1990s* (Boston, MA: Harvard Business School Press, 1993). See also Y.P. Gupta, and S. Heragu, "Implications of Implementing Just-in-Time Systems," *Technovation*, *vol.* 11, No. 3, 1991, *pp.* 143- *] 60.*

[13] John Skibinski, "Automated Information Sharing Cuts Time-To-Market," *Manufacturing Systems,* May *1992,* pp. *60-61.*

[14] Hammond, op cit footnote 12. See also, Thomas Bailey, '"Organizational Innovation in the Apparel Industry" *Industrial Relations*, vol. 32, No. 1, winter 1993, pp. 30-48.

[15] For a discussion of th, impact of standards on automated manufacturing technology, see Gregory Tassey, "Technology Infrastructure," *Research Policy*, vol. *20, 1992,* pp. 345-361.

lish relationships with suppliers or other partners more or less on an ad hoc basis. In this way, they reap the gains of downsizing and, for each project team. they can match the best people to the job. Agile manufacturing is hardly practical, however, in a closed networking environment. Suppliers, manufacturers, and retailers would have much less flexibility in their choice of partners: connectivity instead of efficiency could very well drive the select ion. [16] In fact, many firms use proprietary systems when they want to gain control of a partnering relationship: by using closed systems, they can often 'block-in" their customers or suppliers.] [7]

If interconnection becomes too costly, electronic markets may also be inefficient. reducing the efficiency of the overall economy.[18] Whereas highways and railroads fostered the development of a national market, electronic networks could have the opposite effect, with some groups and geographic regions no longer able to fully participate. Moreover. in an electronic environment, firms can use standards as barriers to entry, if not, in fact. as restraints on trade. [19] This aspect of networking may present problems not only for the U .S. domestic economy-as evidenced by continued antitrust suits against computer reservation systems. real estate multiple-listing services, and automated teller machine providers-but for the global market as well.[20] Thus, for example, although the demand for electronic data interchange (EDI) is growing rapidly, the international EDI market barely exists at present.[21] This delay is partly due to the fact that the United States has adopted one standard (ANSI x. 12) and the Europeans another (EDIFACT). As a result, EDI users are still unsure about which standard they should be using to link up with their trading partners. Standards can also be used as trade barriers, which increasingly has occurred over the last several years .22

Although many users have been pressing for open systems, vendors have been slow to deliver. They are reluctant to move toward more open sys - terns because standards 1imit their abi 1 i t y to differentiate their products, and thus can reduce their profits. There is also the classic "chicken and egg" problem, which is characterist ic of networked systems. Venders are unwilling to design their products to specific standards until they can be assured of a market, while users are reluctant to purchase networked products unless their interoperability is guaranteed.[23]

In addition. standards-setting processes are, themselves, subject to market failures because

[16] B.R. Konsynski, "Strategic Control in the Extended Enterprise," *IBM Systems Journal*, vol. 32, No. 1, 1993, p. 131

[17] Max D. Hopper -- Rattling Sabre—New Ways to Compete on Information, " *Harvard Business Review*, May-June, 1990, pp. 118-125, See al so James E. Short and N. Venkatraman, "Beyond Business Process Redesign, Redefining Baxter's Business Network," *Sloan Management Review*, fall I 992. pp. 7-2 I

[18] See F, Bar and M. Borrus "Fro)m Public Access to Private Connections II: Network Strategy and National Advantage in U.S. Telecommunication," Report for OECD Seminar on Information Network and Business Strategies, Paris, France, October 1989.

[19] Ajit Kambil, "Information Technology and Vertical Integration: Evidence from the Manufacturing Sector," in Margaret E, Guerin-Calvert and Steven S. Wildman (IA.), *Electronic Services Networks: A Business and Public Policy Challenge (New* York, NY Praeger Publishers, 199 I). pp 22-38.

[20] U.S. Congress, of ffice of Technology Assessment, *Global Standards: Building Blocks for the Future*, OTA-TCT-512 (Washington, DC U.S Government Printing office, March 1992).

[21] The European EDI service market generated $100 million in revenues in 1991, and is predicted to reach $500 million in 1996. The North American EDI market, which suffers from less fragmentation, is expected to reach $1.5 billion by 1998. See Donne Pinsky, "AT&T, BT, and IBM Connect Euro EDI," *Communications Week International*, Oct. 19, 1992, p. 48.

[22] OTA, op. cit., footnote 20.

[23] Carl Cargill, *Information Technology Standardization: Theory, Process, and Organizations* (Boston, MA: Digital Press, 1989).

they exhibit "public good" characteristics.[24] Public goods are those goods whose benefits are available to everyone and from which no one can be excluded, and no one can fully appropriate the benefits. As a result, public goods are underproduced.[25] Standards often fall into this category. Other market failures may also weaken standards-development processes. If the most efficient standards choices are to be made, for example, all interested parties must have access to accurate and timely information.[26] However, information about standards, like standards themselves, is a public good, and is therefore likely to be underproduced.[27]

Compounding the situation, the United States standards-setting process has a number of unique problems. Unlike most other countries where governments have entered into formal agreements with private-sector standards bodies—agreements that recognize and actually stipulate that these organizations serve public as well as private sector goals—the U.S. government has made no such agreements. Instead, private-sector bodies have been delegated the task of setting standards on the assumption that, by acting in their own interests, they are bound to act not only in the interest of their user clients, but also in the national interest as well. This has proven to be less and less the case, however.

As documented in the OTA report, *Global Standards: Building Blocks for the Future,* the U.S. standards-setting process has become increasing y paralyzed from a lack of leadership and intense rivalry among standards-setting bodies.[28] This situation has detracted from the main purposes of setting standards; it has also served to undermine the legitimacy of the system in the opinion of standards bodies at home and abroad. Impatient with the lack of progress, some vendors have circumvented the traditional process by establishing special consortia to develop standards in specific areas.[29] Although these consortia have been successful in speeding up standards' development, their membership is purposefully limited; they are established with the competitive

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[24]Pure public goods will not be produced privately. There are only a few pure public goods, one example being national defense. Other goods, like education and standards, are impure public goods. These combine aspects of both public and private goods. A lthough they serve a private function, there are also public benefits associated with them. Impure public goods may be produced and distributed privately in the market or collectively through government. How they are produced is a societal choice of significant consequence. If decisions about impure public goods are made in the market, on the basis of personal preferences alone, then the public benefits associated with them may not be efficiently produced or equitably distributed. See Edwin Mansfield, *Microeconomics Theory and Application (New* York, NY: W.W. Norton, 1 *970).*

[25]C. Kindelberger, "Standards as Public, Collective, and Private Goods," *Kylos, vol. 36,* pp. 377-395; and Sanford Berg, 'Technical Standards as Public Goods: Demand Incentives for Cooperative Behavior," *Public Finance Quarterly,* vol. *17,* January 1989, pp. 35-53.

[26]For a discuss [(m of market failures due to lack of information, see Joseph Farrell and Garth Saloner, "Coordination Through Committees and Markets," *Rand Journal of Economics, vol. 19,* summer 1988, pp. 235-252; and Joseph Farrell and Garth Saloner, "Standardization, Compatibility, and innovation," *Rand Journal of Economics, vol. 16,* spring 1985, pp. *70-83.*

[27]Even when standards-related information can be packaged for sale like other commodities, thus yielding an adequate return, its price may limit its distribution so that people have insufficient information to make sound decisions.

[28]In the United States, most standards are establ ished through a voluntary, consensual process that is orchestrated and carried out by approximately 400 private sector standards development bodies. These groups are organized and function independently, although they all arrive at decisions through a process of consensus and provide some level of due process. All have mechanisms for participation, comment, and appeal. OTA, op. cit., footnote 20.

[29]Consortia have been established, for example, to set standards for switched multimegabit data service (S MDS), Fiber Distributed Data Interface (FDDI) over twisted pair, asynchronous transfer mode (ATM), and frame relay technologies. See, for a discussion, Martin Weiss and Carl Cargill, "Consortia in the Standards Development Process," *Journal of the American Society for Information Science,* vol. *43,* No. 8, September 1992, pp. 559-565.

strategies of vendors in mind, rather than the interests of users or the economy as a whole.

INCREASING IMPORTANCE OF SOFTWARE

Increasingly, all electronic networks--whether public, wide area networks that provide essential transmission services or private networks that support interorganizational business applications --are software driven and software dependent. Software provides structure and functionality to these networks. determining such critical features as interconnection, interoperability, ease of use and rates of technology diffusion.

Given its role in networking, software will also become a more significant factor determining economic relations. Already software-defined proprietary networks can function as market barriers, while distributed computing systems can encourage economic activities that are horizontally rather than vertically integrated. Equally important. software-defined business applications will not only affect the structure of work relationships; they will also help to determine the very nature of work.

Unfortunately, the ability to develop a broad range of high quality, reliable software to support business networking applications has failed to keep pace with software's greatly enhanced role. This gap can inhibit network development and deployment, and the resultant economic gains. It also constrains the kinds of social choices that are available to the nation in determining how to best structure economic activities and outcomes.

Software development is being driven by mounting computer sales[30] and by the growing need for more versatile and complex applications.[31] Businesses, for example, need software that can support: 1) system simulation and integration, not just data processing: 2) distributed systems as well as centralized computing; and 3) graphics and nultimedia-based systems rather than simple text-based ones. Embodying the logic of complex systems, software will also be used to reengineer business processes. Software can be designed to affect the way in which people and machines interact, conceptualize problems, carry out processes and routines, design jobs and role assignments, and define authority and power relationships.[32] Many businesses are using groupware, workflow software, and distributed computing to empower employees and enhance team-based work (see box 2-1). Software quality and speed of delivery are also becoming increasingly important. It is estimated, for example. that software defects and delays can increase business project costs by as much as 50 percent.[33]

Internetworking among firms and across markets is also becoming increasingly dependent on soft ware, which represents an element of network design and operation that is increasingly more costly and complex.[34] The intelligent network, for

30 It is noteworthy in this regard that, whereas at the end Of the 1980s there were more than 1 million computers in the United States, that numher is estimated to exceed 100 million by 1995. John Teresko, "Software: (Still) Made in the U.S.A.," *Industry Week,* Jan. 4.1993. p. 41.

31As described by Rockart and Hofman:"The kinds of information Systcms that are needed to support the process-oriented, interdependent, and information rich organization of today are vastly different. The organization that works across functional (and sometimes divisional) bounderies needs to support cross-functional transacting systems. where the focus is on satisfying end-to-end business events or service strategies rather than discrete activities. . .two implications are clear. First, new systems development, long overwhelmed by maintenance of existing systems, will be necessary if proccess-oriented systems are to be created.The investment will be major. Second, not only the nature of the systems has changed, the speed with which they are needed and. more important, with which they must be changed, has increased as wall."" John F. Rockart and J. Debra Hofman, "Systems Delivery: Evolving New Strategies."' *Sloan Management Review,* summer 1992. pp. 24-25.

32See, for discussions. Shoshana Zuboff, In *the Age of the Smart Machine: The Future of* Work *and Power (New* York, NY: Basic Books. 1988); and Thomas H. Davenport and James E. Short,"Thc New Industrial Engineering: Information Technology and Business Process Redesign."" *Sloan* Management *Review,* summer 1990. pp. I l-27.

33 W. B. Foss, "Software Piecework," Computerworld, Sept. 23, 1991, p. 69.

34 Mansell, op. cit., footnote 1, p. 510.

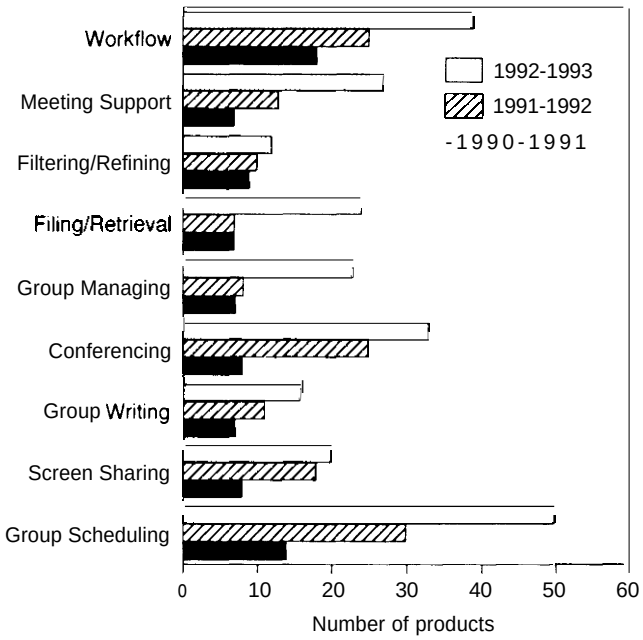
BOX 2-1: Groupware Product Growth by Product Category

"Groupware" IS a general term for software (and sometimes hardware) applications that are designed for the use of collaborate work groups. For example, basic groupware combines simple messaging software such as electronic mail with common databases of work records and memos. Workflow software allows processes to be redesigned and streamlined, and automatically routes work from employee to employee Meeting and conferencing software and hardware facilitates conferencing with audio, video, or just simultaneous text entry Finally, scheduling software coordinates meetings using each colleague's electronic appointment book

Groupware IS on the rise In 1989, the Institute for the Future began systematically tracking the groupware market according to nine categories as shown. Between 1991 and 1992, they found the total number of prod ucts nearly doubled from 77 to 140.

SOURCE Office of Technology Assessment 1994

FIGURE 2-2: Groupware Product Growth by Product Category



SOURCE Institute for the Future, 'The Electronic Enterprise, " contractor document prepared for the Office of Technology Assessment, May 1993, p 25

example, could not exist without the support of software-driven switches and databases[35] (see box 2-2). Employing such software, telephone companies now spend $9 billion annually on information technology, which amounts to about $60 (expense plus capital) per access line, or more than 30 percent of total basic monthly charges.[36] How this software is deployed, and where its contro] resides, will determine the quality and evolu-

[35]Using intelligent switches and databases, together with common channel signaling, the intelligent network allows network control f~nctions to be separated from network switching functions. This capability permits the net work to select the most appropriate services and optimal routes, and to introduce new value-added services via simplified and modularized software. Among the services that the intelligent network can provide are dynamic call routing, call forwarding, call queuing, credit and billing, reverse charging, control of calls based on data held in a central database, and virtual private networks.

[36]Robert G. Docters, Martin G. Hyman, and Raul Katz, "Are You a World-Class Software Developer?" *Telephony*, Apr. 19, 1993, pp. 41-43, 48.

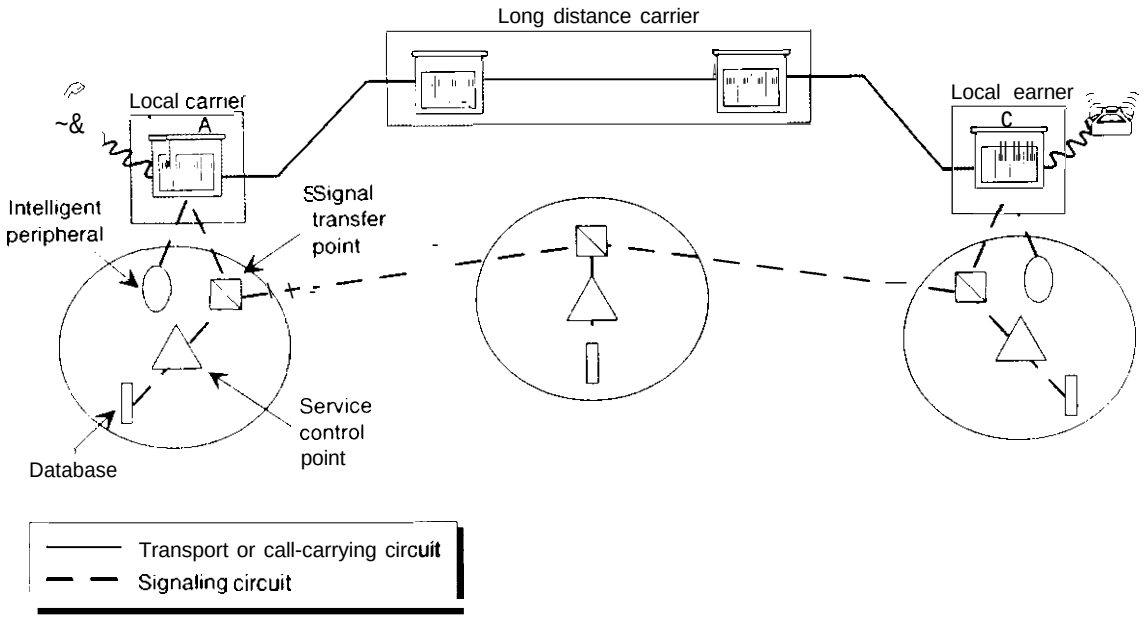
BOX 2-2: Intelligent Network

The advanced Intelligent network, elements of which are currently installed in today's public switched telephone network envisions greatly Increased operating efficiency as well as a broad array of sophisticated network services by separating the call transport (I e , the voice circuit) function from the signaling and control function and employing the powerful software in the switches

Imagine, for example, an instance where a caller places a call to a family member who, while on vacation has Indicated that calls from certain numbers are to be rerouted to the new location and given a unique ring to indicate priority In this illustration, the vacationer would have preprogrammed the priority telephone numbers (other calls might be routed to an answering service or machine) and the new destination number by dialing into the Intelligent peripheral and inputting these data When the caller dials the number, the local switch queries the signal transfer point for billing and accounting information It also ascertains from the service control point a clear path through the local network to the point of presence of the caller's long-distance carrier of choice The signaling networks of the two local exchange companies and the long distance earner Interact to learn the status of the called party and thus how to set the call up, in this case, the call has been redirected to a telephone address in a new location, so a third local company IS involved and once again the status of the called party IS learned (for example if the line were in use, the network would direct local carrier A to transmit a busy signal to the caller) and establishes a calling path Local earner C IS also Instructed to deliver the special ring

SOURCE Office of Technology Assessment 1994

FIGURE 2-3: Intelligent Network



SOURCE Office of Technology Assessment 1994

tion of networking; it will also affect network providers and their competitive positions vis a vis one another in the marketplace.[37]

Because of its increasing importance, software could easily become a barrier to networking development and business use.[38] Rates of innovation and development are already failing to keep pace with those of other information and communication technologies. Whereas the price/performance ratios for hardware have been falling dramatically for a number of years, the costs of developing a line of software code is approximately the same as it was 20 years ago.[39]

Even now, businesses are feeling the pinch of lagging software development, and the situation will be hard to reverse.[40] The slow pace of development stems in part from the lack of unifying technical concepts and proven software engineering tools and methods. These problems are compounded by the need to customize software tools to specific business users' needs.[41] Software development costs are also being driven up by the need for maintenance, upgrades, and documentation, all of which are expensive.

Although software development tools, such as Computer Aided Software Engineering (CASE) and object-oriented methods, are advancing and becoming widely available, the use of these technologies is still limited.[42] Vendors have been discouraged from developing and marketing software development tools because of the lack of standards and the high costs entailed in creating domain-specific interfaces to suit the needs of different users. Moreover, software developers have not been inclined to adopt these tools because they require the development of new skills and practices and the abandonment of old systems and ways of doing things.[43]

Future efforts would likely yield greater results if more emphasis were placed on stimulating commercialization, technology diffusion, and the continued innovation that takes place throughout the entire life-cycle process.[44] The Japanese experience is especially instructive in this regard. Focusing on planning and team development rather than on the engineering technologies, the Japanese have made impressive productivity gains. Today,

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37 Mansell, op. cit., footnote 1.

38 As described by Fichman and Kemerer: "This Imbalance has reached such proportions that it has been termed the software crisis. Software production represents the single biggest obstacle to the successful use of IT in organizations: all precepts such as 'using IT for strategic advantage, ' 'reengineering the business, ' and ' informating the workplace, ' become mere slogans if the necessary software is not properly delivered on time." Robert G. Fichman and Chris F. Kemerer, "Adoption of Software Engineering Process Innovations: The Case of Object Orientation," *Sloan Management Review*, winter 1993.

39 John A. Alic, Jameson R. Miller and Jeffrey A. Hart, "Computer Software: Strategic Industry." *Technology Analysis & Strategic Management*, vol. 3, No. 2, 1991, pp. 177-190.

40 Foss, op. cit., footnote 33, p. 69.

41 As described by Rosenthal and Salzman: "The design of effective software is fraught with subtle complexity. Seemingly technical decisions about the information to be contained on a screen, the sequence of screens, and the types and forms of data entry can fundamentally influence how workers and customers interact. Technical decisions are really decisions about how and what service will be delivered, the structure of customer-worker interactions, and more generally, the firm's operational model of service delivery. These are often not obvious to the software engineer, who views systems design as a technical enterprise involving the automation of clearly defined procedures." Stephen R. Rosenthal and Harold Salzman, "Hard Choices About Software: The Pitfalls of Procurement," *Sloan Management Review*, summer 1990, p. 82.

42 Jonathan A. Morell, Louis G. Tornatzky, and James Behm, *CASE Implementation: Dynamics Through the Technology Life Cycle* (Ann Arbor, MI: Industrial Technology Institute, 1990), and Maryann Olavi, " Making CASE an Organizational Reality," *Information Systems Management, vol. 10,* No. 2, spring 1993, pp. 15-20.

43 Fichman and Kemerer, op. cit., footnote 38, p. 8.

44 See Edward Yourdon, The *Decline and Fall of the American Programmer* (New York, NY: Prentice Hall, 1992). As the author notes: "Attention to peopleware issues can literally cause 10-fold productivity improvement, while investments in CASE methodologies, or other technologies, rarely cause more than a 30-40 percent improvement," p. 28. See also Morrell et al., op. cit., footnote 42.

it is said that Japanese programmers produce 70 percent more code than their U.S. counterparts, and with fewer than half as many defects.[45]

For best results, users as well as vendors need to be more involved in the processes of software development and acquisition.[46] While user involvement is necessary for the development of all innovations, it is particularly important in the use of software, which is itself a process tool that has far-reaching organizational impacts. Too often, software fails to measure up to expectations. It may even give rise to unintended consequences because, in the early stages of development, design parameters are not carefully matched to organizational needs.[47]

Need for a New Regulatory Approach

There is a growing gap between advances in networking technology and the regulatory framework that governs how these technologies are brought together to comprise a national infrastructure. Although information and communication technologies are increasingly being mixed and matched and used interchangeably to create a variety of networks serving different purposes, national regulators continue to compartmentalize them, setting economic ground rules as if these technologies were quite distinct and unrelated. Moreover, regulators and lawmakers are, at times, so focused on establishing the appropriate rules for how the wide range of vendors and serv ice providers should relate to one another that they often fail to consider the larger consequences that the ensuing network architecture may have for the economy as a whole. Even less attention is paid to the evolution of private networks and network components that, while falling outside the bailiwick of the Federal Communications Commission's (FCC's) traditional regulatory mission, still constitute part of the infrastructure that supports and sustains economic activities.

Although the divestiture of AT&T had a revolutionary impact on telecommunications worldwide, its effect on U.S. regulatory policy has been much more circumspect.[48] Despite the convergence of information and communication technologies and the emergence of new complementary and competing networking components, the FCC continues to deal with each technology-as it has in the past—according to a distinct set of rules. Such an approach makes it difficult to develop a comprehensive and strategic picture of how systems will interconnect and services might best be delivered in the future.

This regulatory approach has major implications not only for infrastructure development, but also for business and the national economy. In economic activities, the value of information and communication technologies greatly increases when technologies are effectively networked together, making it imperative that they be considered in relationship to one another. Thus, for example, American Hospital Supply (AHS) (now Baxter Corp.) did not simply use its EDI network to reduce the cost of exchanging trade data. Instead, it added value to its product by packaging the information generated by the system and bundling it for sale together with its hospital supplies.

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[45] Michael A. Cusumano, "A Quantitative Analysis of U.S. and Japanese Practice and Performance in Software Development," *Management .$(ience*, vol. 36, No. I I, November 1989, pp. 1384-1405, Neil Gross, "Now Software Isn't Safe From Japan," *Business Week*, Jan. 1 I. 1991, p. 84, Mark Crawford, "Software industry Braces for Foreign Onslaught," *New Technology Week*, Nov. *18, 1991*, pp. 1,9: and Douglas Marden, "The Japanese Approach to Software Development '" *Chief Information Officer Journal, tel. 5*, No. 4, March April 1993. pp. *18-21.*

[46] See for instance, Sue Newell, Jacky Sw an, and Peter Clark, "The Importance of User Design in the Adoption of New Information Technologies," *international Journal o/ Operations and Production Management!*, vol. 13, No. 2, 1993, pp. *4-22. See* also, Joan Greenbaum and Morten K} ng, *Design at Work" Cooperative Design of Computer Systems* (Hill sdale, NJ: Lawrence Erlbaum Associates, 199 I).

[47] New ell et al., op. cit., footnote 46.

[48] For discussions of the post-div estiture regulatory environment, see Robert W. Crandall and Kenneth Flamm (eds.), *Changing the Rules: Technological Change, International Competition and Regulation in Communications* (Washington, DC': The Brookings Institution, 1989); see also Barry Cole (ed.). *After the Break-Up: A ssessing the New Post-AT& 7' D/\ estiture Era* (New York, NY Columbia University Press, 1991).

BOX 2-3: American Information Exchange (AMIX) Network

The American Information Exchange (AMIX) IS an example of one of the Innovative new electronic marketplaces AM IX, which has been in operation since June 1991, is a computerized forum for buying and selling software, research data, newsletters, and consulting services, according to its operators, the network IS designed to "shave transaction costs to the bone. "[1] The network facilitates the unbundling of Information, instead of buying one large, expensive report, buyers can access and pay for as much, or as little, Information as they need. Sellers post their products and services online, and if a buyer is interested, the materials are downloaded and the price IS debited from his or her credit card. The network pays the seller and keeps a commission Buyers can also use AMIX to advertise their data needs if there is no corresponding seller, the network will provide a mechanism by which buyers and sellers can negotiate a contract to create customized information To be part of the network, all one needs IS a personal computer, a modem, a telephone line, and AMIX software

(continued)

[1] Benjamin Wright, "High-Tech Juice Keeps Electronic Emporiums Humming" *Computerworld,* Oct12, 1992, P 112 See also Esther Dyson, "Information, Bid and Asked, " Forbes, Aug 20, 1990; Joel N Orr "Join the Information Economy, *Computer Aided Engineering* April 1992

SOURCE Office of Technology Assessment, 1994

In this fashion, AHS was able to differentiate its product from its competitors, and thereby gain a strategic advantage.[49]

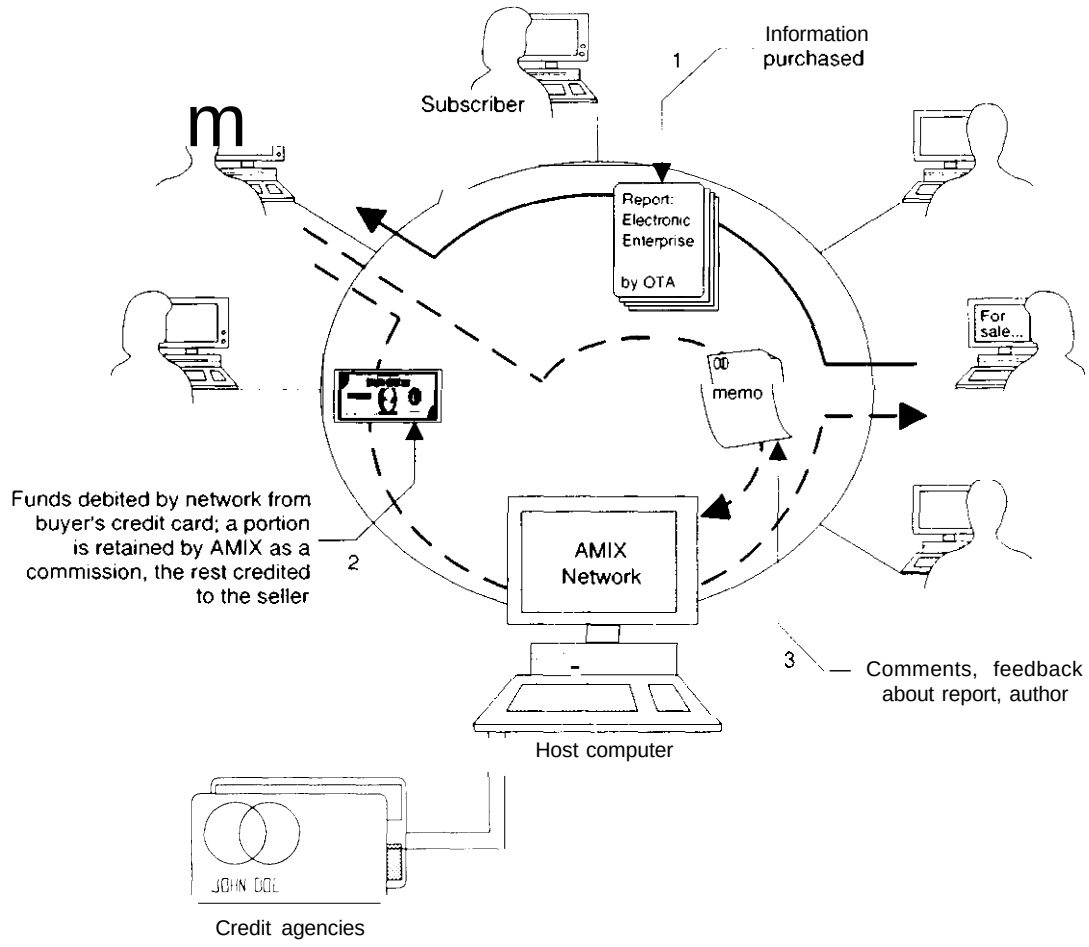
The internetworking of communication and information technologies adds value in the marketplace as well. For example, an electronic catalog may be useful, but its value is considerably increased if it is put online. It is then accessible to more users and can be updated in real time. Additional value can be added if this network is linked to both an intelligent network that offers 1-800 services and a credit card authorization system. By connecting all these services, an actual exchange can take place. Further benefits can be derived by connecting to an electronic funds transfer system and/or an automated clearinghouse. If, as in the case of the AMIX system, multiple buyers and sellers are linked together on a network, true electronic commerce can occur (see box 2-3). Whether, and under what circumstances, the appropriate interconnections allowing for electronic markets will take place, however, will be determined in part by federal and state regulations.

Communication regulations defining vendor relationships and network interconnections will also affect the distribution of economic costs and benefits among American businesses. For example, the FCC regulatory decision to allow interconnection to the public switched network fostered competition and the unbundling of what was once a single, unified telephone system. At the same time, however, this decision shifted the transaction costs entailed in network integration and management from the supplier to the user. These costs are considerable, given the growing variety of technologies from which to choose, the lack of standards and common interfaces, and the complexities involved in assembling networks. Large businesses have thrived in this environment, taking advantage of lower service costs and the opportunity to customize their networks to better meet their needs. Because of their size and resources, large businesses have been able to achieve sufficient economies of scale and scope, making it economical] y feasible for them to develop networks of their own. Given their specialized

[49] Hopper, op. cit., footnote I 7

BOX 2-3: American Information Exchange (AMIX) Network (cont'd).

FIGURE 2-4: American Information Exchange (AMIX) Network



SOURCE Office of Technology Assessment 1994

networking capabilities, many of these businesses—such as Sears and J.C. Penney—have been able to market their communication services or use them strategically to their competitive advantage.[50]

Small businesses, on the other hand, have often been disadvantaged by this situation. If, for example, a small business does not have in-house capabilities to develop its own proprietary EDI system, it will have to bear the full costs of system integration by paying a value-added network (VAN) provider, such as GEIS or EDS, to provide the service. Under such an arrangement, the trading companies rent EDI mailboxes through which or-

[50]See Eli Noam, "The Future of the Public Network: From the Star to the Matrix," *Telecommunications*, March 1988, pp. 58-59, 90; and J. Cash, W. McFarlan, and J. McKenney, *Corporate Information Systems Management*, 2nd ed. (Homewood, IL: Irwin, 1988); and Peter G. Keen, *Competing in Time: Using Telecommunications for Competitive Advantage* (Cambridge, MA: Ballinger Press, 1988).

ders and invoices are sent and received. This setup can be costly, and it is often inconvenient. Because of the high costs of interconnection, many companies access their mailboxes as infrequently as possible. Restricting usage, however, can defeat the purposes of EDI, which strives to support "just-in-time" de ivery. A company that checks its mailbox on] y once a day could be confronted with a delivery even before any paperwork has been done.[51]

The small user could overcome this problem, however, given a different set of interconnection arrangements. With software that is now being developed, businesses will be able to circumvent the VAN and link up their ED] systems through a less expensive transmission medium. such as an architecture like the Internet. In this case. the mailbox would reside on the user workstation instead of with (he VAN provider, Exchanges would likely take place much more frequently, since the user would have more control and the cost would be much less. Equally important, trading partners would be able to send unstructured E-mail messages along with structured EDI messages, which would greatly enhance the effectiveness of the trading partnership. If the Internet were linked to the X 400 E-mail standard, it would also be possible to transmit binary data, computer-aided design and computer-aided manufacturing (CAD-CAM) data, and graphics in this fashion.

It was relatively easy to establ ish rules and regulations governing interconnection when there was a single unified telephone system that was quite distinct and unrelated to other media, such as print and radio-based technologies. All were regulated according to a distinct set of principles. The telephone system operated as a common carrier; print media in accordance with the first amendment; and radio-based media as defined by the "public interest standard."[52] As communication and information technologies converge, and service providers merge accordingly, regulators and lawmakers will need to determine which set of principles should apply.

With the growth in competition, the packaging together of information with communication networks, and the development of private networking, fewer and fewer services are likely to fall within the traditional realm of common carriage. While this development may make sense with respect to the changes that are taking place within the telecommunication and information technology market, it might be problematic with respect to the economy as a whole. Common carriage rcgulation assures equitable access and interconnection to essential facilities. To the extent that networked information systems come to operate increasingly as true electronic markets, more and more issues relating to the principal of essential facilities will certainly arise.[53]

LINKING TECHNOLOGY AND ORGANIZATIONAL INNOVATIONS

Many business and government leaders look to information and communication technologies to

[51]Personal communication, Jonathan Morell, Industrial Technology Institute, Sept. 7, 1993.

[52]Ithiel de Sola Pool, *Technologies of Freedom* (Cambridge, MA: Harvard University Press, 1983); see also U.S. Congress, Office of Technology Assessment, *Critical Connections: Communication for the Future*, OTA-CIT-407 (Washington, DC: U.S. Government Printing Office, 1990), esp. ch. 4.

[53]Wildman and Guerin-Calvert, op. cit., footnote 19. See also Konsynski, op. cit., footnote 16, who, in response to the question of whether government will still have a role, replied: "Yes, because the government has an abiding interest in ensuring that systems built to facilitate business among competing companies are not designed or used in ways that give any business unfair competitive advantage. This principle has been enforced with much controversy in the United States, where the airline reservation systems have come under government orders to alter the ways their systems perform in order to eliminate systemic unfair competitive practices that were facilitated by the designs. We can expect similar concerns to arise with respect to horizontal EDI systems, and in many cases, government agencies are likely to look upon such systems as analogs of "common carrier" networks such as the telephone system. Although such systems can be privatized, as in the Singapore Tradenet System, the government will probably be required to have an ongoing role, ensuring that key social objectives are upheld in the actual functioning of the system."

help American business regain its competitive position and adapt to its rapidly changing economic environment. Experience to date, however, demonstrates that technology alone will not be enough. In cases where technology has made a critical difference it has been employed in conjunction with successful organizational change. Similarly, most obstacles to success have been organizational rather than technological. To develop appropriate technology-based strategies that are sufficiently responsive to the fundamental changes taking place around them, businesses will need to reengineer their business relationships and their ways of thinking about the nature of the business enterprise itself.

Over the past two decades, American business has invested heavily in information and communication technologies to boost productivity. Between 1970 and 1988, for examp]e, the share of information technology as a percentage of stock of capital equipment increased from 16.4 percent to 20.7 percent in the service sector, and from 1.6 percent to 10.6 percent in manufacturing.[54] In 1990 alone, American businesses spent over $61 billion on hardware, $18 billion on software, and over $75 billion on data-processing and computer services. [55]

In spite of the enthusiasm with which American businesses made these sizable investments. the results to date have been disappointing. Although U.S. business investment in information technology has exceeded that of all other major industrial countries, U.S. productivity has not followed suit.[56] Until very recently, productivity gains have been essentially stagnant in services. the very sector in which information technology investment has been highest .[57] only very recently has this trend begun to reverse, with productivity gains in services averaging 2.6 percent over the last seven quarters.[58]

Economists and other business analysts have explained the elusiveness of technology benefits-the so called "productivity paradox''-in a variety of ways.[59] Some have argued that existing productivity measures are out of date. They point out that, while the ratio of output to inputs may have sufficed to measure growth rates in an era of mass production, such a measure is inadequate in a service economy where time. convenience, and customized production are so highly Valued. Others caution against confusing cause and effect, noting that, had investment in information technology not taken place, productivity gains

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[54]David L. Schmitt .. Reengineering the organ ization Using Information Technology, ‘‘*Journal of Systems Management*, January 1993, p. 4.

[55]U.S. Department of Commerce, *US Industrial Outlook 1991* (Washington, DC: U.S. Government Printing Office, 1991).

[56]R. J. Gordon and Martin Neil Baily, "Measurement Issues and the Productivity Slowdown in Five Major Industrial Countries," *Technology and Productivity: The Challenge for Economic Policy* (Paris, France: OECD, 1991).

[57]Stephen S. Roach, *Making Technology Work* (New York, NY: Morgan Stanley, Special Economic Study, Apr. 16, 1993), p. 3.

‘Xlbid., p. 5.

[59]For overall discussions, see Martin Neil Baily and Robert J. Gordon, "The Productivity Slowdown, Measurement Issues, and the E\ pit)-sion of Computer Power," Brookings Papers on Economic Activity, vol. 2, 1988; Gordon and Baily, op. cit., footnote 56, Paul Strassman, The *Business Values o/ Computers (New* Canaan, CT: The Information Economics Press, 1990); and Paul Attewell, "Information Technology and the Productivity Paradox," version 3.1, July 1992, funded in part by a grant #1ST 8644358 from the Information Technology and ( )rgani/ations program of the National Science Foundation. For an alternative point of view, see Erik Brynjolfsson, "1s Information Systems Spending Productive: New Evidence and New Results." MIT Sloan School, Working Paper #3S71 -93.

[60]OTA Workshop on the Productivity Paradox, Harvard University, Ma\ 10, 1993. See also, Peter R. Richardson and John R.M. Gordon, "Measuring Total Manufacturing Performance," Management Review, winter 1980, pp. 47-57, Young Kyu Son and Chan S. Park, "Economic Measure of Productivity, Quality and Flexibility m Advanced Manufacturing Systems," *Journal of Manufacturing Systems*, v {)1. 6, No. 3; and Timothy Bresnahan, "Measuring Spillovers from Technical Advance: Mainframe Computers in Financial Services," *American Economic Review*, vol. 76, No. 4, 1986, pp. 742-755.

may have been even lower.[61] Still others question the existence of a productivity paradox, noting that it can take a number of years to reap the benefits of a new technology, especially in cases involving networked technologies.[62]

Although differing in their assessments of the productivity paradox, many analysts agree that information and communication technologies will not yield substantial gains unless American businesses use them to instigate major organizational change.[63] Embodying social relations and supporting social interactions, communication and information technologies are indeed powerful forces for change. However, if they are to have their intended effect, new technologies will need to be carefully integrated into their organizational environment, taking full account and advantage of the "way people work, learn, and innovate."[64] These technologies will also need to revolutionize the mind-set of those working within business organizations, awakening them to the full range of new organizational possibilities.[65] The lack of mutual adaptation will serve to undermine these efforts[66] (see box 2-4).

Problems of this nature have already become apparent, for example, in the case of business networks. Cooperative partnerships offer a wide range of benefits.[67] In a rapidl y changing environment, they permit firms to enjoy a measure of stability without sacrificing all their flexibility.[68] Partnering benefits can be distributed in two ways. Linked to a large customer or supplier, for example, a small firm can gain access to new markets; share in cost reductions resulting from greater economies of scale; reduce the time required to develop new products; gain access to technology and process innovations; improve quality; provide mutual assistance in a crisis; receive greater market feedback; and receive better financial

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[61] William Bowen, "The Puny Payoff from Office Automation," *Fortune*, May 26, 1986.

[62] David, op. cit., footnote 6.

[63] As Hayes and Jaikumar note "Still, most U.S. managers are having difficulty reaping these advantages. For years, manufacturers have acquired new equipment much i n the way a fam i ly buys a new car. Drive out the old, drive in [he new, enjoy the faster, smoother, more economical ride—and go on with Ii fe as before. With the new technology, however, "as before" can mean disaster. Executives are discovering that acquiring an FMS [flex ible manufacturing system] or any of the other manufacturing systems is more like replacing that old car with a helicopter." Robert H. Hayes and Ramchandran Jaikumar, "'Manufacturing's Crisis: New Technologies, Obsolete Organizations," *Harvard Business Review*, September-October, 1988, pp. 77-85.

[64] As Brown and Duguid note: "Organizational survival may far less depend on more sophisticated technology devices than on a more sophisticated understanding of the way people learn, work, and innovate," John Seely Brown and Paul Duguid, "Innovation in the Workplace A Perspective on Organizational Learning," paper prepared for the Carnegie Mellon University Conference on Organizational Learning, May 1989, p. 3. See also Steven Stanton, Michael Hammer, and Bradford Power, "Reengineering: Getting Everyone on Board," *IT Magazine*, April 1993, pp. 22-27.

[65] Ibid., p. 7.

[66] Henry Mintzberg and Frances Westley, "Cycles of Organizational Change," *Strategic Management Journal*, vol. 13, 1992, pp. 39-59, As the authors point out, organizational change can take place from both the top down and the bottom up. But, as in the case of al I innovations, organizational changes will be redeveloped and reinterpreted to address the situation at hand.

[67] Mark D.)]] inger and Peggy Golden, "Interorganizational and Collective Strategies in Small Firms: Environmental E; ffects and Performance," *Journal of Management*, vol. 18, No. 4, 1992. As the authors point trot: "The future looks more cooperative than we believe. Perhaps the sun i\ ors of the competitive game are the ones who now participate in the cooperative game. As the global economy evolves, strategic alliances are the future and competition will primarily take place among alliances. The advantage of participating in these alliances are multiple and manifest and firms scramble to be members. In other words, firms compete to cooperate"

[68] Andrea Larson "Partner Network: Leveraging External Ties To Improve Entrepreneurial Performance'" *Journal of Business Venturing*, vol. 6, 1991, pp. 173-188. See also, Peter Srni th Ring and Andrew H. Van de Ven, "Structuring Cooperative Relationships Between Organizations," *Strategic Management Journal*, vol. 13, *1992,* pp. 483-498.

BOX 2-4: Organizational Restructuring: The Cases of Saturn and Ford

The great successes in recent years of foreign-based automobile manufacturers in the American small-car market have led the big three American automakers to reassess managerial approaches and production processes Faced with declining market share and well publicized management troubles, General Motors (GM), the nation's largest automobile manufacturer, launched the Saturn Corp in 1983 to compete in this Important segment of the market

The Saturn Corp was created from scratch as a subsidiary of GM, but with sufficient distance from the parent company to allow a new corporate philosophy. In order to compete against Honda, Toyota. and Nissan, Saturn is experimenting with markedly new ways of designing, building, and even selling cars The company's hallmark is its reemphasis on people—both its workers and customers Instead of a dichotomy between management and labor, Saturn organizes the company in teams, each of which is responsible for its performance, budget, and hlring, further, the involvement of team members in decisions about production and the product is a significant departure from normal practice and is often credited with Improving the quality of the work environment and the product itself A second innovation is the integration of computers into the design and production of Saturn cars With support from GMs EDS subsdiary, Saturn electronically connects the various departments—for example, directing purchasing to order parts to match a production schedule—as well as Important suppliers the network even links with dealers to track information on customer preferences and automobile maintenance

The Ford Motor Co , in 1926, faced an analogous predicament declining market share was proof that the philosophy and manufacturing process that had worked so successfully for the Model T had become obsolete In order to build a new product line, it was necessary for Ford to rebuild its company

During the first two decades of the 20th century, Henry Ford and his motor company revolutionized manufacturing with the introduction of assembly -line mass production for the flagship Model T Ford and emphasized maximum production at minimum cost, though there were numerous refinements of the process in the course of the Model T's illustrious 20-year history, the product itself remained remarkably similar Ford's hallmark was to build cars in very large quantities using machine tools specifically designed for a single task similarly, Ford realized significant Improvements in productivity by breaking down human tasks into very small pieces Ford refined the assembly-line system of production to such a degree that no competitor could match Ford on price however, this great efficiency came at the expense of Innovation, and GMs Chevrolet division Instead won over consumers in Increasing proportions on the basis of more modern styling and a greater variety of features and options, such as colors other than black

By 1926, when the 15-millionth Model T came off the assembly line, Ford's market share had slipped to 30 percent from a peak of over 50 percent in 1921 In that year, Ford announced that it would stop making the Model T and Introduce a new car, the Model A. In doing so, Ford largely revamped its own organization, purging the company of the old management, the company also relocated to a new facility and redesigned the production tools and process in preparation for the new Model A

SOURCES David A Hounshell *From the American System to Mass Production* 1800-1932 (Baltimore MD The Johns Hopkins University Press 1984) pp 217-301 Kevin Doyle "Can Saturn Save GM?" *Incentive*. December 1992, pp 30-37 Keith A Linton and L sa W Churitch Managing and Measuring the Performance of Vehicle Design at Saturn, ' *1993* AACE *Transactions* Jeremy Main Computers of the World Unite! *Fortune* Sept 24, 199(, pp 115-122, John Teresko "Engineering Where Competitive Success Begins *Industry Week Nov* 19 1990 pp 30-34

terms.[69] Larger firms that are parties to such arrangements also gain; most important, small firms can help them gain access to future markets as well as provide a stimulus for innovation and change .70

Establishing such arrangements is not without difficulties, however. Above all, successful networking takes time and continued effort; it requires that trust be established over time through a process of repeated successful transactions.[71] It also requires a commitment and willingness to share all forms of information among business partners[72] (see figure 2-5). Having been steeped in a bureaucratic and competitive mentality, many businesses have found it difficult to shift from an adversarial approach to a more cooperative one. For example, many manufacturers find it difficult to commit to a specific set of suppliers.[73] And, even after making such a commitment, they are reluctant to share proprietary product data. At the same time, suppliers have been unwilling to let their customers, or other competing suppliers, share their cost data.[74] Failure to share information within firms also inhibits partnering, since effective interorganizational relations require cooperation across all sectors of both firms.[75]

Total quality management (TQM) groups have encountered similar problems. The concept of TQM, which traces its early roots back as far as the 1920s, gained considerable popularity in the late 1970s and early 1980s when American manufacturers learned from their successful Japanese counterparts that it is quality, and not just cost, that drives sales in a post-industrial economy.[76] Fundamental to total quality management is the assumption that, when things go wrong, the problem generally stems from organizational rather than human failures. To solve such organizational problems, TQM calls for employees, working in teams and closely with management, to identify the problems and find ways to overcome them. Work teams also need access to company-wide information to properly analyze issues and solve problems.[77]

Although American businesses have taken many formal steps to adopt team-based, quality-

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[69] Ibid., p. 179

[70] "Ibid., p. 180.

[71] As described by Ring and Van de Ven: "Reliance on trust by organizations can be expected to emerge between business partners only when they have successfully completed transactions in the past and they perceive one another as complying with norms and equity. The more frequently the parties have successfully transacted, the more I ikely they will bring higher levels of trust to subsequent transactions. As the level of trust increases, greater reliance may be placed on the actions of the trusted party. " Ibid., p. 489. See also R.G. Eccles and D. Crane, "Managing Through Networks in Investment Banking," *California Management Review, vol. 30, 1987,* pp. 176-195.

[72] Mark Dodgson, "Learning, Trust, and Technological Collaboration," *Human Relations, vol. 46,* No. *1,* January 1993, pp. *77-95.*

[73] As noted by Richardson: "Developing long-term, tightly integrated relationships with fewer suppliers, especially with a sole source, conflicts with conventional wisdom and historical U.S. practice. "James Richardson, "Restructuring Supplier Relationships in U.S. Manufacturing for improved Quality," *Management International Review,* vol. 33, Special Issue, January 1993, p. 55. See also, Martin Everett, "Why Partners Sometimes Part," *Sales and Marketing Management,* April 1993, pp. 69-74.

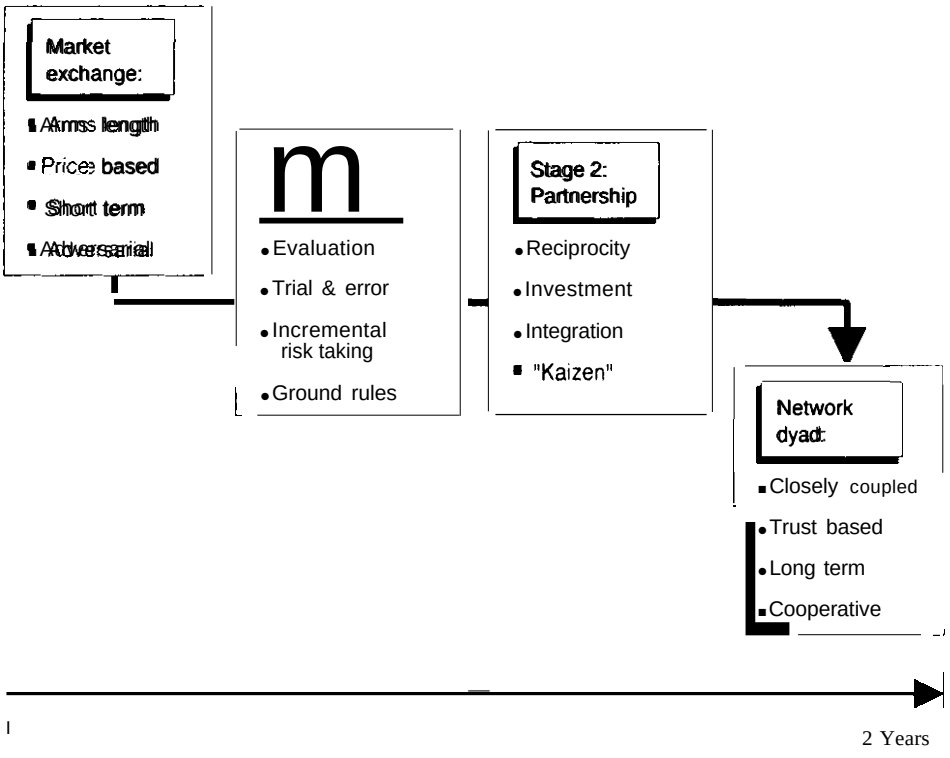
[74] See Max Munday, "Buyer-Supplier Partnerships and Cost Data Disclosure," *Management Accounting,* June 1992, pp. 28-36.

[75] See Morels M Kleiner and Marvin L. Bouillon, "information" Sharing of Sensitive Business Data With Employ ees," *Industrial Relations,* vol. 30, fall 1991, pp. *480-491.* Motohiro Morishima, "Information Sharing and Firm Performance in Japan," *Industrial Relations, vol. 30, No. 1,* winter 1991, pp. 37-61. See also Motohiro Morishima, "information Sharing and Firm Performance in Japan," *Industrial Relations,* vol. 30, No. *1,* winter *1991.* pp. 37-61.

[76] For a discussion of the history and philosophy" of TQM, see Stephen J. Harrison and Ronald Stupak, "Total Quality Management: The Organizational Equivalent of Truth in Public Administration Theory and Practice," *Public Administration Quarterly,* pp. 420-429.

[77] 1 bid., p. 424.

FIGURE 2-5: Forming the Partnership: A Two-Stage Process



SOURCE Andrea Larson Partner Networks Leveraging External Ties to Improve Entrepreneurial Performance *Journal of Business Venturing* May 1991

oriented approaches, many old behavioral patterns persist.[78] To implement TQM, management must renounce its traditional hierarchical style—based on the specialization of tasks, workplace stability, product iv it y, obedience, and control--in favor of a more trust-oriented approach that calls for leaders who can inspire group motivation, loy - alty, commitment, and worker pride.[79] Workers, on the other hand, must not only be willing to learn new skills and adapt to different incentives and re - ward structures; they must also trust management's intentions. This will be hard to do, given years of adversarial relations. It is even more diffi - cult when TQM groups are established as part of a total business reengineering process. in which case jobs might be at stake .80 Under such circum-

[78] In a study comparing U.S. and Japanese quality management styles, Ebrahimpour and Cullen found, for example, that "A merican managers emphasize concrete results rather than processes. Additionall y, they make decisions in a less participate\ e fashion than do Japanese. Individual responsibility and top-down decision making appear to be common features of the Americans} stem. Furthermore, the U.S. manage - ment favors a control mechanism based on close supervision and an explicit formal control patter n." Mailing Ebrahimpour and John B. Cullen, "Quality Management In Japanese and American Firms Operating in the United States: A Comparative Study of Styles and Motivational Be - liefs," *Management /r] ternational Review*, vol. 33, Special Issue, January 1993, p. 37. See also David Graves, "Forget the Myths and Get on With TQM—Fast," *National Productivity Review*, summer 1993. See also Thomas Bailey, "Organizational Innov ations in the Apparel Industry," *Industrial Relations*, vol. 32, No. 1, winter I 992, pp. 30-48.

[79] + arrison and Stupak, op. cit., footnote 76, pp. 4 '6 "429

[80] David Fagiano, "The Downsizing and Loy alty Conundrum," , *Management Review*, June 1993. p. 4.

stances, it is not surprising that many quality management programs have yet to show clear-cut positive results.[81]

Technology, although by no means a panacea, offers one way of breaking out of this organizational impasse. As Michael Hammer, a leading proponent of business engineering, has pointed out, "The power of the new technologies is that they allow you to redefine what your problem is. "8[2] And there are clearly many who agree. According to one estimate, the work flow software market in the United States will grow tenfold by 1996, when it will constitute a $2.5 billion industry.[83]

There is a major problem is viewing technology in this way, however. Like organizational innovations, technology is viewed all too often as a "fix" to be implemented from the top down. Although technology plays a major role in structuring human relations, rarely do businesses, or the people working in them, play a major role in its design. The real choices about technologies are not made when vendors put them up for sale on the market, but when the problem to be solved is first defined. As experience with TQM groups demonstrates, the task of identifying problems is often performed best by those who are doing the work.[84]

NEED FOR A FLEXIBLE WORKFORCE

Over the last several decades, the U.S. workforce has undergone tremendous change as businesses implemented information technology. With new advances in the technology and new organizational forms emerging to use them, workforce changes will likely continue. Furthermore, the overall shift in the structure of the economy from one dominated by mass production to one that is more flexible and centered on services will require a workforce that is similarly flexible and skilled. Experience indicates that information technologies can both upskill and deskill jobs. Recent advances in information technology, however, will likely have more significant impacts because they can increase the levels of both cooperation and control in workplaces. These changes are not understood nearly as well as the role of information technology in affecting skill levels.

The demands for increased flexibility and lower costs are forcing American business to reconsider traditional management techniques. The success of Japanese workplace practices has motivated American businesses to emulate them. Continuous improvement (kaizen), lean production, and just-in-time (kanban) manufacturing are the new standards of performance in production, distribution, and retail. Similarly, the forming of worker teams and quality circles to motivate employees is gaining adherents. This approach to work sees cooperation as a central goal. Employers recognize that encouraging employees to share the firm's goals is not only profitable in the long run, but also necessary for the development of flexible response processes.

Information technology supports these shifts to new ways of managing. EDI, for example, is a critical component in just-in-time distribution because it allows suppliers and customers to coor-

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[81] See John Iacovini, "The Human Side of Organizational Change," *Training and Development*, January 1993, pp. 65-68. As (he author notes: "Research has shown that few quality-improvement efforts go beyond lip service. Examined more closely, most quality failures result from some fundamental imbalances between the human and business sides of change." I bid., p. 65. See also Richard S. Belous, "Human Resource Flexibility and Equity: Difficult Questions for Business, Labor and Government," *Journal of Labor Research*, vol. 10, No. 1, winter 1989, pp. 67-72.

[82] Michael Hammer, "Reengineering," *Across the Board*, June 1993, p. 32. See Also Ram Charan, "How Networks Reshape Organizations-for Results," *Harvard Business Review*, September-October 1991, pp. 104-115.

[83] John Gantz, "Surviving the Re-engineering Revolution," *Networking Management*, January 1993, pp. *20-21.*

[84] Robert J. Thomas, *What Machines Can't Do: Politics and Technology in the Industrial Enterprise (Berkeley, CA:* University of California Press, in press). See also John Alic, "Who Designs Work? Organizing Production in an Age of High Technology," *Technology and Society*, vol. 12, 1990, pp. *301-317.*

dinate the flow of goods. "Concurrent" or "simultaneous" engineering is largely a computerized approach to team-oriented design. Manufacturers find lean production easier to implement with the development of computerized numerically controlled (CNC) machines.

There are other ways to achieve a flexible workforce, but these reduce the quality of work life and can have serious national implications. Layoffs, downsizing, and shifting to contingent workers (such as temporary employees) are also responses to demands for flexibility[85] (see box 2-5). By hiring temporary workers, employers avoid paying fringe benefits and can release workers in economic downturns. Such firms have less incentive to train their employees and upgrade their skills because the chance of recouping their investment is small. Indeed, in this respect, the United States already has a very flexible workforce because of the high rate of labor mobility—the willingness to work for different companies.[86] The experiences of Japan and Germany, however, indicate that achieving flexible workers by improving training and skills also results in higher productivity.[87]

Despite the potential value of the new management techniques, information technology can perpetuate the vestiges of the work-flow-control model typical of the industrial era. Electronically

BOX 2-5: A Flexible or Fragmented Workforce?

The workforce IS undergoing a long-term structural change in which workers are more fragmented from the workplace The traditional employee worked for one employer for life with an understood relationship, exchanging loyalty of service for salary, benefits, and career mobility. Today, however, more people work in a variety of settings—home, satellite offices, rented or temporary offices, or the offices of suppliers, partners, or competitors—and through different arrangements with their employers—part-tilme, contractual, temporary, or other individually negotiated arrangements For years, such ad hoc and contingent workers were at the margin of organizations and in the workforce. With the restructuring of organizations and the continued outsourcing, downsizing, and rightsizing that characterizes the current business environment, these workers are Increasingly in the mainstream In the near future, the terms part-time, contract, temporary, and so forth may be replaced by new terms that focus less on working conditions and more on the culture of work and the predominant activities performed by workers and their electronic tools

SOURCE Off Ice of Technology Assessment, 1994

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[85] See L, Lynne Pullman, "Temporary Employees: What Are An Employer's EEO Responsibilities?" *Employee Relations Law Journal*, vol. *18,* No. 3, winter 1992, pp. 533-538. See also G. Pascal Zachory and Bob Ortega, "Workplace Revolution Boosts Productivity at Cost of Job Security," *Wall Street Journal,* Mar. 19, 1993,

[86] See U.S. Congress, Office Of Technology Assessment, *Technology and Structural Unemployment: Reemploying Displaced Adults*, OTA-ITE-250 (Washington, DC: U.S. Government Printing Office, February 1986), page 144.

[87] In what was one of [he most comprehensive studies of its kind, researchers compared the use of CNC equipment in the United Kingdom and Germany. German plants had productivity rates 60 to 130 percent higher than the U. K., and German machinists could reach top-speed production in 2 days on equipment the British machinists took weeks to master. The results were attributed to differences in training. British management practice traditionally is similar to that of the United States. See for example, A. Serge et al., *Micro-electronics and Manpower in Manufacturing: Applications of Computer Numerical Control in Great Britain and West Germany* (Aldershot, UK: Gower, 1983).

monitoring clerical workers, operators, and others working at computer terminals is an example .88 New technologies can track areas of work that have traditionally been immune to monitoring. For instance, the location, status, and activity of workers, delivery personnel, and truckers can be more closely monitored. Another example is employer access to employees' electronic mail to monitor workers. The courts are currentl y evaluating employee and employer rights with respect to e-mail monitoring in a case involving the employees of Epson America.[89] Another example is Cypress Semiconductor corporate software. Every 4 hours it scans manufacturing inventory. If a part remains on the shelf beyond a predetermined time, the software shuts down the inventory system, stops manufacturing operations, and notifies the rest of the company through the corporate network. Other departments within the firm face similar performance standards that are tied to corporate goals.[90]

Information technologies support a broad range of employer-employee relationships. The interaction between employee and employer is one balanced by trust, cooperation, and delegation of authority on the one hand, and monitoring and accountability on the other-, Depending on the work environment, information technology can shift the balance in either direction. Workplaces that develop trust and delegate authority tend to implement information technology with a vision of worker participation and cooperation. However, technology is sometimes used to monitor activity, control behavior, and restrict choices.

A strategy that pursues high-wage, high-skill jobs and fosters cooperative, collaborative work environments will improve both the work environment and the standard of living for employees. Policies that work toward that goal recognize the enabling role that information technology can play. Information technology can also be used to deskill jobs and enhance the employer's ability to control and monitor employees. Information technology alone is clearly not a panacea (o improve the quality of work life, It must be linked to enlightened management and a nurturing culture to be successful.

EFFECTS OF TECHNOLOGY CHOICES IN A KNOWLEDGE-BASED SOCIETY

The age-old adage that "knowledge is power" is nowhere more evident than in a knowledge-based society. Regardless of whether referring to work relationships in a firm, competition in the marketplace, or trading relations among nations, having access to information and the ability to package it for a particular use is a key determinant of winners and losers. While this was always the case, the difference today is the extent (o which knowledge is embedded in information and communication technologies. As a result, choices about these technologies—their design, architecture and structure, or the rules and regulations governing their availability and use—will likely have far--reaching social and economic consequences.

Many of these choices will be irreversible, at least in the short and medium terms. Once a decision is made, technology tends to become firmly fixed to a given trajectory. This pattern is especial - ly evident with networked information technologies, which require vast capital and social investment. Thus, periods of rapid technology

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[88] See for example, U.S. Congress, offic, of Technology Assessment, *The Electronic Supervisor: New Technology, New Tensions*, OTA-CIT-333 (Washington, DC U.S. Government Printing office, September 1987). See also Paul Attewell, "Big Brother and the Sweatshop. Computer Surveillance in the Automated office,'" *Sociological Theory*, vol. 5, 1987, pp. 47-69.

[89] In a case currently in appeal the employees of Epson America Inc. are suing the firm for allegedly copying and reading their e-mail messages. See, for example, Da\ id Bjerklie, "E-mail: The Boss is Watching," *Technology Review*, vol. 96, No. 3, April 1993, page 14.

[90] For example if the purchasing department does not reevaluate cases of customers whose credit was revoked within 6 months, the program restores credit. If a shipper is late for delivery without warning or adequate explanation, the shipment is refused. See Stephen Govoni, "License to Ki II ," *Information Week*, Jan. 6, 1992, page 22. See also Thomas Valovic, *Corporate Networks: The Strategic Use (!/ Telecommunications* (Boston, MA Artech House, 1993), pp. 124-125. For similar examples, see Zuboff, op.cit., footnote 32.

advances, such as are occurring today, provide a rare opportunity for reassessing and redirecting both the nature of a particular technology itself, and the economic and social relationships that are structured around it. Given the significance of the moment, and the potential consequences for winners and losers, consideration should be given not only to what technology choices are being made, but also to the process of how, and by whom, these choices are made.[91]

Economic outcomes and performance have always been greatly affected by those who had control over information and the networks that supported and channeled its circulation. Civilizations spanning centuries have recognized the power of information. For example, the city of Venice—at the height of its economic power—sought to control all trade-related information, going so far as to segregate and conduct strict surveillance over all foreign merchants.[92] Similarly, in the bazaar economies of the Middle East, it is the fierce competition for privileged information that drives events. As described by anthropologist Clifford Geertz:

> . . . bazaaris [participantsl are as interested in making search fruitless for others as they are in making it effectual for themselves. The desire to know what is really occurring is matched with the desire to deal with people who don't but imagine they do. The structures establishing search and those casting obstructions in its path are thoroughly intertwined.[93]

New communication and information technologies have led to the redistribution of economic power, and a shift in economic advantage. The history of the printing press is a case in point.[94] Before the development of printing, inventors retained their ideas under their personal control and did not concern themselves with the prospect of others unfairly profiting from their work. They went from town to town selling their intellectual wares, But once their ideas were printed and made public, inventors lost control and, with it. their bargaining power.[95]

The invent ion of the telegraph also served to redistribute economic power. In the early history of the United States, for example, New York City was able to capitalize on its position as a national in fro-mat ion center to become the center of worldwide trade.[96] News continued to flow faster and more fully in and out of New York than any other city, giving it a strong economic advantage. Southern cities, in fact, communicated faster with New York City than within their own region, a fac -

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[91] As emphasized by Thomas: ". . .it is not enough to claim that technology 'Impacts organizations; it is essential to also ask how and why particular technologies are chosen (or refused) such that they have the impacts [hey do. Second, it is not enough to claim that technology is the simple product of social choice; it is essential to ask how technological alternatives were themselves framed, how the objectives or interests of different organizational actors shape [he range of possibilities considered, and most importantly, how differences in objectives or interests influence the outcomes of change. " Thomas, op. cit., footnote 84. See also Jos Hu igen, "Information and Communication Technologies in the Context of Policy Networks," *Technology In Society*, vol. 15, 1993, pp. 327-338.

[92] As described by Braudel "All trade to and from the Terra Firma, all exports from her islands in the Levant or cities in the Adriatic (c\ en goods travelling to Sicily or England) were obliged to pass through the port of Venice. Thus Ven ice had quite deliberately ensnared al I the surrounding subject economies, including the German economy, for her own profit; she drew her I iving from them, preventing them from acting freely and according to their own lights. " Femand Braudel, *The Perspective of the World, Civilization and Capitalism /.$ I/I- /8 I/I Century*, vol. 3 (Berkeley, CA University of California Press, 1992), p. 228.

[93] Clifford Geertz, "The Bazaar Economy Information and Search in Peasant Marketing," i n Mark Granc)\ etter and R ichard S wedberg (eds.), *The Sociology of Economic Life* (Boulder, CO: Westview Press, 1992), p. 228.

[94] See Elizabeth L. Eisenstein, The *Printing Press as an Agent of Change: Communications and Cultural Transformation In Early Modern Europe*, vols. 1 and 2 (Cambridge, UK Cambridge University Press, 1982).

[95] See Bruce W. Bugbee, *Genesis (// American Patent and Copyright Law* (Washington, DC Public Affairs Press, 1967)

[96] See Ronald F. Abler, "The Geography of Communications," Michael Eliot Hurst (ed.). *Transportation Geography: Comment and Read- In ~* (New York, NY McGraw-Hill, 1874).

(or that engendered increasing resentment in the South for cultural as well as economic reasons.[97] With the invention of the telegraph, however, New York central position in the national market began to erode. The opening of the New York-Philadelphia Line, for example, enabled brokers in one city to learn prices in the other, and to place orders before the market had closed. Similarly, prices in other distant markets, such as western grains, also became items of trade through instantaneous communications.[98]

Current technological advances will likely have equally profound effects. Much of the information and knowledge that once was held personally is now embedded in electronic components and networks, where it can be used to support a wide range of economic activities. Information can be programmed in software that performs work routines; stored in databases where it can be updated, processed, and randomly accessed as needed; or even incorporated into information gateways or communication switches to provide network intelligence. To leverage information for economic advantage today, therefore, requires having some control over the access, uses, and design of the technologies in which it is embedded.

Although new technologies have the potential to expand economic opportunities and ease the nation adaptation to a radically changing economic environment, a successful outcome is not assured. Just as the Venetian merchants and Middle Eastern bazaars tried to secure their economic advantage by controlling information access, the powerful economic interests today are likely to attempt to do the same. Thus, a CEO might adopt new computer-based manufacturing technologies for the purpose of gaining greater control over job-related knowledge. Similarly, manufacturers might seek to lock in customers and suppliers by controlling database access through proprietary network standards. Likewise, vendors of information and communication services might try to 1im-it competition by restructuring access to the information gateway or intelligent network switch.

How, and to what effect, new communication and information technologies will be employed depends to a large extent on the future role of business. Ironically, precisely at the moment when technological advances provide a unique opportunity for the United States to rethink its technological and socioeconomic choices, the locus of decisionmaking is being transferred from the public to the private sector. With deregulation and the shift of network intelligence and control to the user, many network components that are needed to support electronic commerce now fall outside the government's traditional purview. If new technologies are to generate social and economic changes, therefore, many of these changes must originate within the business community itself.

Finding themselves operating in a highly competitive and rapidly changing knowledge-based, global economy, American businesses are now faced with a number of inducements for change. New ways of conducting business will be required. Cooperation may prove more rewarding than competition, and information-sharing more fruitful than information control. Given the socioeconomic changes taking place, businesses that succeed will be those that are flexible in adapting to take advantage of new situations and events.

New information and communication technologies can help businesses to make the necessary adjustments. However, barring fundamental changes in the way businesses operate, new technologies will more likely be used to bolster

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971=+. Robert Albion, *The Rise of New York Port, 1815-1939* (New York, NY: Charles Scribners Sons, 1939); and Al Ian Pred, "Urban Systems Development and the Long Distance Flow of Information Through Preelectronic U.S. Newspapers," *Economic Geography*, vol. 47, October *1971,* pp. *498-524.*

[98] See Kenneth D. Garbade and William L. Silber, "Technology, Communication, and the Performance of Financial Markets 1840-1975," *Journal of Finance*, vol. 33, June 1978, pp. 8 19-983; and Richard DuBoff, "The Telegraph and the Structure of Markets in the United States, 1840-1890," *Research in Economic History*, vol. *8, 1983.*

existing power relationships and perpetuate the status quo.

CRITERIA FOR EVALUATING POLICY OPTIONS

As defined in this report. economic performance entails three essential elements: 1) an increase in the average standard of living; 2) sharing of the benefits of growth among the groups; and 3) sustainable growth. Based on this definition, it is clear that communication and information technologies can contribute to greater economic performance. However, it is also obvious that technology alone is not enough. If the nation economy is to benefit from advanced networking technologies, a number of technological, organizational, and institutional criteria must be met. To the extent that policy measures fail to address al1 of these criteria, the chances for success will be diminished. The outcome" will resemble less a "positive sum game" where all are winners, and more a "zero sum game" in which many tire losers.

| Technological Criteria

Versatile and Open Networks and Applications

Versatile networks and applications will be increasingly critical in a global economy characterized by rapid technological and socioeconomic change and a greater variety in preferences, products, and business processes. To perform well, businesses will have to rapidly reconfigure their networks in response to changing circumstances and market demand. Versatile networks will provide the leeway needed to customize applications and networks to support redesigned business processes and flexible working relationships. With the freedom to mix and match a variety of network components, businesses can use technology to add value and develop new products and services.

Interoperability and Seamless Interconnection

To reap the full economic benefits of communication and information technologies, networks and network components will need to be interoperable and open for interconnection. Such networks can reduce transaction costs, whereas closed systems increase the cost of doing business and can create significant barriers to market entry. Interoperable components provide greater network flexibility, are easier to use, and reduce network costs. These capabilities encourage technology diffusion and equity of access. In addition, interoperable systems provide a standard platform for new components and applications.

Ubiquitous and Even Deployment

If the economic benefits of networking are to be broadly shared, technology must be deployed in a time] y and ubiquitous fashion. Business networks can give rise to a significant "first mover" advantage. Networks benefit from considerable economies of scale and scope; therefore, latecomers may be unable to generate the critical mass of users and services to develop a network. Latecomers will also be disadvantaged because business networking not only requires extensive expertise, but also considerable "learning by doing."

| Organizational Criteria

Technology Deployment Matched to Business Needs

Technology will not enhance business performance if it does not match business needs. Where technology has been introduced independently of a business plan, efficiency and effectiveness have often declined. Experience suggests that technology and businesses' needs will be most closely matched when: 1) business management takes the initiative in applying technology; 2) technology experts understand and practice business principles and participate in developing the technolo-

gy plan; and 3) technology users, at all levels, have an opportunity to influence the technology design and deployment strategy.

Versatile Organizational Structures and Role Relationships

In the future, business organizations and processes will need to be more flexible to take advantage of the new opportunities available in a global, knowledge-based economy. Although information and communication technologies can foster and support such organizational change, they cannot substitute for it. Organizations can more easily employ technology to bring about organizational change when roles and routines are broadly defined, resources (especially knowledge and information) are widely shared, and relationships are flexible and loosely coupled.

Supportive and Adaptive Organizational Cultures

Organizational cultures—like organizational structures—need to be adaptable and innovative if technology is to yield positive economic results. Relationships will need to be defined and reinforced less by contractual arrangements and rigid hierarchical rules and regulations, and more by consensual group norms and trust. Interorganizational relations will need to be oriented as much toward cooperation as competition. In addition, businesses will need to develop new and more broad-based criteria for assessing the performance of both individual employees and the enterprise itself.

| Institutional Criteria

Regulation Geared to National Economic and *Social Goals*

Electronic commerce can only occur once the communication and information networks to support it are widely in place. If these networks are to be deployed in a timely fashion, and with an appropriate architecture that will support improved economic performance, regulatory policy will need to be more responsive to, and consistent with, national economic and social goals. To do so, government will need to broaden its perspectives beyond the communication industry, which to date has been the major focus of regulatory policy, and pay greater attention to the economic impacts of technology choices. In addition, as information and communicant ion technologies converge, greater attention must also be paid to the information, or content, aspects of networking technologies.

Need to Reevaluate and Revise the Marketplace Rules

Rapid advances in information and communication technologies, together with business responses to new technological opportunities and constraints, are challenging many of the traditional notions that have governed the marketplace rules and practices of the industrial era. Tensions in the system have already emerged, especially in the areas of antitrust, intellectual property rights, and other laws governing the ownership and use of information. For electronic commerce to flower, and its benefits to be equitably distributed, the rules governing it will need to be brought into line with the fundamental socioeconomic changes taking place. Given a global economy, a consensus regarding these rules will need to be developed on both national and international levels.

Support for Long-Term Resource Maintenance

It will be essential to maintain national capabilities in a global economy where knowledge and information, capital, and labor are not confined to national borders. Support for science, research and development, and an educated workforce will be important. If, for example, care is not taken to develop and maintain a highly educated and skilled workforce, global networks will likely facilitate the substitution of offshore labor for U.S. workers. Similarly, unless efforts are taken to diffuse and commercialize new information technologies more rapidly, their benefits will be realized elsewhere, On the other hand, if communication and other infrastructure are maintained, global networking can attract foreign capital to the United States.

Regulating the Electronic Enterprise

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In the United States, most communication goals have been pursued by private industry through a regulatory framework. This is a decidedly American approach. While fostering the private sector. this approach provides government some control over the negative impacts of the single-mindedness of the market. [1] It has proved highly successful in the past. However, with the advance of technology and the expansion of competition across industry lines, determining the precise role for regulation and which goals are most appropriately sought in a regulatory arena has become increasingly difficult.

The past 10 years have witnessed the breakup of what was once an integrated and unified Bell telephone system in favor of an increasingly diverse and highly competitive communication/information marketplace. This trend has been fueled by both technology" advances and procompetitive regulatory policies. Since 1959. when the Federal Communications Commission (FCC) approved the "above 890'" decision allowing MCI to offer discount private 1ine service, the advance of competition has continued relat ively unabated. [2] Today, it is marked by the emergence of new wireless technologies, the rise of competitive access providers. and regulatory policies—such as collocation and re-

How these electronic markets are deployed and interconnected, and the rules by which they operate, will be critically important.

[1]Michael D. Reagan, *Regulation: The Politics of Policy* (Boston, MA: Little, Brown, and Co., 1987).

[2]The "above 890" decision greatly liberalized the licensing of private microwave. With the subsequent Carterphone decision in 1969, the FCC also opened the customer premises market to competition. And finally, with the Execunet decisions in 1967 and 1978, requiring AT&T to provide interconnection to MCC, the FCC struck the final blow to the AT&T monopoly by opening long-distance service to competition.

laxed cross-ownership rules—that aim to extend competition to the last stronghold of monopoly, the local exchange.[3]

Business users have been the major beneficiaries of these developments. Competition has not only driven down the costs of business-related products and services; it has also spawned a variety of highly innovative vendors and service providers eager to meet the mounting, and increasing-1 y diverse, communication and information needs of business. Competition has also fostered the unbundling of communication systems and networks, thereby allowing business users much greater flexibility and control.

Despite these gains, however, it is unlikely that the future needs of all businesses will be adequately met through competition alone. Competing providers of communication and information networks will not necessarily volunteer open access to business users. Consider, for example, a situation in which there are three competing local exchange carriers that are vertically integrated. Each may offer an alarm service. There are no guarantees that a fourth alarm service provider will be able to get connected to customers through any of the three carriers. Some form of government regulation may, thus, be required.[4]

In an economy based on electronic commerce, businesses will also require new forms of access. Having access to a variety of advanced communication and information technologies, although necessary, will no longer suffice. Equally important will be the ability to gain access—in real time—to these technologies as they are configured and reconfigured into electronic networks of buyers, sellers, and information that together comprise a "virtual" marketplace.

How these electronic markets are deployed and interconnected, and the rules by which they operate, will be critically important. If they are deployed unevenly, or fail to interconnect, those who can gain access most easily and/or negotiate among them will enjoy a considerable—and in some cases unfair-competitive advantage. The national economy will also suffer to the extent that trade and economic growth are constrained, and resources poorly allocated as a result. To avoid such an outcome, a number of regulatory options could be considered.

OPTION A: Provide for Open Access and Interconnection by Extending Common Carriage Requirements

The principle of common carriage seeks to assure that certain services, considered to be critical to the public, are provided on an open and nondiscriminatory basis to all who are willing and able to pay for them.[5] In the United States, the notion of common carriage was first used to provide farmers equal access to grain elevators. Later it was extended to infrastructure-related services such as transportation and communication.[6] The obligation to provide communication services on a common carrier basis is embodied in the Communications Act of 1934.

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[3] See Robert M. Entman and Charles M. Firestone, "Local Competition: Options for Action, " Forum Report of the Eighth Annual Aspen Conference on Telecommunications Policy, Aspen, CO, Aug. 8-12, 1993.

[4] See for a further description, Francis Dummer Fisher, "Identifying the Potholes in the information Superhighway: A Public Interest Perspective,'" *Telecommunications Magazine, vol. 28, No. 4,* April 1994, p. 23.

[5] The origins of common carriage can be traced back to the Roman Empire when shipowners, innkeepers, and stablekeepers were held accountable for such public service obligations. As the notion of common carriage evolved under English common law, it was applied to public occupations such as "bakers, brewers, cabdrivers, ferrymen, innkeepers, millers, smiths, surgeons, tailors and what-f ingers." Eli Noam, "The impending Doom of Common Carriage," prepared for the Aspen Communication Council's Forum, Jan. 7-9, 1993, Wye River House, Wye, MD, revised July 1993, pp. 4-7. See also William K. Jones, "The Common Carrier Concept as Applied to Telecommunications: An Historical Perspective." submitted to the Federal Communications Commission as Appendix to the Rep] y Comments on International Business Machines Corp. in "Competitive Carriers Rulemaking," FCC Docket No. 79-252 (filed Apr. 4, 1980).

[6] Ibid.

Despite its long tradition, the principal of common carriage, as it applies to communication today, is invoked less frequently and its scope has become more narrowly defined. For example, based on the distinction made in Computer Inquiry 11[7] between basic and enhanced services, value--added network providers—such as system integrators or electronic data interchange (EDI) service providers—are not subject to common carriage principles.[8] The principle of common carriage may erode even further in the future because of the growth of the value-added services market and the emergence of new technologies and providers who are often exempt from common carriage responsibilities.[9] In fact, common carriage may not be economically sustainable over the long term, given the separate systems of contract and common carriage. Contract carriers, having fewer public obligations than common carriers, have a significant competitive advantage. [10]

The waning of common carriage has not been greatly lamented in the post-divestiture regulatory environment. On the contrary, viewing common carriage primarily as a mechanism for encouraging competition, most regulators have seen no need for it in today's more competitive communication marketplace. It is assumed that, with competition, prices will be held in check and government kept to a minimum; it is also assumed that access will no longer be a problem because of multiple and competing providers. Thus, for example, the FCC held—until recently challenged by the Federal District Court-that interexchange carriers competing with AT&T (e.g., MCI, Sprint, etc.) were no longer obliged to publicly file their tariffs.

New service providers have also played a role in restricting common carriage. Not wanting to bear the obligations of common carriage, they have lobbied, often successfully, to differentiate

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[7]The FCC, in its 1980 Computer Inquiry II decision, maintained (he regulation of basic services, but deregulated enhanced services. AT&T could compete in the enhanced services and customer premises equipment markets only by establishing a fully separate subsidiary.

[8]See for a discussion of *this sequence* of events, Ithiel de Sola Pool, *Technologies of Freedom* (Cambridge, MA: Belknap Press of Harvard University, 1983), pp. 220-223.

[9]For example, the Cable Act of 1984 explicitly prohibits the regulation of cable as a common carrier or public utility. Nor is the Internet considered to be a common carrier. Most recently, the Omnibus Budget Reconciliation Act of 1993 amended Sec. 332 of the Communications Act to create a special class [) f commercial mobile services subject to common carrier regulation under Title II of the act. However, it also pro- ~ ides that the FCC can exempt such services from certain obligations, including the tariffing requirement.

[10]Noam, op. cit. footnote 5. The common carrier will not (rely be singled out to pay a subsidy. Unlike the contract earner, he will not have the benefit of being able to select his customers so as to maximize profits or to price discriminate. Despite this unstable situation, the answer is not necessarily to eliminate common carriage obligations and/or to establ ish a mechanism for sharing the costs of subsidy among all providers. The question of whether openness should be imposed by regulatory authority still must be addressed.

[11]See, 203 of the Communications Act of 1934 requires a]] common carriers to file all of their charges for interstate services. Inkeeping with Sec. 203(c), they must not "charge, demand, collect or receive compensation other than the charge specified." In an effort to streamline regulations, the FCC, in 1980, declared that all rates that were filed by nondominant carriers would be presumed to be lawful. In a second report, adopted in 1982, the FCC initiated a policy of forbearance that exempted many resellers from procedural filing requirements. In 1983, it ex - tended this policy to all resellers and ""specialized carriers," leaving AT&T as the (rely company that had to file tariffs. Responding to a law suit initiated by AT&T, the U.S. Court of Appeals ruled in October 1992 to vacate this policy. See David Irwin and Kevin Walsh, "'Understanding the FCC's Forbearance Policy, *Telecommunications*, September 1993, pp. 41-42.

themselves. As in the case of the cable industry, emergent providers have often claimed that, if precl uded from providing content as well as carriage, they will be unable to generate sufficient revenue to deploy new technologies. [12] They emphasize that because they are not the dominant providers, they pose no competitive threat to common carriage.

Notwithstanding the growth in competition, there are a number of reasons for reconfirming the principle of common carriage at this time. Common carriage serves not only to enhance competition, but also to facilitate interconnection and reduce transaction costs. When regulators view common carriage solely in terms of competition, these other values are not sufficiently taken into account.

Recent alliances and proposed mergers among communication vendors and service providers (e.g., AT&T and McCaw) also raise fundamental questions about just how competitive the future communication marketplace will be (see figure 3-1). Such alliances will likely increase, given converging technologies and recent court decisions challenging the constitutionality of regulatory prohibitions of cross-ownership. If the future marketplace is made up of a limited number of vertically integrated firms, instead of a market consisting of a number of independent vendors competing head-to-head with one another to provide a variety of communication and information services, the notion of common carriage will take on a new, prominent significance.

The scope of common carriage may also need to be expanded to include not only the providers of transmission facilities, but also those who provide networking services. The traditional definition of common carriage fails to give due credit to the fact that—in a knowledge-based, global economy—being able to access information from a variety of sources or to transmit it from one point to others is not sufficient (see figure 3-2). It is essential to be able to interconnect in a timely fashion to the entire interactive network of buyers and sellers, together with the information that constitutes an electronic marketplace. Only by operating within such a networked environment are transaction costs minimized and "economies of agglomeration"] [3] achieved (see figure 3-3). Losses due to increased transaction costs will be especially high in an economy in which competing in time and on the basis of information are more important than ever before. Despite the increasingly essential nature of networking services, they are currently presumed to be enhanced services and, hence, excluded from public service obligations.

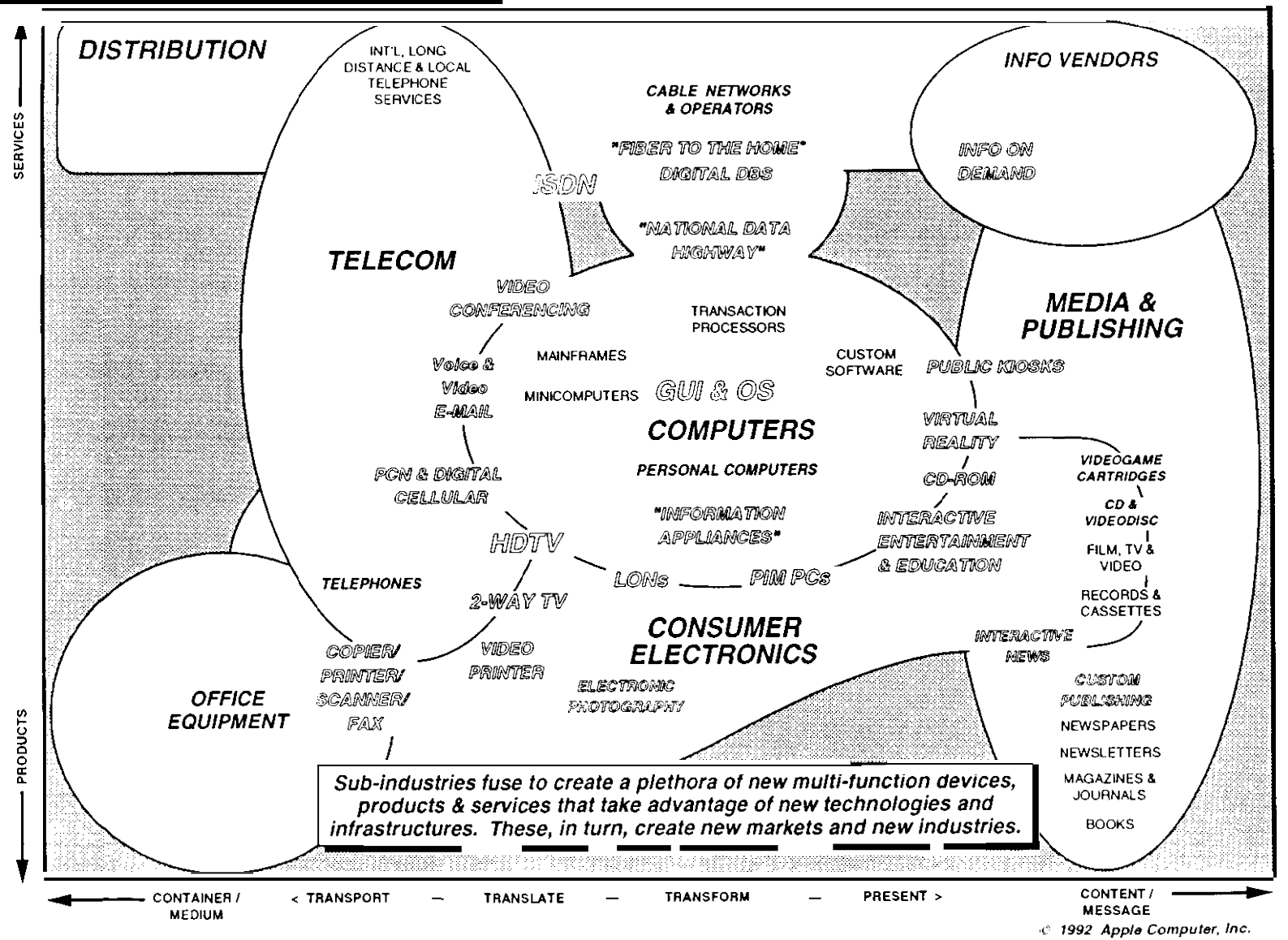
One way of providing for greater access to, and interconnection among, future electronic networks would be to apply common carrier obligations not only to the providers of the "public switched telecommunication network" and to any monopoly conduit providers, but also to all who take advantage of common carrier access to provide value-added services. [14] This would create a mixed system in which all vendors could provide both common and contract carriage, as long as those claiming common carriage in a downstream direction provided equivalent services upstream. All common carriers would provide unrestricted communication services, which are neutral with

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[12] Throughout cable's history, a number Of people have suggested that it be treated as a common carrier, an idea that cable companies have fiercely resisted. In 1970, fore example, the Sloan Commission on Cable Television toyed with the common camera approach, but concluded that if cable companies were given common carrier status, they would not have enough economic incentive to develop their systems. See Ithiel de Sola Pool, op. cit., footnote 8, p. 169. A similar argument is being put forward today with respect to set-top boxes and whether-or not their architectures should be open. For cable's argument as to why it should enjoy first amendment rights, see G. Shapiro, P. Kurland, and J. Mercurio, *Cab/c.speech: The Case for Firs/ Amendment Protection (New* York, NY: Harcourt Brace Jovanovich, 1983).

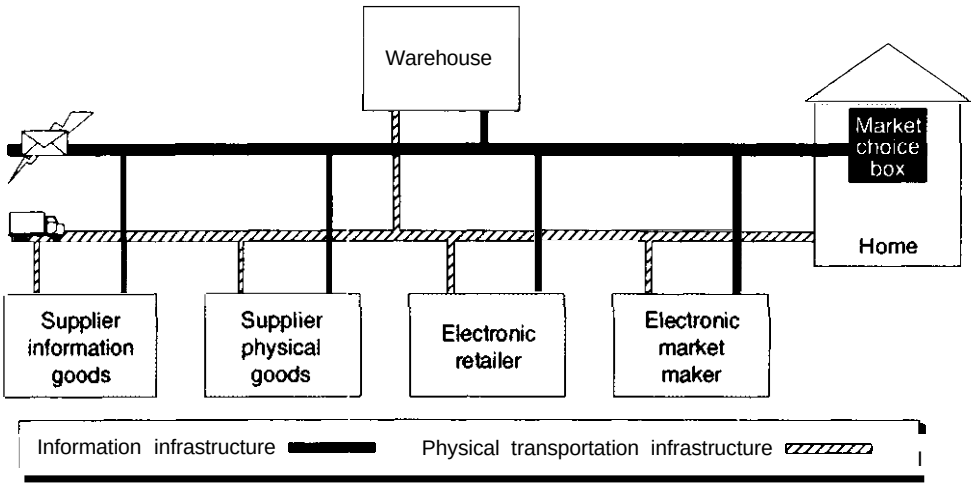
[13] Sometimes re ferred to as "economies of aggregation. "

[14] This option is derived from Eli Noam, "The Superstructure of Infrastructure: Thinking About a Future Without a Public Network," Columbia University Working Paper, Series 1992, #476, pp. 5-7.



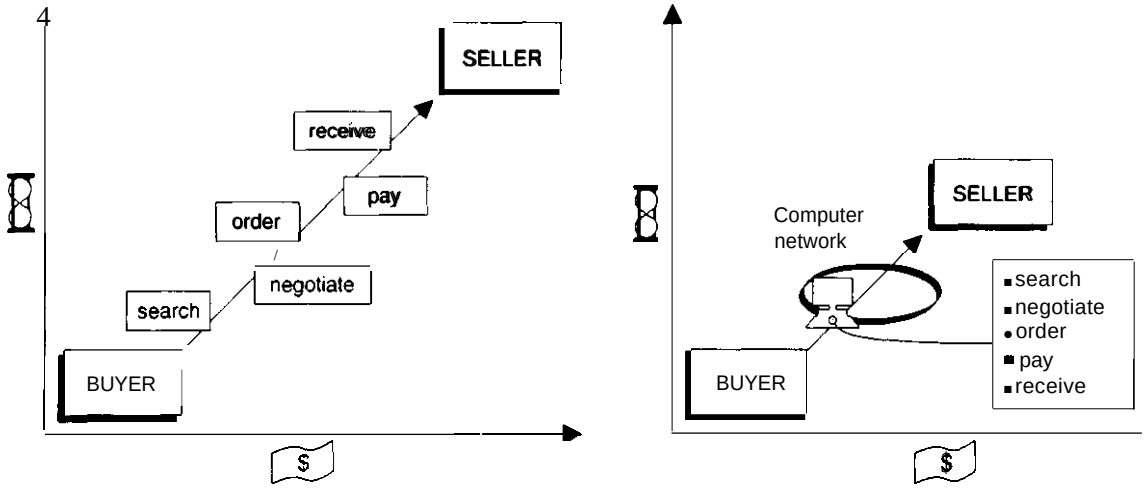
SOURCE: Apple Computer, Inc., 1992. Reprinted with permission.

FIGURE 3-2: Electronic Market to the Home



All markets need to be arranged At the very least, a site needs to be determined where buyers and sellers can come together and space needs to be allocated These arrangements have traditionally been made by middlemen—wholesalers, retailers, financiers, advertisers, etc —who transmit price and product information and establish the link between buyers and sellers Because "market makers" control critical market reformation, they can create bottlenecks With electronic commerce, the market maker might be a value-added network provider, or it might be embodied in technology, as in the case of a home-based "market choice" or "set-top" box

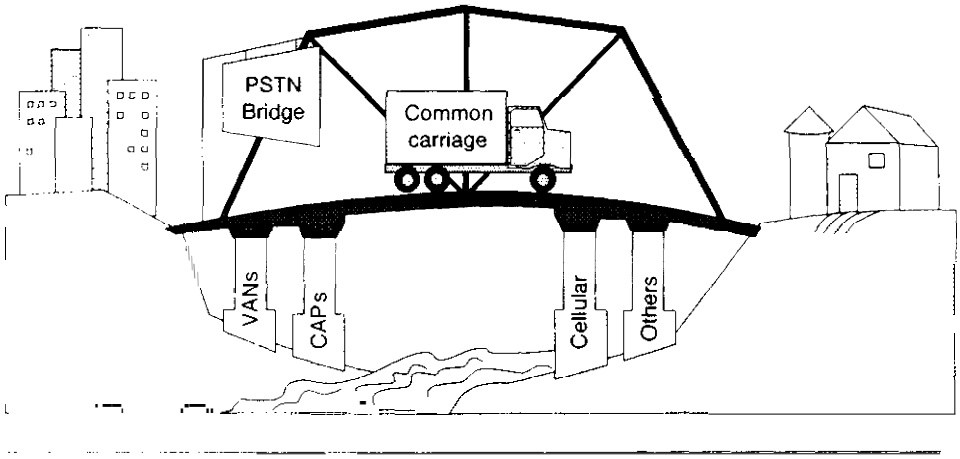
SOURCE Robert Benjamin Consultants, 1994



Much like a medieval fair or a marketplace, electronic networks permit "economies of agglomeration ''—different transaction functions (for example, searching, ordering, and paying) can be done in one place by one provider In the past, this place was, in fact ,a physical space An electronic market accomplishes an analogous agglomeration without being confined by spatial dimensions This agglomeration creates value by reducing transaction costs

SOURCE Off Ice of Technology Assessment, 1994

FIGURE 3-4: Common Carriage "Rights-of-Way"



SOURCE: Office of Technology Assessment, 1994.

respect to content. use, and users. In turn, they would not be held 1iable for the content transmitted over such networks. All private carriers not linked to a common carrier would be exempt from common carrier obligations. In this way, the principles of private property and freedom of association would be held inviolate. Such a system would create common carriage "brights-of-way" that would ● .fLlnction like public roads and highways that pass private property, or like easements that allow public passage through private land. "[15] (See figure 3-4).

one problem with such a solution is that it does not answer the persistent question of how far to extend the right to interconnect. Every information activity-even those wholly between parts of a firm-' 'connects" in some manner to the activities now conducted by common carriers. A telephone instrument connects, for example, but does not require enforced interconnectivity because standards suffice. At the same time, there are networks that do not connect with common carriers—such as cable television—which, some people would argue, should nevertheless be subject to interconnection and openness requirements.[16]

A new common carrier policy, which calls for revamping the existing system of common carriage, might be very difficult to implement and administer. The current system is bound together not only by an extensive history, but also by the entire regulatory structure that has evolved to execute it. Most people tend to associate common carriage not only with interconnection, but also with regulation and---depending on one's perspective—all of the costs and benefits associated with it. Those

[15]As further described by Noam "They would permit the unimpeded transmission of content and services across the various interconnected networks and enable end-to-end connectivity, although not on the entire bandwidth of a transmission, Some rights-of-way would be quite wide superhighways, while others could be narrow but otherwise unobstructed lanes, " Ibid., p. 6.

[16]Fisher, op. cit., footnote 4.

seeking to minimize government regulation would likely oppose a new common carriage policy on the grounds that it would undermine competition and all of the benefits that deregulation has already achieved. On the other hand, those who have viewed common carriage as a way of promoting social as well as economic goals may be unwilling to accept the confines of a pol icy such as this, which would be focused primarily on developing an open network architecture.

Strong opposition to a revised common carriage policy can also be expected from the many stakeholders who have an interest in maintaining the current system. For example, large business users, who can now directly access the local exchange provider's central office switch, will not be willing to lose control over their networks. Nor is it likely that the growing number of value-added providers will be willing to relinquish control over how they price and to whom they prov ide services.

Despite the potential problems of extending common carriage, the time is ripe to consider this option. The present regulatory regime is stretched to its limits. Increasingly, it is the courts, rather than Congress, that must grapple with—and often decide—fundamental regulatory issues. Reformulating common carriage policy would also be timely, given the convergence of technology and the rash of industry alliances and mergers. Unable to predict what services they will be providing in the future—and thus which team they will be on—stakeholders will likely be more inclined to make concessions and agree on what constitutes a level regulatory playing field. If Congress fails to act now to redefine common carriage, its opportunity to do so may be overtaken by the avalanche of technology change, the hardening of stakeholder positions and alliances, and the force of international developments and events.

OPTION B: Promote Business Access to New Technologies and Services by Redefining the Notion of Universal Service

To support technology deployment for business, as well as equitable access to the services and economic opportunities that advanced communication and information technologies offer, Congress might extend the notion of universal service to take into account the social and economic changes taking place today. A revised definition of universal service would need to be based on some agreed-upon criteria for determining which services are essential and should be made available at reasonable costs and on a universal basis. Any expansion of universal service would also need a new financing mechanism because the traditional system based on cross-subsidies is no longer viable in a competitive, deregulated environment. [17]

The concept of universal service has always been a vague term whose meaning was never formally defined. [18] First described by Theodore Vail in the *Annual Report of 1910,* as part of his vision of the telephone industry, the goal of providing universal service was incorporated in its essential intent in the Communications Act of 1934, which states:

> [T]o make available, so far as possible, to all the people of the United States, a rapid, efficient, nation-wide and world-wide wire and radio communication service with adequate facilities at reasonable charges. . .

The mandate for universal service reappeared more concretely in the 1949 law that directed the

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[17] See for a discussion of the problems and a potential solution, Eli Noam, "Net Trans Accounts: Reforming the Financial Support System for Universal Service in Telecommunicatio ins," second draft, Columbia Institute for Tele-Information, Columbia University, New York, NY, September 1993.

[18] As noted b, Gordon and Haring: "The term 'universal service' appears in no public law and there is no public law defining precisely what it means. It is a shorthand expression generally used to refer to [the policy articulated in] Title I of the Communications Act of 1934." Ken Gordon and John Haring, "The Effects of Higher Telephone Prices on Universal Service," FCC office of Planning and Pol icy, Working Paper Series, 1984.

Rural Electrification Administration (REA) to promote nationwide telephone service.

Defining universal service more specifically was not necessary when there was one uniform service provided by AT&T and users essentially had the same communication needs. Businesses and households used the telephone for voice communication in the same ways. The FCC and state regulatory commissions were charged with ensuring that overall costs were equal to overall prices, and that rates and profit levels were kept within a reasonable range regardless of use. To carry out its mandate. AT&T adopted a subsidy system that set prices on the basis of value of use rather than cost of use. [19] These subsidies served well as a means of expanding telephone service. By 1952, AT&T operated almost entirely under a nationwide price averaging system. and by July 1989, 93.3 percent of Americans had a telephone in their home.[20]

With technology widely available and universal service ostensibly achieved, many began to question the rationale behind the traditional telecommunications regulatory framework.[21] Government, it was believed, needed only to ensure that "plain old telephone service" would be affordable to all. This objective could be accomplished either by providing direct subsidies to the poor-as in the case of lifeline service-or by adopting special pricing schemes that capped, or limited, price increases for basic services. These approaches were particularly appealing because they were compatible with the stereotype of a deregulated, competitive. telecommunication environment, whereas the traditional way of financing universal service through cross-subsidies was not. With competition, nonregulated providers, with no obligation to cross-subsidize, could undercut regulated providers by pricing their services closer to real costs.

The issue of universal service could not, however, be settled so easily or permanently. Universal service is a relative term whose meaning is bound to change over time and in different circumstances. In the early years of the United States, the goal of universal service was to provide equitable access to the postal system. The concept had to be redefined repeated] y to take into account changes in the social and economic environment, as well as the development of new means of information delivery-the public school system, mass media, telegraph, and telephone .22 Once again, as the United States moves from the industrial era into an age where knowledge and information play an enhanced role, and the variety of information and communication services is continually evolving, the term "universal service" must be revisited.

Technological advances, realignments and restructuring in the communication and in formation industries, and the Clinton Administration vision for a National Information Infrastructure (NII)[23] are creating a need to reexamine the notion of universal service and the mechanisms for financing it. To this end, for example, the National Communications Competition and Information Infrastructure Act of 1993 (H.R. 3636) would create a joint federal-state board that is charged with assuring universal high-quality telephone

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[19] See Anthony Oettinger, "The Formula 1s Everything Costing and Pricing in the Telecommunications Industry," Program on Information Resources, Center for Information Policy Research, Harvard University, Cambridge, MA, P-88-2. October 1988.

[20] Federal Communications Commission, Common Carrier Bureau, Industry Analysis Division, "Telephone Subscribership in the United States," 1990.

[21] See, for instance, Gerald Faulhalber, *Telecommunications in Turmoil: Technology and Public Policy* (Can] ridge, MA Ballinger Publishing Co., 1987), esp. ch. 3.

[22] U.S. Congress, Office of Technology Assessment, *Critical Connections: Communication for the Future*, OTA-CIT-407 (Washington, DC ~', S. Government Printing office, January 1990).

[23] The Clinton Administration first presented its vision of a new National Information infrastructure in February 1993 in a white paper entitled "Technology for America's Economic Growth: A New Direction to Build Economic Strength " This vision was updated in September 1993 in the NTIA report, "The National Information Infrastructure Agenda for Action."

service and determining the exact nature of the universal services that the telephone company must provide. Similarly, as part of the NII Agenda for Action, the National Information and Telecommunications Administration (NTIA) will hold public hearings on universal service, and work with the state regulatory commissions to "determine how the universal service concept should be applied in the 21st century." Added to these government initiatives are a number of private and nonprofit sector proposals for a new look at universal service.[24]

This growing awareness of the need for updating the notion of universal service is not accompanied by any agreement about what a new vision entails. Some contend, for example, that universal service should apply only to touch-tone digital service; others call for an open platform, allowing for two-way switched access to voice. data, and video service; still others would require two-way switched broadband services to the home bundled with certain kinds of "public" information such as essential health services and/or K-12 educational services. In other cases, the problem of definition has simply been postponed or circumvented through the use of vague references such as "affordable, advanced communication services."

In the current deregulated, competitive market environment, it is particularly important to agree on a definition of universal service and to devise an efficient and equitable means of financing and administering it. Whereas the subsidies that financed universal service in the past were indirect and hidden, future subsidies will be subject to public scrutiny and increasingly will be forced to compete with a variety of other social and economic priorities. Moreover, in a competitive environment, issues will likely arise with respect to how, and to what extent, the responsibility for meeting the goal of universal service should be shared among communication and information providers. Care will be needed to assure that funding mechanisms do not favor some providers over others.

Efforts to redefine a universal service policy befitting the 21st century may also founder if the term "universal service" becomes a catch-all phrase with too many demands placed on it. Many people have already called for a definition of universal service that incorporates the goals of common carriage, privacy, security and survivability, and intellectual property protection. While such goals may have merit, it is not clear that a single policy, which is designed primarily for promoting deployment and enhancing access, will be the most suitable and cost-effective mechanism for achieving all of these objectives. In the past, it was possible to reconcile multiple goals within a single policy framework because there was a single, unified service provider. However, when there are many different players capable of prov iding, accessing, and controlling parts of the infrastructure, a broader based and more highly targeted policy strategy is called for.

While this report cannot provide a definitive answer to the question of what should constitute universal service, it can shed 1ight on the factors-given the growth of electronic commerce—that must be considered when developing an operational definition. OTA identified four major factors:

1. *A greater overlap between business and residential communication needs.* Although the communication needs of businesses and residential users diverged greatly since the breakup of the Bell system, they will overlap more in the future. High capacity, advanced technologies will need to be widely dispersed if vertically integrated businesses downsize and distribute their operations horizontally, and if there continues to be an in-

[24]See, for instance, Benton Foundation/Columbia University Seminar on Universal Service; Susan Haddon, "Extending Universal Service Through the Nil,"' testifying on behalf of the Alliance for Public Technology, at the New Mexico Public Hearing on Universal Service; Computer Professionals for Social Responsibility, "Serving the Community: A Public Interest Vision of the National Information Infrastructure", and Electronic Frontier Foundation, "Open Platform Campaign, Public Policy for the In formation Age."

creased reliance on contingent workers and telecommuting. Under such circumstances, "plain old digital service" will likely prove inadequate as a basic service.[25]

2. *The role of "electronic" transastion costs.* There are economic transaction costs associated with accessing knowledge and information. In an economy in which knowledge, speed, and flexibility are critical for success, how transaction costs are distributed will be very important. As more and more commerce takes place electronically, network architecture (as determined, in part, by those providing networking services and the structure of the market) will be an increasingly important factor accounting for such costs, and technological expertise will become a measure of one ability to bear these costs. To minimize transaction costs, economic players must be able to access and share information both within and across electronic networks (markets). If, in such an environment, all businesses and consumers are to operate on relatively even playing fields, gateways will need to be open, navigational tools will need to be available, and some basic level of systems integration will need to be guaranteed.

3. *The critical role* of *the network administrator and network market information.* Markets do not exist in a vacuum: they must be "made" and administered in one form or another. Administrative tasks might include, for example. ordering, shipping. billing, and funds transfer. To participate in electronic commerce. therefore. economic actors will need much more than simple network interconnection: they must also have access to the substantive in formational and administrative infrastructure that supports market transactions. In most cases, the network administrator will both provide these services and control this information. As electronic commerce becomes more prevalent, the network administrator may gain so much economic leverage that rules and regulations will be required to assure equitable access, not only to networks but also to essential marketing services and marketing information.

4. *The shift of control and equipment costs to the user* The greatly improved performance of computer technologies and their convergence with communicat ion technologies have facilitated the dispersal of intelligence and control throughout communication systems and toward the user, This development will make future information and communication technologies and systems more flexible and versatile. At the same time, however, it will shift some of the equipment costs to the user. If these costs are beyond the means of some people, regulators may need to expand the definition of universal service—and the subsidies that support it—to take customer premises equipment into account. This is, in essence, the kind of policy that the Government of France pursued when it subsidized the distribution of Minitel receivers (see box 3-1).

OPTION C: Relax Antitrust Constraints and Cross-Ownership Rules

A third way the government might seek to meet the technology criteria would be to relax antitrust constraints and allow for greater market entry. If companies were permitted to enter new markets and vertically integrate, they could benefit from greater economies of scale and scope; thus, they would have greater financial and technical resources available for technology innovation and deployment. Although regulatory agencies, the courts, and Congress have been moving in this direction, they have been unable to keep pace with the convergence of technology and the market and

[25] A recent Pacific Bell study, for example, differentiates between four types of telecommuters and their needs 1) voice communicators who do sales, research, and consulting; 2) documents exchangers, such as lawyers, accountants, and real estate agents, who use fax and electronic mail; 3) basic data communicators, including financial managers, computer programmers, and telemarketers who need to access data from host computers; and 4) advanced data communicators, such as engineers, scientists, and industrial designers who require advanced multimedia technologies. As reported in "Pacific Bell Tailors Services to Telecommuters," *Telecommunications Reports*, vol. 59, No. 34, Aug. 23, 1993, p. 11

BOX 3-1: Support for Minitel in France

To assure widespread access and promote the use of information services, the French Government played a major role in the initial financing and deployment of the Minitel system. As of January 1992, 6,000 terminals had been deployed and French consumers and businessmen had access to more than 2,500 videotex services, 70 percent of which were commercially oriented In recent years, Minitel use has begun to shift from personal communications to more business-related services, approximately 30 percent of the time spent online is now devoted to professional applications. Minitel also provides access to major databases, a service that grew 187 percent between 1989 and 1990 This trend toward business applications is also reflected in home use, Increasingly, individuals are using Minitel to carry out transactions such as banking and home ordering Minitel services are, moreover, global in scope, among the countries that can access the system, for example, are Italy, Germany, the United States, the Ivory Coast, Korea, Japan and Singapore,

SOURCE Wallys Conhaim, "Maturing French Videotex Becomes Key International Business Tool," *InformationToday*, vol 9, *No* 1, January 1992, p 28

merger opportunities that technology advances afford.

The regulations that constrained integration in communication industries were aimed at promoting information access and diversity in the marketplace of ideas. These prohibitions were implemented through antitrust law and consent decrees, as well as by regulatory limitations on ownership rights. Thus, for example, in the case of the mass media, the FCC prohibits one entity from owning a newspaper and a TV station in the same market. Until 1984, the government prohibited the common ownership of three commercial AM, FM, or television stations where any two stations were located within 100 miles of the third, and where the primary service areas of any of the stations overlapped. In like fashion, local telephone companies were, under the 1984 Cable Communications Policy Act, prohibited from providing video programming within their service areas. The Modified Final Judgment (MFJ), which led to the divestiture of AT&T, also restricted the line of businesses in which the Regional Bell Operating Companies (RBOCs) could engage (see box 3-2).

This regulatory approach was based on two major assumptions. First, with spectrum scarcity and the potential for monopoly in delivering telecommunications services, regulators acted as though the means of communication were limited and competition had to be promoted and enforced. Secondly, they assumed that each technology-print, telephony, or radio-was technologically restricted in the services that it could provide. Thus, they believed that it was possible to insulate services, as well as service providers, from one another.

With technology advances, both of these assumptions have proven false. For example, new technologies such as digital radio and fiber optics provide many new transmission pathways. Others, such as spread spectrum and high bit-rate digital subscriber lines, are being used to make more efficient use of existing communication channels. Moreover, with the shift from analog to digital technologies, it is increasingly difficult to differentiate among technologies, much less set legal boundaries between communication services.

Responding to these changed circumstances, and viewing these restrictions as impediments to the development of the U.S. communication infrastructure, government policy makers have called for their relaxation or elimination. As part of this strategy, the FCC, for example, adopted an

BOX 3-2: The Modified Final Judgment

A consent decree entered into by the American Telephone & Telegraph Co (AT&T) and the Justice Department in 1982 settled a decade-long antitrust suit. AT&T was broken up into eight companies the reorganized AT&T and seven regional holding companies Local service was assigned to the newly formed holding companies under certain restrictions, developed and administered by Federal District Court Judge Harold Greene The basic premise of this divestiture settlement was that the Bell system's competitive markets should be separated from their noncompetitive monopoly markets in order to prevent unfair monopoly abuses, such as AT&T forcing captive local ratepayers to bear the burden of subsidizing equipment and long-distance service against emerging rivals. The competitive markets had begun with MCI'S challenge to AT&T's monopoly on long-distance service, starting in 1968, and the entrance of competing manufacturers of customer premises equipment

A Modified Final Judgment (MFJ) went into effect at the beginning of 1984, clarifying and expanding the terms of the 1982 consent decree The Bell system's 22 local telephone operating companies (BOCs) were separated from the parent company (AT&T) and grouped into seven regional Bell holding companies (RBHCs), which were entrusted with providing local services The seven regional Bell holding companies (Ameritech, Bell Atlantic, BellSouth, NYNEX, Pacific Telesis, Southwestern Bell, and U S West) were specifically prohibited under the MFJ from entering the three lines of business deemed competitive and therefore assigned to AT&T 1) designing and manufacturing telecommunications network and customer premises equipment, 2) providing Information services (such as electronic yellow pages), and 3) providing long-distance service

The Information-services ban was to prevent RBHCs from using their control over the local loop "bottleneck" to engage in anticompetitive conduct toward other information services providers The prohibition was subsequently amended at the triennial review in 1987, and later reversed and remanded by the U S Court of Appeals for the District of Columbia The other two provisions of the MFJ are the subject of intensifying congressional activity

SOURCE Off Ice of Technology Assessment, 1994

open network architecture (ONA)[26] pol icy requiring that RBOCs unbundle their services and provide competitors equal access to the local exchange. Deregulation, it was argued, could proceed once the local telephone companies were no longer able to leverage their control of local switching to gain an unfair competitive advantage. With the Cable Act of 1992, Congress also authorized the telephone companies to enter into the cable business, a decision that gained legal support in the recent federal court decision ruling it unconstitutional to prohibit Bell Atlantic Corp. from providing cable service because it violated

[26]Open Network Architecture (ONA) is the network design conceived by the FCC to assure that competitive service providers could gain equal access to exchange carriers' networks for the purpose of implementing new services. The underlying idea is that, if the Bell Operating Companies pro\ ide their competitors equal access to their networks, they will no longer need to be subject to line-of-busInc~s restrictions. In November 1993, the FCC ruled that, to fulfill this requirement, the Bell Operating Companies would have to allow competitors to collocate their operations at the telephone companies' central sw itch ing fac ilities.

the company's first amendment rights.[27] There are a number of bills pending in the 103d Congress that would, to a greater or lesser extent, free the Bell operating companies from line-of-business restrictions. The Clinton Administration has generally favored these developments, announcing its own intent to work toward the eventual elimination of all cross-ownership regulations.[28]

Despite these initiatives, policy makers have been hard pressed to keep abreast of technology advances and market developments. Taking advantage of technology convergence and the globalization of the communication marketplace, for example, many companies have found ways to proceed with their long-range plans to develop the technological and financial capabilities to provide advanced, integrated services. Similar to what is occurring in other sectors of the economy, communication and information technology vendors and service providers are entering into a rash of new mergers, alliances, and joint ventures that often span the globe. Virtually every kind of information-related business is getting into the act, pairing up with partners that a few years ago would have been considered unlikely. Thus, joint ventures and alliances are occurring between cable and telephone companies, cable companies and internet providers, and telephone companies and providers of electronic data interchange services. Equally striking is the extent to which this integration is occurring at the international level. The international telecommunications market is currently comprised of five major multinational groupings (see figure 3-5).

This trend toward integration will likely continue in the future as a result of the mutually reinforcing conditions driving it. These include, for example:[29]

- the very high costs and uncertainty entailed in performing R&D and the need to share resources and risks;
- the rapidity of technology change and the need to monitor, explore, and strategically exploit new markets and product niches;
- the need for technology transfer among complementary and converging technologies;
- the need for interoperability in networked systems; and
- the need to circumvent trade barriers and regulatory policies.

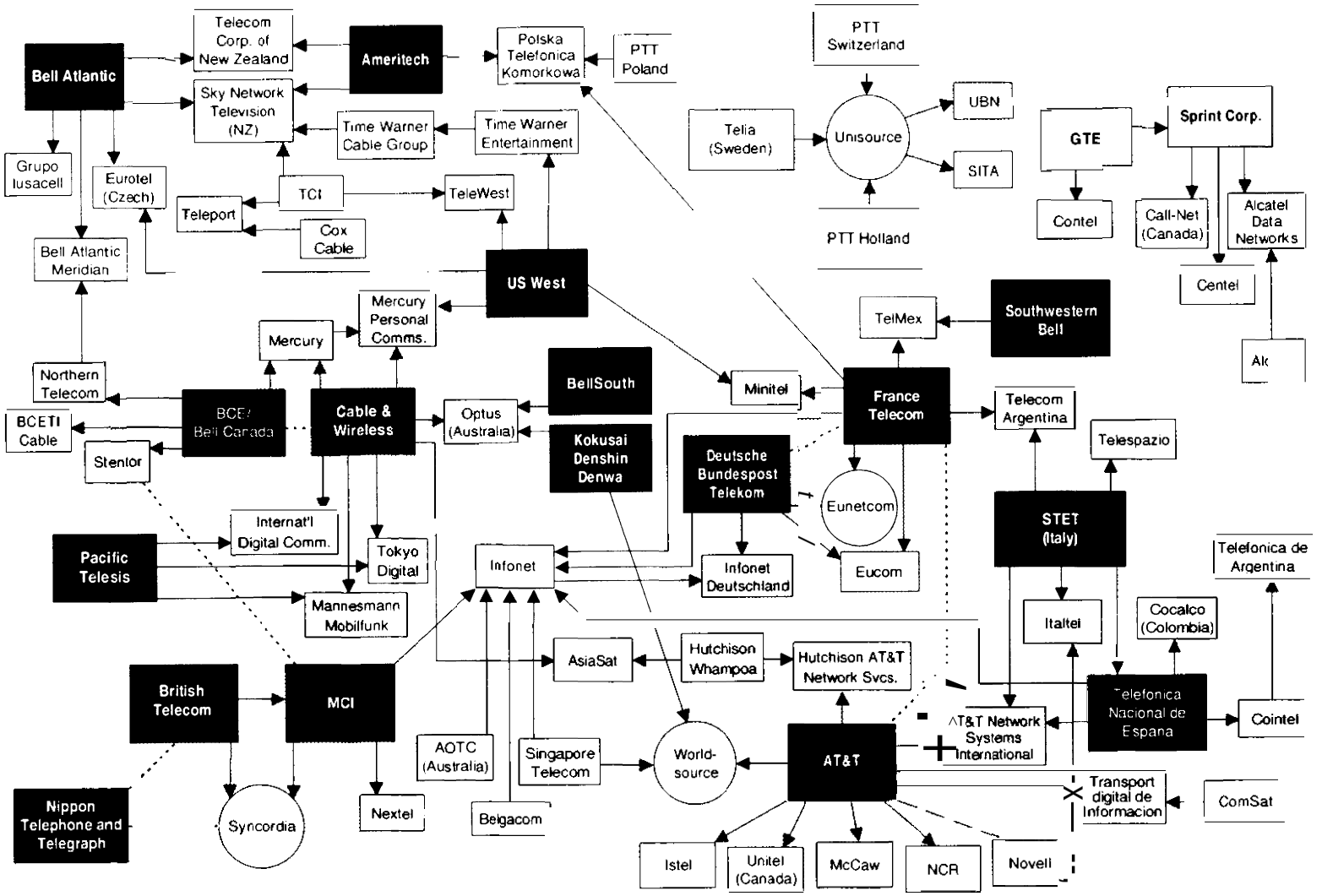
Acknowledging such imperatives, Raymond W. Smith, Chairman of Bell Atlantic Corp., claimed that the companies that will be most successful in delivering future interactive multimedia services will be those that can "put together the right combination of programming, packaging, and distribution platforms," and that recognize

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[27] On Aug. 24, 1993, U.S. District Court for the Eastern District of Virginia ruled that the statutory prohibition barring telephone companies from providing viewer programming directly to subscribers in their service areas is unconstitutional. The Justice Department subsequently asked the court to clarify its decision by limiting its scope to the plaintiffs in the case (Chesapeake and Potomac Telephone of Virginia and Bell Atlantic Telephone Corp.,) and to enjoin enforcement solely of section 533(b) of the Communications Act, rather than the entire section. The other Bell regional holding companies, as well as GTE Corp. and Rochester Telephone Co., have tiled a joint motion to allow them to intervene in the case, on the grounds that the court's decision should apply to them as well. In a subsequent ruling, U.S. District Judge T.S. Ellis 111 "reluctantly" denied the joint motion, thereby limiting the scope of its decision to the Bell Atlantic case. The other companies may still file lawsuits on their own behalf. See "Judge Rules Video Programming Decision Applies Only to Bell Atlantic Companies, Denies Intervention Plea," *Telecommunications Reports*, *vol.* 59, No. 40, Oct. 4, 1993, pp. 4-5.

[28] According to Administration spokesmen, the Administration will try to put together such legislation by the end of 1994. See "White House Hope Telecom Bill Will Pass in 1994," *Telecommunications Reports*, *vol. 59, No. 46, Nov. 15,* 1993.

[29] See, for discussions, John Hagedom, "Strategic Technology Alliances and Modes of Cooperation in High-Technology Industries,"' in Gernot Graber (cd.), *The Embedded Firm: On the Socioeconomic of Industrial Networks* (London, UK: Routledge, 1993), pp. 116- 137; Peter Cowhey and John Aronson, *Managing the World Economy: The Consequences of Corporate Alliances (New* York, NY: Council on Foreign Relations, 1993); and Jay Blumer, *The Role of Public Policy in the New Television Marketplace* (Washington, DC: The Benton Foundation, I 990).



SOURCE: ARC Associates, 994.

that "market leadership in the multimedia era will require capabilities that transcend any one industry segment."[30]

Pointing to this rapidly changing business environment, many in industry argue that, if they are to participate, the government must move quickly to eliminate the remaining cross-ownership rules and line-of-business restrictions. They claim that deregulation would not only encourage greater technology innovation and deployment; it would also create new opportunities for growth and employment.[31] Not surprisingly, the RBOCs are among the chief proponents of this point of view. They contend that regulatory safeguards to assure local competition are unnecessary, citing the development of wireless technology, the growing success of competitive access providers, and collocation rules as evidence that sufficient local exchange competition already exists.[32] This perspective is increasingly shared by those in the cable industry who are now looking to partner, rather than to compete, with the local exchange telephone companies.[33]

Others are less sanguine. While agreeing that local competition may emerge over the long term, they contend that it is currently insufficient, and call on government to retain safeguards against the potential abuse of the persistent bottleneck in the local exchange. As a prerequisite for lifting restrictions, they would require a test to prove that competition exists and that customers have real choices. It is a mistake, they argue, to equate competition with deregulation, adding that even where competition exists, government action may be required to assure that competition continues to flourish in an environment of rapidly changing technology. These views are prevalent among long-distance carriers, competitive access providers, value-added network providers, and business users who depend on the local exchange for access.[34]

Parties have aligned differently regarding the prospect of large-scale mergers cutting across traditional industry lines. For example, while favoring cable/telco integration, the RBOCs looked askance at the proposed AT&T-McCaw Cellular merger. They claim that the creation of a vertically integrated company that can bypass the local exchange will serve only to undermine competition.[35] On the other hand, long-distance carriers and/or wireless operators, who advocate a slow pace in relaxing the MFJ prohibitions, have generally welcomed mergers that involve themselves. In these cases, they minimize the prospect of anticompetitive impacts, pointing out that it is almost always the local carrier that hauls cellular traffic to the interexchange carrier's switch.[36]

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[30] As cited in "Marketing, Services Seen as New Battleground for Telcos, Cable TV as Barriers to Entry Fall," *Telecommunications Reports*, vol. *59*, No. *39*, Sept. 27, 1993, p. 21.

[31] According to a recent study conducted on behalf of the RBOCs, the lifting of the line-of-business restrictions would generate approximately 3.6 million high quality jobs. As reported in *Telecommunications Reports*, vol. *59*, No. *48*, Nov. *29, 1993*, p. 14.

[32] See, for discussions, "Local Competition Debate Dominates Senate Hearing; Inouye Calls for Third Hearing, Suggests Clinton Official Attend," *Telecommunications Reports*, vol. *59*, No. 37, Sept. 13, 1993, pp. *3-6;* and "Weiss Says Entry Barriers Are Blocking Info Highway," *Telecommunications Reports*, vol. *59*, No. *47*, Nov. *22*, 1993, pp. 37-38.

[33] Cable companies, which are highly leveraged, are looking to the telephone companies for the capital they need to develop advanced network platforms.

[34] "Commenters Urge Safeguards for Inter-LATA Entry," *Telecommunications Reports*, vol. *59*, No. 37, Sept. 13, 1993, p. 30; and "AT&T Wants Stiff 'Competition' Test for RHC Entry Into Long Distance: RHCS Urge Immediate Relief," *Telecommunications Reports*, vol. 59, No. 44, Nov. 1, 1993, pp. 16-17.

[35] See, for a discussion, "Proposed AT&T- McCaw Cellular Merger Revives Significant Questions About Local Loop Competition," *Telecommunications Reports, vol. 59*, No. *34*, Aug. 23, 1993, pp. 3-7.

[36] Ibid See also "AT&T Says McCaw Merger Won't Hurt Competition," *Telecommunications Reports*, vol. *59*, No. 38, Sept. 20, 1993, pp. 22-23.

Of course, no merger has brought these issues into greater focus than the short-lived deal between Bell Atlantic, TCI, and Liberty Media Corp.[37] This merger, much larger than any other telco/cable agreement to date, was outlined in a letter of intent dated October 12, 1993. It would have given rise to one large Bell Atlantic company with a combined cable and telephone subscriber base of 22 million customers.[38] Seeking to allay any antitrust concerns, John Malone, President and CEO of TCI, promised that the company's full-service networks would maintain an open architecture. Many remained skeptical, however. They feared that instead of the hoped for competition between cable and telephone companies there would be the reincarnation of monopoly. A number of consumer-oriented groups were concerned that consumers would be forced to pay higher prices for less access.[39] On the other hand, the proposed merger received support from key players, including the tacit approval of the Administration, on the grounds that it would lead to greater infrastructure investment and deployment.[40]

In sorting out precisely where to draw the line among businesses, it is important to remember that there are no easy or permanent solutions. If nothing else, the recent merger activity should be a reminider that the technology and market environment is in a state of flux. Thus, the policies and policymaking processes will need to be flexible and devoid of ideology. In addition, choices about the communication market structure will necessarily affect the appropriate rules for interconnection and the definition of universal service. Equally important, policy choices will need to take into account the globalization of the communication marketplace; hence the need to look also to the international arena in developing potential solutions.

Market regulation, moreover, cannot solve all bottleneck problems. There will always be bottlenecks; they will simply occur in different guises and places depending on the situation. In a highly competitive market environment, for example, the sheer number and variety of providers and networks may present a bottleneck, requiring the development of gateways and navigational tools. Even on the Internet,[41] often characterized as the ultimate in democratic networking, bottlenecks are likely. In such a loose and user-oriented environment, the organizational culture and the need for special skills will constitute a bottleneck to usage, at least for some. Administrative bottlenecks will also be likely when increased usage requires making decisions about access priorities, payments and settlements, and rules governing security and intellectual property rights.

[37] See, for discussions, "Bell Atlantic's Smith Defends Proposed TCI Merger Against Charges of Anticompetitive Behavior," *Telecommunications Reports*, vol. 59, No. 44, Nov. 1, 1993, pp. 1-s.

[38] "Blockbuster Proposed Merger Between Bell Atlantic, TCI Liberty Media Raises Media Concentration Issue," *Telecommunications Reports*, vol. 59, No. 42, Oct. 18, 1993, pp. 3-8.

[39] As Mark N. Cooper from the Consumer Federation pointed out: "To believe that these two companies would suddenly be converted into vigorous competitors requires a leap of faith that responsible public policy makers cannot make. In truth, the merger can (rely make matters worse." As cited in "Metzenbaum Plans Bill To Change Cable TV Act: Allen Questions Pending Bell Atlantic-TCI Merger," *Telecommunications Reports*, vol 59, No. 47, Nov 22, 1993, pp. 16-17.

[40] For instance Bell Atlantic spokesmen said [hat the merger would lead to a $15 million investment over planned capital expenditures for a 5 year period, while TCI claimed that it would spend $1,9 billion over the next 4 years building regional fiber optic "'hubs.'" [bid., p. 2.

[41] The Internet is a "network of networks" that connects users in all parts of the United States and around the world. Users communicate using electronic mail, retrieve data stored in databases, and access distant computers. See also ch. 4, box 4-5.

Cooperative Networking

4

Americans often turn to each other for help. Early in the nation's history, Americans were already well known for forming associations. Visiting the United States in the mid- 1800s, Alexis de Tocqueville noted that:

> . . . Wherever at the head of some undertaking you see the Governmnt of Francc, or a man of rank in England, in the United States you will be sure to find an association. [1]

Although cooperative action is instinctive for Americans, it often requires encouragement and, at times, a decisive push. People may not know of others with common interests, and when they do, efforts may be needed to establish a basis for trust. Or people may fail to cooperate because they are unaware of common solutions to their problems. Often the costs of cooperating may seem too high and the benefits too uncertain. Similarly, the cost of cooperative for an individual may not reflect the larger group benefits to be gained, so everyone holds back.[2]

The government may serve as the catalyst for cooperative ventures, especiall y when major social benefits are at stake. Government might provide information and expertise, broker relationships among actors, or extend limited, temporary financial support. The cost of such intervention will generally be small

If small and medium-sized businesses are to share the benefits of cooperative research ventures, government may have to become more active on their behalf.

[1] Alexis de Tocqueville, *Democracy in America* (1963 ed.), p. 110. For a comparative perspective, see Robert Wuthnow (ed.), *The Voluntary Sector in Comparative Perspective* (Princeton, NJ: Princeton University Press, 1991).

[2] For a discussion of group formation, see Mancur Olson, *The Logic of Collective Action: Public Goods and the Theory of Groups* (Cambridge, MA: Harvard University Press, 1973). For a discussion of the motives for cooperation, see Robert Axelrod, *The Evolution of Cooperation* (New York, NY: Basic Books, 1984).

compared with the potential gains. Policies based on such a strategy are also in keeping with the American preference for private, pluralist solutions.[3] By supporting cooperate private sector efforts, the chances are less that government action will interfere with the market.

Communication-related, networked activities are suited for this kind of government support. Being interdependent, net works require cooperation. Cost-sharing is often necessary because networking is capital intensive. In addition, although financial support may be needed in the early stages of network development and deployment, its need is 1imited because networks are general 1 y self-sustaining once they reach a critical mass. A number of policies based on a cooperative strategy might be adopted to provide for versatile and open networks, as well as widespread deployment and equitable access.

OPTION A: Foster the Development of Cooperative Networking Services To Support Electronic Commerce

Traditional regulatory policies may prove inadequate in assuring the rapid, even, and ubiquitous deployment of advanced networking technologies. Some form of demand pooling, cost-sharing, or cooperative arrangement among users may be required. Government could support such efforts in a variety of ways.

Some industrywide organizations already operate cooperative joint networks. The insurance industry, for example, supports a number of cooperative efforts. The 10-year-old Insurance Value Added Network Services (IVANS) is a nonprofit organization that links agencies and property/casualty companies to promote efficient, low-cost, insurance-related electronic communications.[4] Over the past 10 years, members and subscribers have saved more than $72 million on voice and data communication services based on discounts of up to 48 percent. Even greater savings are expected in the future as the network expands to include the life/health insurance businesses. A second network, RINET (the reinsurance and insurance network) operates globally to foster the development of international electronic data interchange (EDI) standards for reinsurance, and to provide EDI service support for its members. RINET members are able to reduce their EDI costs by taking advantage of centralized resources that are specifically designed to meet the needs of a wide range of users with different levels of expertise. American subscribers are also eligible for rate reductions through IVANS.[5]

Firms in the textile industry are cooperating among themselves and with the federal laboratories to develop industrywide networking. In March 1993, leading firms from the textile/apparel industry joined with eight Department of Energy (DOE) laboratories to create the American Textile Partnership (AMTEX), a Cooperative Research and Development Agreement (CRADA) as provided for under the Technology Transfer Act of

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[3] In the United States, the support for voluntary, private sector associations was reinforced by a general suspicion of the state and preferences for market-based solutions. Although these values were often supported more by rhetoric than practice, they were greatly popularized by the progressive movement, which had its heyday in the late 1800s just at the moment when industrialization was primed to take off. Whereas in many other countries government actively sponsored the growth and development of business, in the United States industrial development was managed, directed, and financed primarily by the private sector. See, for discussions, Annemarie Hauch Walsh, *The Public's Business: The Politics and Practices of Government Corporations* (Cambridge, MA: The MIT Press, 1978), pp. 25-26; and David Vogel, "Government-Industry Relations in the United States: An O\ erview, " in Stephen Wi lks and Maurice Wright (eds.), *Comparative Government-Industry Relations* (Oxford, UK: Clarendon Press, 1987), ch. 5.

[4] See Charles C. Ashley, "IV ANS: A Vigorous Decade, " *Best's Review*, May 1993, pp. 67-72.

[5] RINET is also linked to the Brokers and Reinsurance Markets Association, the Reinsurance Association of America, and the London Insurance Market Network through Joint Venture, an in itiative that seeks to develop a common set of standards for the transmission of reinsurance information based on the U. N. Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT) conventions. RI NET will work with I VANS in the United States to implement these standards. See Kathrine Huelster, "ED] Initiative Launched for Reinsurers and Brokers," *Best's Review*, May 1993, p. 68.

1986.[6] One of the five undertakings included in this collaborative venture is the Demand Activated Manufacturing Architecture (DAMA) project. This project will use the expertise, technology, and demonstration/prototyping capabilities available in DOE's national laboratories to design, develop, and implement an information technology infrastructure for the 26,000 companies comprising the textile industry. Using this network to share and access industrywide production and sales data, the industry hopes to enhance its competitive position in the global marketplace.[7] The federal laboratories are considered essential to the program not only because of their expertise, but also because they are nonpartisan, allowing an industrywide focus. In addition, the project will benefit from $25 million in funding from DOE.

Several major banks are also taking advantage of the opportunity to establish CRADAs with the federal laboratories.[8] Through the Financial Services Technology Consortium, a nonprofit organization that includes a number of universities, these banks will collaborate with four major laboratories to develop standards and technologies to support online banking. Priority items include network security and the response-rate and bandwidth issues associated with large-scale file transfers. For banks, the cost of participating is $30,000. Project funds will be matched by federal funding.[9]

To date, small and medium-sized firms have benefited far less from these kinds of collaborative initiatives. These businesses often lack the financial and administrative resources and leadership necessary to rally participants, locate the expertise, package a project proposal, and pilot it through the appropriate channels to gain government approval. Even large businesses, for example, have found that the road to a CRADA is costly and paved with bureaucratic obstacles. [10] Moreover, with the laboratories' focus on advanced technology applications, they may be unsuited to meet small businesses' most pressing needs. Small businesses may also have less incentive to work together than large ones, Because there are fewer to share the rewards. a few large businesses are more likely to see a return on their investment—and hence take action—than are many small businesses. [11]

If small and medium-sized businesses are to gain the benefit of collaborative networking. incentives and brokering will be required. In some cases, large firms within an industry can provide sufficient leadership. However, where the sharing of proprietary data is involved and there is a potential for small firms to become "locked into" a net-

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[6] Included in the industry consortia, for example, are Cotton Inc., $(TC)^2$, and the National Textile Center. For discussions, see Jack Schultz, "A Look at AMTEX, " *Stores*, May 1993, p. 10; "AMTEX Announces First Funding and Project," *Textile World*, vol. *I* 43, No. 9. September 1993, Lawrence A, Christiansen, Jr., "CWP. QR and now AMTEX," *Textile World*, vol. 143, No. 4, April 1993, p. 15.

[7] The proposed tasks include 1) development of the [~\ erall concept and vision for the industry's demand-activated manufacturing architecture; 2) development and implementation of a communication infrastructure to serve as the backbone; 3) definition and implementation of industry access tools; 4) definition and implementation of industry analysis tools; 5) definition and implementation of an "industrywide" model; and 6) public outreach to the industry.

[8] Among the banks are Citibank, Chase Manhattan, Chemical Bank, Bank of Boston, Bank of America, Huntingdon Bancshares of Columbus, OH, and Nationsbank of Charlotte, NC. The labs participating include Lawrence Livermore, Los Alamos, Sandia, and Oak Ridge National Laboratories. See "Banks Eager To Participate in Interactive Information Highway," Meal/a *Week*, Jan. 19, 1994, p. 8.

[9] Ibid.

[10] See, for a discussion, U.S. Congress, Office of Technology Assessment, *Defense Conversion: Redirecting R&D*, OTA-ITE-552 (Washington, DC (J. S. Government Printing Office, May 1993), esp. ch. 4. As the OTA study points out "Though there are no good statistics on how long it takes to put a CRADA into operation, nearly everyone involved, inside the agency and labs and in the private sector, agrees that the process has been much too slow, especially early tin." Ibid., p. 107.

[11] Olson, op. cit., footnote 2

work, working through a third party may be preferable.

To help small businesses establish better commercial networking arrangements, the government could set up a program modeled after the Rural Electrification Administration (REA). Established in 1935 under the Roosevelt Administration, the REA was designed to help extend electricity to rural areas by providing low-cost loans to local electrical cooperatives. Although the government first sought to encourage private and municipal utilities to provide such service, these groups continued to bypass rural areas, explaining that demand was too low and the technical problems too high. The REA, in contrast, proved quite successful in achieving the goals of universal, high-quality service and rapid deployment at low rates. Although fewer than 12 percent of all farms had electricity in 1935, by 1959, 96 percent were equipped. Few rural cooperatives defaulted because usage rose so quickly.

Having completed its mission by the late 1940s, the REA assumed the task of deploying telephones to rural areas, which were still largely unserved at the time. [12] By providing low-cost loans and technical support, the REA was able to achieve high-quality, state-of-the-art telephone service, working mainly with the "independents." REA pioneered technology to reduce the size of wire, its installation cost, and its vulnerability to lightning and icing. REA borrowers replaced party lines with one-party service. Rates were standardized and comprehensive "area" coverage was provided. By 1980, 94 percent of all rural households had telephone service. [14]

Adapting this model to current needs, the government might establish a program to support the pooling and sharing of networking resources among small and medium-sized businesses that lack the financial and technical wherewithal to fully benefit from electronic commerce. Taking advantage of the flexibility inherent in networking technologies, such a program could support virtual small-business communities rather than geographically based rural areas. [15] At a minimum, a government program might assist business-users in pooling their demand for services to reduce their costs and enhance their market power. Or, it might provide assistance in developing nonprofit third-party providers catering to small-business needs and/or the establishment of small-business service cooperatives. On an even greater scale, a cost-sharing program could link technology deployment and technology transfer, helping small and medium-sized businesses to set up shared networks and networking services and use them to their economic advantage.

Such a program might be administered under the auspices of the Department of Commerce's National Institute for Standards and Technology (NIST) through the seven regional Manufacturing Technology Centers (MTCs) (see box 6-1 in chapter 6) and the Manufacturing Outreach Centers that were established under the 1988 Trade and Competitiveness Act. These centers, which are supported by federal, state, and private funds, were designed to assist small and medium-sized businesses by providing them with technology analysis, information, and access to management,

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[12] Legislation permitting REA to play such a role was first introduced in Congress in 1945, where there was considerable support. However, strong opposition from the independent telephone companies and private utilities prevented its passage. A compromise bill was passed in 1949 allowing REA to form rural telephone cooperatives as had been used in rural electrification, but charging them to give the "independent" telephone companies the right of first opportunity. As it turned out, most REA loans went to the independents. Some telephone cooperatives were also undercut by Bell companies, which moved quickly to offer modem services in contested areas.

[13] Don F. Hadwiger and Clay Cochran, "Rural Telephones in the United States," *Agriculture History*, vol. 58, 1984, p. 232.

[14] U.S. Department of Agriculture, Rural Electrification Administration, *A Brief History of Rural Electric and Telephone Programs* (Washington, DC: USDA, REA, 1989), p. 7.

[15] For a discussion of how this concept might be applied to rural areas, see U.S. Congress, Office of Technology Assessment, *Rural America at the Crossroads: Networking for the Future*, OTA-TCT-471 (Washington, DC: U.S. Government Printing Office, April 1991).

financial, marketing, and training services, With their expertise in manufacturing, telecommunications networking, and business, the regional MTCs are well situated to carry out such a program. They are also linked electronically so they can operate, and draw on other resources, on a nationwide basis. The funding for such programs might well be available because the federal budget for these manufacturing outreach programs is slated to increase from $32.2 million in fiscal year 1994 to $90.2 million in fiscal year 1997.[16]

Although a government-sponsored networking program for small and medium-sized businesses would promote technology deployment and small business development, it would not be equally well received by all. In the past, private and municipal electric utilities and independent phone companies viewed REA as a threat; today, value--added network service providers might react to a similar program in the same way. Large businesses that partner with small businesses might also be opposed. Large business can generally call the tune: for example, they have sometimes made doing business contingent not only on the use of electronic data interchange or computer-integrated manufacturing, but also on the use of a preferred value-added network provider. By linking smaller firms into their own networks, large businesses are often able to exploit the combined transactional data to their sole advantage. If small and medium-sized businesses were served by providers that were especially attuned to their needs, they might be able to strike better bargains for themselves.

OPTION B: Provide Greater Incentives and Support for Cooperative Standards-Setting Efforts

Standards are essential to the open access and seamless interconnection required for electronic commerce. To promote these objectives, the government might play a greater role in fostering the cooperative development of standards. Government can undertake standards research, identify critical standards, help to lay out a standards agenda, create appropriate incentives, and, when necessary, provide financial support, [17]

Standards are generally established in three ways. They are set in the marketplace on a de facto basis; developed through consensus in formal standards-setting bodies; or established through administrative or regulatory processes. Each process has its unique strengths and weaknesses. and each is more effective in some circumstances than others (see box 4-1).

For many electronic commerce standards, the voluntary consensus process will work best. By reducing transaction costs and facilitating information exchange, standards organizations can often outperform the market in coordinating standards activities. [18] Such an outcome can be expected when—as in the case of many networking and product data exchange standards—there are significant network externalities; there are repeated interactions among the players involved; the level of uncertainty is high: and information exchange is complex (see box 4-2). [19]Consensus-based processes are generally more effective than

'6W'11 ILepkow ski, "NIST Accelerates Its New Mission Under First Woman Director," *Chemical and Engineering News*, Sept. 6, 1993, p. 20.

[17]See Jonathan A. Morel I et al., "Improving the Deployment of Open System Technology: Lessons From the Manufacturing Automation Protocol," Industrial Technology Institute, Ann Arbor, MI, Sept. 17, 1992.

[18]Economic research and analysis on standards and past experience suggest that this market approach is most likely to result in standardization \\ hen all interested parties 1) prefer the same standards, 2) have something positive to gain from standardization; and 3) hav e adequate information about the intent of other parties. This optimal situation occurs only rarely, however. See Stanley M. Besen and Garth Saloner, "Compatibility Standards and the Market for Telecommunications Services," The Rand Corp., February 1988; and Stanley M. Besen and Leland L. Johnson, "Compatability Standards, Competition, and Innovation in the Broadcast Industry," The Rand Corp., November 1986.

[19]See Oliver E. Williamson, *Markets and Hierarchies: Analysis and Antitrust Implications* (New York, NY: The Free Press, 1975).

BOX 4-1: Standards Universe: Type of Standard by Goals

The three kinds of standards and three kinds of standards processes can be paired to form a matrix that scopes the standards universe and the standards-setting process (see figure 4-l),

FIGURE 4-1: Type of Standard by Goals

Standardization mechanism	Control	Product/quality	Process/ interoperability
De facto	Warner-Amex database- privacy standards	VCR standards	Language customs Bills of lading Computer interface standards
Regulatory	Auto safety regulations Fuel economy standards	NSA encryption standards Department of Agriculture Product classification standards	Open network architecture standards ETSI standards for European telecommunication standards
Voluntary consensus process	Standards for medical devices Pressure vessel standards Petroleum standards	Refrigerator standards	Map-top protocols for OSI/ standards Standards evolving legislation Electronic data interchange standards

SOURCE Office of Technology Assessment, 1994

(continued)

BOX 4-1: Standards Universe: Type of Standar

STANDARDIZATION PROCESSES

De Facto *Standards-Setting Process* De facto standards are set in the marketplace through the process of exchange They evolve from the bottom up, in accordance with the forces and mechanisms that drive the market When the market operates effectively, appropriate standards wiII emerge at the right time through the process of supply and demand Producers wiII agree on the "best" standard for the product in the face of competition from other suppliers and the demand of users Producers may press for the adoption of their own standards Or they may select strategically from among other competing standards evaluating each in terms of its potential impact on the costs of production profitability and market share Users wiII demand standards that reduce purchasing prices, Improve utility, and are easily integrated with other products and systems

Regulatory Standards Processes Standards can be mandated from the top down as a result of political choices Standards might be set In the political arena for a number of reasons For example if the market structure for standards-setting IS uncompetitive, economic outcomes wiII be inefficient Some market decisions might fail to Incorporate or account for environmental, safety, and other social externalities In some cases standards decisions entail conflict of values and policy tradeoffs Their resolution may require a broad-based consideration of values Timeliness may also be a factor

Voluntary Consensus Process Standards can also be set through organized negotiation processes that reduce transaction costs and facilitate Information exchange among key players Such processes can provide for better coordination than the market when levels of uncertainty are high when there are frequent recurring exchange activities among the parties, and/or when Information exchange is complex People participate in the voluntary standards-development process for a number of reasons They may for example want to Influence the development of standards, or they may simply want to keep abreast of technological developments

SOURCE Off Ice of Technology Assessment 1994

government efforts to set standards. Organized and carried out by private sector players with major stakes in the outcome, they are more attuned to market forces and, hence, will more readily have a real impact. [20] There is also a strong preference in the United States for consensus-based standards-setting, which is reflected in a long historical tradition and reaffirmed in recent public policy.[21]

The formal, voluntary. consensus-based standards process is not, however, devoid of serious problems, especially in the case of information networking technologies.[22] Relying on the slow and often arduous process of consensus-building, standards bodies have generally failed to keep pace with the rapid advances in communication

[20]For a discussion emphasizing the need to incorporate business needs, see "Standards Development for Information Technology: Best Practices for the United States," summary of workshop deliberations, sponsored by the National Institute of Standards and Technology and the Industrial Technology Institute's Center for Electronic Commerce, November 1993.

[21]Most recently, this preference was reaffirmed, for example, in the 1979 Trade Act, which formally recognizes the private sector's role in standards development, and in the Office of Management and Budget (OMB) Circular A-119, which directs federal agencies to use voluntary standards wherever possible in both regulatory and procurement activities. In both instances, however, the federal government retains the right to assume a greater role when necessary.

[22]For an overall description and general critique of the U.S. standards-setting process, see U.S. Congress, Office of Technology Assessment, *Global Standards: Building Blocks for the Future*, OTA-TCT-512 (Washington, DC: U.S. Government Printing Office, March 1992).

BOX 4-2: The National Initiative for Product Data Exchange (NIPDE)

As manufacturers use computer networking to integrate their internal operations and link up with suppliers and customers, they are faced with numerous incompatible ways to exchange information about products, Product Data (PD) describes every aspect of a product related to its design, analysis, characteristics, and support. Incompatibilities exist because of the many ways in which products are described. For example, a simple circular part can be described equivalently by its radius, diameter, circumference, or even its area. This means that different manufacturing systems cannot readily exchange data,

Product Data standards are a critical component of operations and commerce in the manufacturing sector. Increasingly, teams of geographically dispersed engineering, manufacturing, and service firms must work together to design, manufacture, and support products, Incompatible PD systems lock corporations, large and small, out of profitable national and international collaborations because of the expense and time penalties involved in translating the data Using a single PD standard would best facilitate the flow of information and enable manufacturing techniques such as concurrent engineering and computer integrated manufacturing (CIM)

The problem of coordinating agreement for a single PD standard, however, is immense because of the many levels at which incompatibilities exist—between individuals, departments, corporations, industries, and countries, The problem is generally that corporations have sunk costs in computer applications that may be difficult or impossible to convert to new PD standards

In the United States today, there are at least 400 ongoing product data standardization, implementation, and education efforts underway, accounting for $50 million to $70 million of annual corporate and government expenditures, The National Initiative for Product Data Exchange (NIPDE), an Industry -led, government-facilitated partnership between the private and public sectors, was set up to coordinate this activity [1] Industries such as aerospace, automotive, electronics, textiles, shipbuilding, and construction are heavily involved. Activities largely concern the emerging international standard, the Standard for the Exchange of Product Model Data (STEP)

The government plays two roles in NIPDE The Department of Commerce's NIST acts as a broker and facilitator of the standards and coordination processes by providing a headquarters and administrative services In addition, a number of government agencies act as stakeholders in partnership with other NIPDE members Because government is both a direct stakeholder and a representative of the public interest it has assumed these two roles Industry, faced with coordinating such a vast undertaking, instigated NIPDE and subsequently has worked effectively with government agencies [2] With some exceptions, industry generally acknowledges the leadership role that government may be called on to play in the international arena

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[1] Members include, for example, Boeing, Digital Equipment Corp General Motors, IBM, Martin Marietta Westinghouse, the Departments of Commerce, Defense, and Energy, NASA, CALS Industrial Steering Group, Auto Industry Action Group, STEP Tools, Inc , PDES Inc Electronic Industries Association, the Industrial Technology Institute, the Institute of Electrical and Electronic Engineers, IGES/PDES Organization of the U S. Product Data Association, Petrotechnical Open Software Corp , Microelectronics and Computer Technology Corp , National Center for Manufacturing Sciences, and the Society of Manufacturing Engineers

[2] Importantly, the Implementation plan for NIPDE called for no new independent watchdog organization Also, NIPDE unlike other national initiatives, is a limited term (3-year) initiative slated to end in February 1995

SOURCE Private communication, Merrill Hessel, Deputy General Manager of the National Initiative of Product Data Exchange, National Institute of Standards and Technology, March 1994

and information technologies. To encourage agreement, make allowances for technology change, and facilitate interoperability among an increasing number of interdependent parties, networking standards are often incorporated in elaborate reference models and defined in overly broad and generic terms[23] (see box 4-3). Thus, even after standards have been formally set, users still have to specify the particular uses to which these standards will be applied; vendors have to implement compatible technologies that meet standards and specifications; and products need to be certified as to their compatibility with one another.[24] The process can be so complex and time-consuming that the window of opportunity sometimes closes and those standards are overtaken by new technologies and events (see box 4-4).

Discouraged by the lagging process, many vendors and users have begun to circumvent the traditional standards-setting process by developing standards consortia.[25] Operating in a relatively closed environment, these groups are said to have greatly simplified the standards process. Unlike traditional standards organizations, consortia are not bound by rules guaranteeing openness and consensus. In fact, so long as consortia remain within the bounds of antitrust law, they are free to set up their own requirements for membership and publication. Membership is generally restricted, and fees can reach as high as $650,000 per year.[26] Given such exclusivity, consortia often replicate the dynamics of the market.[27] Instead of consensus, they can lead to competing vendor alliances, each supporting a different standard. In such cases, consortia may serve to reduce the total number of technology alternatives, but they offer little in terms of developing open systems.

One standards body that stands out for its success in achieving both openness and speed is the Internet Engineering Task Force (IETF), responsible for developing standards for the Internet** (see box 4-5). The IETF's open process owes much to the Internet unique history. Like the network itself, Internet standards evolved in a very informal way as part of the efforts of the Defense Advanced Research Projects Agency (DARPA) to establish computer networks linking researchers across the country. The original participants were few and were bound together by a common research purpose. As described by one participant:

> RFCs (Requests for Comments) were explicitly viewed as working documents to be used within a relatively small community. They ranged from casual ideas to detailed specifications and from expressions of operations concerns to whimsical fantasy. If an idea seemed attractive, an individual might spontaneously specify a protocol or a group might meet to dis-

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[23] These standards are refereed to as anticipatory standards because the process of setting the standard anticipates the creation Of the product. See, for a discussion, Carl F. Cargill, *Information Technology Standardization: Theory, Process, and Organizations* (Cambridge, MA: Digital Press, 1 989).

[24] Ibid.

[25] Vendor corsortia have been established, for example, to set standards for Switched Multimegabit Data Sew ice (s MDS), Fiber Distributed Data Interface (FDDI) over twisted pair, asynchronous transfer mode (ATM), and frame relay technologies. The major user consortia include the Corporation for Open Systems (COS), Manufacturing Automation Protocol (MAP), and the Technical Office Protocol (TOP). For a discussion, see Martin Weiss and Carl Cargill, "Consortia in the Standards Development Recess," *Journal of the American Society for Information Science*, September 1992, vol. 43, No. 8, pp. 559-565.

[26] Ibid., p. 560.

[27] As described by Weiss and Cargill: "Application consortia are usually the creation of a group of vendors who want to use collective action to accomplish a result that cannot be agreed to in an SDO [Standards Development Organization], due to conflicts, options, or basic disagreements on the nature or intent of the technology being standardized. On occasion, a consortium is formed by a group that is trying to avoid the standards process and go directly to market with a product." Ibid., p. 261.

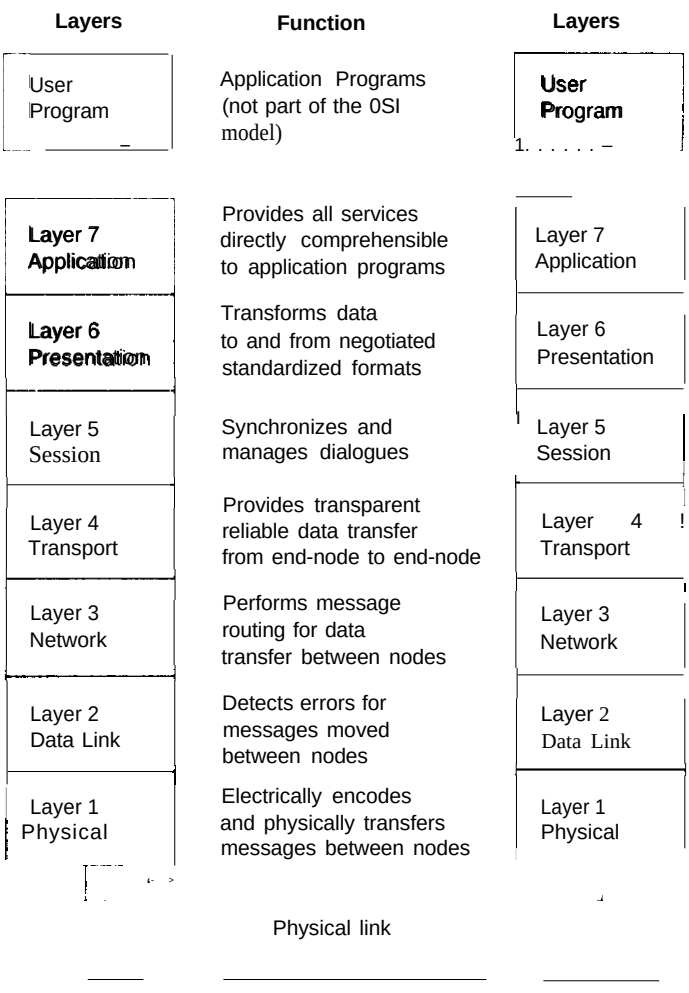
[28] The Internet Activities Board, which manages the Internet, established the IETF in 1989 to "provide near-term solutions to technical difficulties in Internet operations and to develop near-term enhancement for the Internet." D. Crocker, "Making Standards the IETF Way," *StandardView*, vol. 1, No. 1, September 1993, p. 50.

BOX 4-3: OSI Reference Model

Open systems Interconnection (0SI) Is an architecture for computer networks and a family of standards that permit data communication and data-processing among diverse technologies OSI-based standards are anticipatory, in the sense that they are developed prior to any applications or products They provide a reference model that defines and categorizes seven layers of function that need to be performed in any computer network if effective communication IS to take place, as well as the protocols and services at each layer (see figure 4-2) These layers are designed to be independent of one another so that altering one layer will not require alterations In others These several layers are, themselves, generally divided into three groups

- the four lower layers (physical, data linklng, networking and transport), which handle the interconnection of end systems,
- layers 5 and 6 (session and presentation), which support the exchange of information between end systems using data transfer facilities provided by the transport service, and
- layer 7 the applications layer, which provides for interworking between applications processes in end systems

FIGURE 4-2: OSI Reference Model



SOURCE National Institute of Standards and Technology (formerly National Bureau of Stand. ards)

0SI standards are International in scope and are being developed by the Joint Technical Committee 1 (JTCI) of the I SO and the International Electrotechnical Commission (I EC)

SOURCE Office of Technology Assessment, 1994.

BOX 4-4: Integrated Services Digital Network

Integrated Services Digital Network (ISDN) is a public switched service that allows the digital transport of voice, data, and image communication over a single network Although originally lauded for its ability to provide advanced services on a ubiquitous basis over the public network, its prospects seem much less promising today After 10 years of development ISDN is still not widely deployed

ISDN's poor showing is the result in part, of Ineffective marketing, regulatory barriers, and poor pricing [1] However, these problems might have been more easily overcome had it not been for the problem of interoperability Like all networking technologies, ISDN required a critical mass for the market to take off but such a market could only develop if vendors" systems could Interconnect. However, the momentum to create the requisite standards for Interconnection was lacking, given the competitive environment.

Notwithstanding years of considerable effort to develop ISDN standards, vendors continued to create products that, although they were said to conform to these standards, were Incompatible Even when AT&T, Northern Telecom Inc , and Siemens Stromberg-Carlson agreed to modify their switches to conform to a single standard, the Regional Bell Operating Companies (RBOCs) continued to deploy ISDN at varying rates Even Bellcore's effort, ISDN1—which sought to produce a standard basic rate Interface protocol—was a disappointment Within a week of Transcontinental ISDN Project Trip 92, a major industry-sponsored event designed to demonstrate coast-to-coast ISDN interoperability two RBOCs----Southwestern Bell and U S West—announced that they would not, in fact, adhere to the new standard

[1] Focusing on the technology rather than on applications the RBOCs had a difficult time convincing users that ISDN was something they wanted Initially they focused their marketing efforts on large users But these users wanted more functionality so they looked to alternative technologies and either built their own private networks or leased lines from alternate providers More recently the RBOCs have begun to concentrate on small businesses where their real market may lie Pricing also presented the classic chicken and egg problem As long as the market remained underdeveloped prices were too high Divergent stale regulatory policies also served as a barrier because they undermined the whole notion of ubiquitous service

SOURCE Off Ice of Technology Assessment 1994

cuss it further. If a protocol seemed interesting, someone implemented it, and if the implementation was useful, it was copied to similar systems on the net.[29]

Although the Internet has subsequently grown by leaps and bounds (recently estimated to comprise about 40,000 networks and 30 million users worldwide), the IETF has held to its tradition of openness and inclusivity. There are, for example, almost no financial barriers to participation, since standards forums are conducted online. In addition, access to standards and standards-related materials—also provided online—is free. Because formal membership does not exist, conflicts are resolved on an informal basis without voting. Such an approach depends on maintaining the integrity and legitimacy of the process, as well as a shared sense of "good will ."[30]

This open process does not occur at the expense of timeliness. For example, electronic delivery greatly improves response time. Timeliness also is achieved by limiting the standards agenda to specific problems requiring immediate solutions. Equally important, the IETF process avoids the implementation and conformance-testing prob-

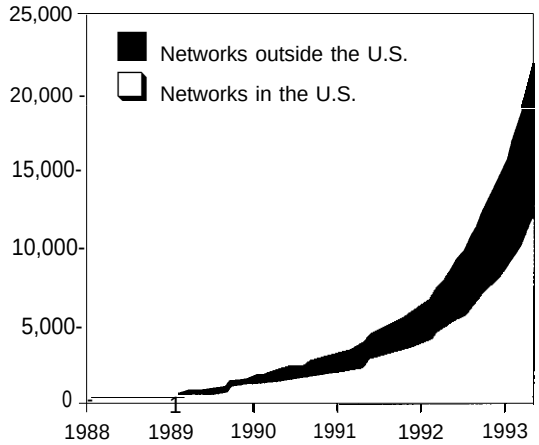
[29] I Id, For a full description of the standards process, see also A.L. Chapin, ""The Internet Standards Process" RFC131 (). Internic (AT&T) (admin@ds internic.net). March 1992.

[30] I hid.

BOX 4-5: The Global Internet, the World's Largest Internetwork

An internetwork is a computer network of interconnected computer systems and networks that can seamlessly communicate, The Internet IS the U.S. portion of the largest such global internetwork, estimated to have about 30 million users in more than 146 countries (electronic mail connectivity). The global internetwork has many names such as the Global Internet, the Net, the Matrix, or Cyberspace. In 1993, more than 20,000 networks (2,5 million computers) worldwide comprised the Global Internet (see figure 4-4). The current estimate IS over 30,000 networks

FIGURE 4-3: Growth of Networks Connected to the Internet



SOURCE Internet Society, 1993

The story of the Internet begins in 1969 with ARPANET, the first wide area network (WAN) that was a project of the U.S. Department of Defense's Advanced Research Projects Agency. ARPANET was a defense prototype to demonstrate uninterrupted communications with packet switching technology, as might be necessary during wartime, The story continues in 1985 with the Installation by the National Science Foundation (NSF) of a new national backbone (I.e. , ahtgh-capacity link between regional networks) For several years, the Internet primarily served the information, computing, and communications needs of scientists and engineers, The first applications were remote use of computers, file transfers, and electronic mail (e-mall)

Since 1985, NSFs open interconnection policy has catalyzed network expansion beyond defense and research networks to Include government, education, and commercial networks, and beyond the United States to include the whole world. This expansion was fostered by an established transmission protocol, the Internet Protocol (1P), that all new entrants agreed to use (72 countries now have full IP backbone connectivity) Today, there are many lP internetworks in addition to those that comprise the Global Internet While most Global Internet networks are research networks, the bulk of IP internetworks, in general, are commercial (see figure 4-4).

Today, large on line Information databases—such as the Library of Congress card catalog and the Security and Exchange Commission's EDGAR database—and database search tools, such as Archie, Veronica, Gopher, World-Wide Web (WWW), Wide Area Information Servers (WAIS), and Mosaic are available and their use is Increasing precipitously During March 1994, the Internet Society recorded astounding new traffic records Traffic on the NSF backbone alone Increased 20,7 percent for a total of 11.226 Terabytes (1 Terabyte = 1012 bytes) Use of the Gopher and W search tools increased 17.6 and 32,9 percent, respectively.

Altogether there are thousands of individual applications running on the Internet and dozens of application categories (groups of similar applications). The slx most used applications, in terms of percent of total bytes of traffic in March 1994 on the NSF backbone, are the Gopher and WWW search applications (3 4 and 37 percent, respectively), telenet remote computerese (5 percent), smtp electronic mail (7 percent), netnews news service, (9 percent), and ftp file transfer (37 percent)

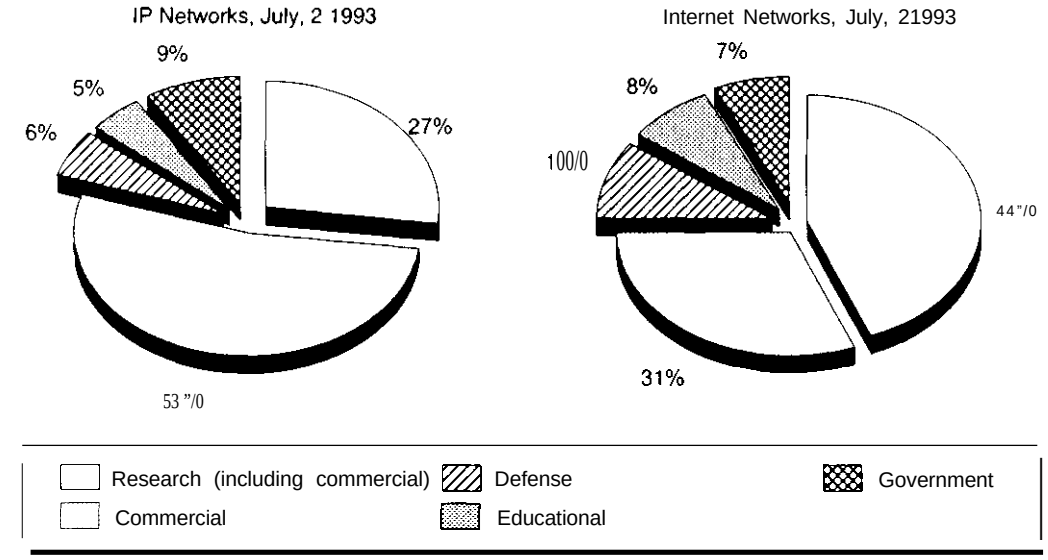
(continued)

BOX 4-5: The Global Internet, the World's Largest Internetwork (Cont'd.)

In the future more growth can be expected, most of it from new commercial traffic Business applications such as electronic data Interchange (EDI) are newly available, and prototype commercial networks such as Commercenet in Silicon Valley, CA, are being developed. This change in orientation from research to commerce will present new challenges, but has the potential to turn the Internet into the nation's premier economic resource, serving government, academia, and Industry.

SOURCE Private communication, Anthony M Rutkowski, Executive Director, The Internet Society, Reston, VA, April 1994

FIGURE 4-4: Uses of Internet Networks and IP Internets



SOURCE Internet Society 1994

lems associated with anticipatory standards; before becoming a draft standard, all specifica-(ions need to be implemented and demonstrated to be interoperable. Similarly, to become a full standard, a draft standard must be field-tested and proven capable of maintaining a community of interest over time. Given this iterative process, Internet standards are—in contrast to many anticipatory standards—timely and put to immediate productive use.

The challenge for the IETF—and the ultimate test of its usefulness as a model for other standards development efforts—will be to sustain this proc - ess as the Internet becomes more complex and the

number and diversity of its participants increase.[31] Many of its past successes can be attributed to the unflinching efforts of a small number of dedicated individuals working together to achieve common goals. Government funding has also been critical; because government has no financial stakes in the outcome, standards can be distributed widely and gamesmanship kept to a minimum. As the Internet expands to incorporate new users with decidedly commercial agendas, and to the extent that it becomes increasingly dependent on these players for financial support, it will have to deal with more and more issues similar to those faced by traditional standards bodies.[32]

Drawing on the experiences of the Internet, as well as those of other voluntary standards-development organizations. there are four specific areas that, for the purposes of electronic commerce, would 1ikely merit and benefit from greater federal support: 1) sponsorship of open standards development; 2) standards dissemination; 3) broad-based standards efforts; and 4) support for ongoing trials to test for conformance.

Sponsorship of Open Standards Development

Vendors try, where possible, to avoid open standards. As a result, some of the most important open standards have been developed by those who have little or no proprietary interest in them. For example, the operating system standard, UNIX, was developed at Bell Labs at a time when they were prohibited from selling computers, and the networking standard Transmission Control Protocol/Internet Protocol (TCP/IP) was the result of a government research effort. Having nothing to gain by withholding, these standards' developers were quite willing to disperse them liberally.[33] In similar fashion, to foster openness and interoperability where they are considered essential for electronic commerce today, the government may want to limit the proprietary gains to be made by sponsoring cooperative standards efforts among competing vendors to support standards development.

Standards Dissemination

The high cost of standards can be an important factor affecting their dissemination and use. In the cases of UNIX and TCP/IP standards, for example, rapid dissemination can be attributed, in part, to their relatively free distribution. Similarly, the general lack of appeal of open systems interconnection (0SI) (see earlier discussion) is due in part to its high price, especially compared with that of its chief rival—TCP/IP. Equally important, early standards choices based on cost can have significant long-term results. Because networking standards are—like networks themselves—highly interdependent and subject to externalities, their adoption requires a critical mass of users. Once a given standard has gained a critical mass, alternative standards may no longer be able to compete. To foster the deployment of open standards, therefore, the government may choose to support and perhaps even subsidize their widespread dissemination, especially early on. One way in which

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[31] As described by Chapin: "The rapidly expanding market for hardware, software, and services inspired by the Internet and its technology has attracted the attention and investment of the world's largest companies, The financial consequences to these companies of decisions that affect the course of Internet evolution will be enormous. It is naive to imagine that they will leave those decisions entirely in the hands of engineers—notwithstanding the extent to which the present Internet's success is due to the strong preference of those engineers for decisions based on technical merit rather than economics." A. Lyman Chapin, "The State of the Internet, " *Telecommunications*, vol. *28,* No. *1,* January 1994, pp. 13-16.

[32] The Corporation for National Research Initiatives (CNRI) currently serves as the Secretariat for the IETF. Funding is provided by several U.S. government agencies and the Internet Society. This support, however, is scheduled to diminish over time and be replaced by funding from a broad range of national and international, private and public organizations.

[33] Martin C. Libicki, *The Common Byte or, Why Excellent Information Technology Standards Are Absolutely Essential and Utterly Impossible* (Cambridge, MA: Harvard University)', Center for Information Policy Research, forthcoming), pp. 43-47.

the government might do this, for example, is to support standards dissemination online.

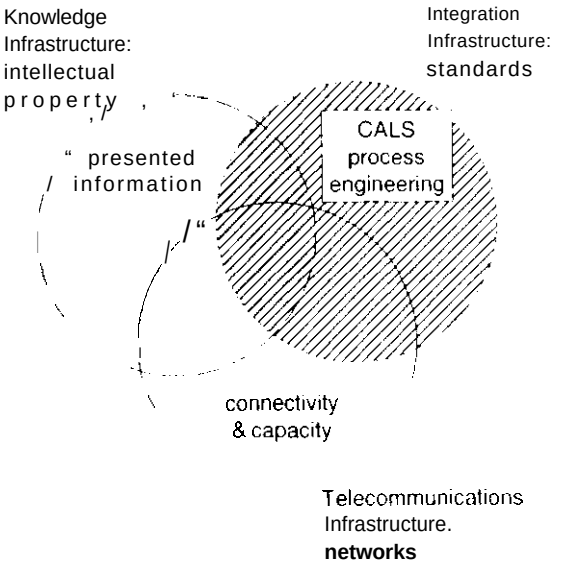
Broad-Based Standards Efforts

As a major user of networking technologies, the federal government can support efforts to foster open systems through the use of its market power. To be effective, however, the government must foster standards that havc a broad appeal. Although the government market is sufficient to ensure vendor support for a particular standard, it is not large enough to forestall and may in fact serve to perpetuate) the emergence of two or more competing ones.[34] This lesson has particular relevance today in the case of the standard CALS (Continuous Acquisition and Life-Cycle Support) (see figure 4-5). Care will be needed to ensure that CALS and related Department of Defense (DOD) standards efforts, which are designed primarily to sup - port defense logistics and procurement, work in conjunction with broader based national efforts to develop standards for electron ic commerce. [35]

Support for Ongoing Trials To Test for Conformance

As Open Systems Interconnection (0SI) and Integrated Services Digital Networks (ISDN) illustrate, the lack of interoperable products has been a major factor in the delay of standards development and the adoption of open standards. Vendors hesitate to implement standards until there is an established market. and, even then, may differ significantly in how they implement them. In turn, users are unlikely to buy new products without some assurance that they will work together with other system complements. One way of dealing with this problem has been to establ ish consortia such as the Corporation for Open Systems (COS) and X/open, which develop test suitcs and test vendor products for interoperability. While helpful, these efforts have not entirely solved the problem. The Internet experiences suggest another approach that might go even further to compress the

FIGURE 4-5: CALS[1] in the Context of the Information Infrastructure



[1]Continuous Acquisition and Life Cycle Support

As depicted in this figure, CAl S can be viewed as an umbrella concept that embraces all process engineering standards As such, it forms an integral part of the information infrastructure that will support electronic commerce

SOURCE: Brian Kahin, J F Kennedy School of Government, Harvard University, 1994

[34]A comparison of the cases of COBOL (Common Business-Oriented Language) and ADA (After Date of Award of contract), both computer programming languages, can serve to illustrate the point. By using its procurement power, for example, the government helped to induce vendors to support COBOL as a computer language standard. Equally critical to this standard's fate, however, was the support COBOL received from business users, who found that it allowed them to work very efficiently with large data files. In contrast, when DOD standardized on ADA as a general purpose computer language, it did so on the basis of its own, relatively specific, criteria. Not surprisingly, although vendors and DOD contractors were forced to support ADA, few others followed suit. Instead, they continued to favor C, and its successor C++, which were more suitable for a broader range of computing purposes. See Libicki, op. cit., footnote 33, pp. 171-198.

[35]The acronym CALS originally stood for Computer-Aided Acquisition and Logistic Support. The CALS program is somewhat at a loss in the post cold-war environment, with many of its vendors and supporters now looking to electronic commerce for a new raison d'etre. See, for a discussion, Andrew Jenks, "Digital Disintegration?" *Washington Technology*, June 24, 1993, pp. 23-30.

standards process. Instead of performing tests only after products have been developed and standards implemented, vendors and users could work together to field-test standards as they are developed. In this way, standards can, themselves, be judged partially on the basis of how well they can be implemented to work with other parts of the network.[36] To generate such cooperative efforts, greater government leadership, as well as incentives (and possibly sanctions), will likely be required.

There are many in the U.S. standards community who would likely oppose any options that call for a major role for government in standards-setting. They contend that the private sector voluntary consensus processes work well as they are currently constituted. At hearings held in 1990 by NIST to determine whether the government should become more active in standards-setting, especially in the international arena, the response of those testifying was an emphatic "No."[37] Government, they argued, should participate in standards-setting as a user, and contribute funding in proportion to these activities.

To narrowly cast the government in the role of "user" is, however, a mistake that could have serious consequences for the national economy. Participant users, who are essentially consumers of standards, are generally interested in the availability of standards and the particular form they take. And, as noted above, all too often the standards favored by one large user agency, such as DOD, conflict with the standards needs of other agencies and/or the nation as a whole. Moreover, the government has a stake in the outcome of the standards-setting process not only because it uses standards, but because the government alone is responsible for ensuring the well-being of the nation's economy.

Networking standards are especially important from the national perspective. In a global, information-based economy, networking technologies provide a basis for productivity and economic growth. These technologies will provide the infrastructure for all economic activities. If networks fail to interconnect for lack of standards, the nation could suffer considerable economic loss. Although government may have a relatively small interest in the development of some product standards, its stake in standards for open systems and for ensuring interoperability is very high.

OPTION C: Provide Support for Cooperative Research and Development Efforts

A strategy for the government to broker and support collaborative research for electronic commerce also merits consideration. Cooperative research facilitates technology transfer and allows vendors to share research and development costs, which continue to grow.[38] Cooperative efforts can improve networking quality because interdependent components of a system can be developed jointly, which will ensure accountability. Government support for such research and development may also induce business to address technology problems that otherwise might not be addressed.

Technology consortia can be used to accomplish cooperative research.[39] The goal of these research consortia of businesses, universities, and

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[36] One organizational model that might be followed, for example, is that of the High Performance Computing and Communications (HPCC) testbed program, which is described under option c, below.

[37] See Proceedings, National Institute for Standards and Technology, Public Hearings, "Improving U.S. Participation in International Standards Activities," Apr. 3, 1990.

[38] OECD, *Technology and the Economy: The Key Relationships* (Paris, France: OECD, The Technology/Economy Program, 1992), p. 32; and David C. Mowery and Nathan Rosenberg, *Technology and the Pursuit of Economic Growth* (Cambridge, UK: Cambridge University Press, 1989), p. 213.

[39] For a general discussion, Michelle K. Lee and Mavis K. Lee, "High Technology Consortia: A Panacea for America's Technological Competitiveness Problems?" *High Technology Law Journal*, vol. 6, No. 2, 1991, pp. 335-363.

government is to improve industry performance and U.S. competitiveness through technology transfer and cost-sharing. Taking advantage of a greatly relaxed antitrust environment, high technology research efforts have become more popular in the United States over the past several years.[40] The 1984 National Cooperative Research Act, which frees joint research ventures from many antitrust constraints, has reinforced this cooperative climate,[41]

One of the first, and by some accounts most successful, consortia to have been established is SEMATECH, a partnership between DOD (through ARPA) and 11 private semiconductor companies. who together account for about 75 percent of U.S. microelectronics manufacturing capacity. SEMATECH was created in 1987 to revive the U.S. semiconductor industry, which was losing out to the Japanese.[42] Viewing a healthy semiconductor industry as being critical to U.S. military efforts, DOD chose to partner with the industry in a joint venture, contributing approximately half of SEMATECH's funding.[43]

With the resurgence of the semiconductor industry, many look to SEMATECH as a model for other government/industry joint ventures.[44] A 1992 General Accounting Office evaluation, for example, praised SEMATECH's organizational structure, attributing the joint venture's success to the primary role cast for industry and the emphasis placed on industry needs. Although DOD helps to establish program objectives, SEMATECH's management and staff are drawn entirely from industry.[45] SEMATECH also received acclaim for its success in linking its program with the university research community and working jointly with equipment manufacturers.[46]

Praise for SEMATECH has not been universal, however. Some analysts, for example, oppose such joint ventures in principle, Joint ventures, they contend, are not only subject to pork barrel

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[40]For one discussion of the impact of antitrust law and its impact on R & D and U.S. competitiveness, see Thomas M. Jorden and David J. Teece, "Innovation, Cooperation, and Antitrust Striking the Right Balance,"' *High Technology Law Journal,* vol. *1,* No. 3, *1989.*

[41]In accordance with this law, joint research and development ventures are no longer considered to be illegal per se. Moreover, so long as a consortium is registered, it will no longer be subject to treble damages. See Lee and Lee, op. cit., footnote 39; see also Donald K. Stockdale, Jr., "Antitrust and International Competitiveness: Is Encouraging production Joint Ventures Worth the Cost'?" *High Technology Law Journal*, vol. 7, No. 2, 1993, pp. 270-296.

[42]The industry was, at the time, in very bad straits. When [he Japanese began to flood the American memory chip market *in* the mid- 1980s, many U.S, companies began to withdraw from the production of memory products. By 1987, Japan, selling chips below cost, completely dominated the world semiconductor market. Lee and Lee, op. cit., footnote 39, p. 346.

[43]Defense Department support for SEMATECH was critical. As Cohen and Nell point out: ". . .Sematech failed to win congressional approval as a Commerce Department activity, although in the next year it emerged successful (and unchanged) through DARPA as a national security imperative. DARPA supports a score of programs with immediate commercial applications; however, from 1987 to 1992, attempts to establish a civilian counterpart agency all failed." Linda Cohen and Roger Nell, "R & D Policy," Center For Economic Policy Research, No. 298, Stanford University, Stanford, CA, pp. 15-16,

[44]As Spencer and Grindley point out: "The establishment of SEMATECH has coincided with a resurgence in the U.S. semiconductor. In 1992, the U.S. won a larger share of the world market than Japan for the first time since 1985 and U.S. firms took the leading positions in both the semiconductor and equipment markets. Though much of this may be due to market dynamics beyond SEMATECH's influence, there seems to be widespread recognition that it has helped with some of the industry's problems. " William J. Spencer and Peter Grindley, "SEMATECH After Five Years: High Technology Consortia and U.S. Competitiveness," *Cal ifornia Management Review*, summer 1993, pp. 9-32.

[45]U.S. General Accounting office, *SEMATECH's Technological Progress and Proposed R&D Program,* GAO/RCED-92-223BR (Washington, DC U.S. Government *printing* Office, July 1992). For the White House's positive evaluation, see *Technology for America's Economic Growth: A New Direction To Build Economic Strength* (Washington, DC: White House Press Office, Feb. 22, 1993).

[46]Spencer and Grindley, op. cit., footnote 44.

politics; because they shield businesses from competition, they may actually inhibit innovation in the long run.[47] Viewed from this perspective, the recent growth in the semiconductor industry should be attributed not to SEMATECH, but rather to a troubled Japanese economy and the poor investment choices made by the Japanese semiconductor industry. Equally important has been the rallying and aggressive competition of a number of small, innovative firms, many of which are not even associated with SEMATECH.[48] Others have criticized SEMATECH for its total emphasis on industrial needs. These critics are not opposed to joint ventures per se; rather they believe that such efforts, which are funded by taxpayers, should be related to broader social goals.[49] For example, they would urge that more attention be paid to meeting the needs of the environment, small businesses, and workers.[50]

These differing views of SEMATECH illustrate how difficult it is to generalize about the costs and benefits of cooperative research ventures. For example, consortia that are mission-oriented and designed to achieve a certain social goal will need to be evaluated by different criteria than those used to evaluate joint ventures that are designed to overcome market failures.

Judged on economic grounds alone, joint ventures can be said to be beneficial when the social rate of return on investment exceeds the private rate of return, giving rise to knowledge "spillovers." These spillovers can be significant in the case of R & D expenditures, since research and development results—like information itself—are inherent] y leaky. Thus, they cannot be full y appropriated by the original investor, but are available for use by others. [51] Th$_e$ magnitude of these *spill*overs will vary depending on the industry, the structure of markets, and the rules governing intellectual property rights. Generally speaking, knowledge spillovers are like] y to be greater to the extent that participation is broadbased, markets are competitive, and intellectual property rights are not too constraining.[52] organizing joint ventures to maximize spillovers may be difficult, however, since industry will be incl ined to support such efforts only when they can increase their return on investments in innovation.[53]

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[47] See for instance, Cohen and Noll, op. cit., footnote 43; Murray Weidenbaum, "A New Technology Policy for the United States," *Executive Speeches*, June-July 1993; and Richard R. Nelson, Merton J. Peck, and E. D. Kolachek, *Technology, Economic Growth, and Public Policy* (Washington, DC: Brookings Institution, 1967).

[48] See, for example, testimony of T.J. Rodgers, "The American Semiconductor Industry: Winners or Whiners?" in U.S. Congress, Legislation Concerning Production Joint Ventures, Hearings before the Subcommittee on Antitrust, Monopolies and Business Rights of the Senate Committee on the Judiciary, 101st Congress, 2d Session. See also Michael Marks, "Industrial Policy at Work. . .or True Grit'?" *Technology Transfer Business,* summer 1993, pp. 29-33.

[49] See Tracy Cohen, "A Model—But What Kind'?" *Technology Review*, January 1993, pp. 16-18.

[50] Ibid.

[51] Thus as Mansfield and his associates point out, even in cases when social returns are very high, the private returns may be so low 'hat 'he firm would not likely have made the original investment with the advantage of hindsight. See E. Mansfield, J. Rapport, A. Romeo, S. Wagner and G. Beardsley, "Social and Private Rates of Return from Industrial Innovations," *Quarterly Journal of Economics, vol.* 77, No. 2; and E. Mansfield, "How Rapidly Does New Industrial Technology Leak Out'?" *Journal of Industrial Economics,* December 1985. See also R.R. Nelson, "The Simple Economic Basis of Scientific Research,' 'Journal of Political Economy, *1959,* pp. 297-306; and K.J.K. Arrow, ''Economic Welfare and the Allocation of Resources for Invention," Universities-National Bureau Committee for Economic Research, The *Rate and Direction of Inventive Activity* (Princeton, NJ: Princeton University Press, 1%2).

[52] OECD, op. cit., footnote 38, pp. 61-63.

[53] See Cohen and No] I who point out: "Our most important conclusions are that RJVS (Research Joint Ventures) are not a generally appl icable panacea for curing problems of international competitiveness, and that, in particular, RJVS can be expected to enhance innovation (rely under certain cond it ions. Moreover, because these conditions usual ly make RJVS unattractive either to firms in the industry or to the government, we see a very limited useful role for them in United States R & D policy. " Op. cit., footnote 43, p. 27. See also Linda R. Cohen and Roger G. Noll, "Privatizing Public Research: The New Competitive Strategy," *Scientific American*, forthcoming.

One program that has struck a workable balance between public and private returns is the High Performance Computing and Communications Program (HPCC).[54] The HPCC program is a multiagency project that supports research on advanced supercomputers, software, and net-Works.[55] Although its major focus is on technology, the HPCC program was designed, in part, to address the "Grand Challenges:" science and engineering problems in climate change, chemistry, and other areas that can only be solved with the use of powerful computer systems.[56]

Cooperation with industry and universities is also an integral part of the HPCC Program. It is being conducted at six testbeds, using high-speed fiber optics to link three or four sites—universities, industry laboratories, supercomputer centers, and federal laboratories. Administered and funded for 3 years by the National Science Foundation (NSF) and the Advanced Research Projects Agency (ARPA) under a cooperative agreement with the Corporation for National Research Initiatives (CNRI), the testbed teams are responsible for demonstrating emerging high-speed network technologies and identifying and investigating outstanding research questions relating to them.[57]

This kind of program has a number of benefits. Federal funding has helped to leverage industry support even though the research is not always directl y related to commercial needs. 58 Virtually the entire cost of building the networks has been borne by industry participants in the form of contributions of transmission capacity, prototype switches, and research personnel .59 Industry's expertise is critical to the development of many of the components needed for high-speed network research. The fabrication of these components is extremely complex, requiring customized integrated circuits and high-speed circuit design. An equally valuable aspect of the program is its interdisciplinary and interorganizational design. Each research group, for example, involves both network and applications researchers. The applications researchers have experience with supercomputers, visualization, and graphics in a variety of scientific disciplines. Network researchers draw on their expertise with switches, transmission equipment, protocols, signal processing. and computer architecture. Working together, these scientists and engineers not only promote technology transfer, but also improve overall network design and performance.

The federal Digital Library Initiative is similarly structured to assure both a broad range of participants and support for different agency needs. Administered through NSF in conjunction with NASA and ARPA, this program will fund research, prototyping, and testbed activities in support of digital libraries. Approximately six grants will be awarded, each totaling up to $1.2 million and lasting for up to 4 years. Research areas in-

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[54]This discussion draws from U.S. Congress, Office of Technology Assessment, *Advanced Network Technology*, OTA-BP-TCT-101 (Washington, DC: U.S. Government Printing Office, June 1993).

[55]High-Performance Computing Act of 1991 (HPCA), Public Law 102-194, Sec. 102 (a).

[56]As one of its four basic components, network research receives approximately 15 percent of the $1 billion annual program budget. Office of Science and Technology Policy (OSTP), "'Grand Challenges 1993: High Performance Computing and Communications," 1992.

[57]The principals of CNRI, a nonprofit organization, played significant roles in the development of both the ARPANET and the Internet. CNRI is responsible for organizing the testbeds and coordinating their progress.

[58]Much of the research, for example, centers on higher bandwidth and more specialized applications than are expected to have near-term commercial significance for the telecommunications industry. industry planning is oriented more toward medium-bandwidth multimedia applications—applications that require more bandwidth than can be supported by current networks, but significantly less than the gigabit/second rates required by the supercomputer community. For example, the telecommunications industry ATM-based Broadband Integrated Services Digital Network (B-ISDN) standard envisions 155 megabit/second channels to each customer in the near term. Furthermore, many of the interesting issues related to the operation of fast packet networks can be studied with lower bandwidth networks, although a few problems may only become apparent at gigibit second speeds. See OTA, op. cit., footnote 54.

[59]Ibid.

elude data capturing and formatting; advanced software and algorithms for browsing, searching, filtering, abstracting, and summarizing; and the utilization of nationally and globally distributed databases.[60] To qualify for funding, applicants must contribute at least 25 percent of the project costs, and they are required to allow participation of all stakeholders. These key players might include, for example: 1) client groups (e.g., specific research communities or other users); 2) commercial enterprises that would be involved in the commercialization of a digital library system (e.g., publishers, software houses, stock exchanges, equipment manufacturers, and communication companies); 3) archival establishments, either private or governmental (e.g., libraries, data repositories, clearinghouses, and government or private information or data services); and 4) relevant computer and other science and engineering research groups (e.g., academic departments, supercomputer centers, and industrial laboratories) .61

Because government-sponsored joint ventures often require an industry initiative as well as matching funds, large businesses and large-scale projects have been the major beneficiaries to date.[62] Large businesses generally have greater economic, technological, and scientific resources, which are essential for R&D.[63] Equally important, they are likely to have the necessary contacts and networking skills needed to assemble research coalitions. In addition, the larger the project and the more prominent the participants, the greater the chances that it will gain adequate political support.[64]

If small and medium-sized businesses are to share the benefits of cooperative research ventures, government may have to become more active on their behalf. Because innovation and technology transfer entail learning by doing, using, and interacting, these businesses can only gain the full benefits of research and development if they participate in the process.[65] However, to become actively involved, they will need help identifying joint problems, developing small-business networks, developing proposals, and providing up-front financial support.[66] Although requiring a more proactive federal role, such programs can have a high payoff because small businesses are generally more innovative than large firms.[67] Because small businesses are numerous

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[60] Digital Library Initiative, FY 1994, NSF 93-141.

[61] Ibid.

[62] Brian Robinson, "promises, Promises: Clinton and the Technology Programs He Now Fosters," *Technology Transfer Business*, winter *1994,* pp. 35-38.

[63] As the OECD has pointed out: "Firms below *a certain size* cannot bear the cost of an R&D team. The critical size has been calculated to be on the order of one thousand employees in low technology industries, and 100 employees for high technology using simple indicators such as the share of turnover devoted to R&D activities, and the average cost of an industrial researcher. . ." OECD, op. cit., footnote 38, p. 27.

[64] Explaining some of the allure of large-scale projects, Cohen and Nell point out, for example: "Larger, more concentrated projects exhibit a form of political economies of scale. A large project not only will provide visible economic benefits to a large number of citizens in a community, but will come about through a visible political process in which the role of political representatives will be easy to observe. In contrast, small grants are not likely to receive any public attention, and are not likely to have been influenced much by elected politicians, so that the local community is not likely to base political support on whether it receives them." Op. cit., footnote 43, pp. 24-25.

[65] As Rosenberg and Mowery Point out, 'The fruits of research do not consist solely of information that can be utilized by others at minimal cost for innovation. transferring and exploiting the technical and scientific information that is necessary for innovation constitute a costly process that itself is knowledge intensive." Mowery and Rosenberg, op. cit., footnote 38. See also, OECD, op. cit., footnote 38, pp. 17, 27; and S.J. Kline and N. Rosenberg, "An Overview of Innovation," in National Academy of Engineering, *The Positive Sum Strategy: Harnessing Technology for Economic Growth* (Washington, DC: The National Academy Press, 1986).

[66] As described by Roberts, "[Matching.fund partnerships between government and industry]. . can be a considerable burden to smaller companies, particularly since indirect costs associated with the programs cannot be laid off against program funding. That means many small companies have to find partners before they can apply for federal funding in these programs or not apply at all." Op. cit., footnote 62, p. 38.

[67] Small companies, for example, have been found to account for a disproportionate share of significant inventions, and their rate of innovation per employee is two and one-half times greater than in large firms. See "SBIR Accolades," *Technology Transfer Business*, winter 1994, p. 6.

and hold little market power, the knowledge spillovers in joint undertakings may be high, while the dangers of anticompetitive behavior are likely to be low.

One recently established program designed to broker small-business relationships is the Small Business Technology Transfer Grants Program. With funding from the Departments of Defense, Health and Human Services, and Energy; NASA; and the National Science Foundation this 3-year pilot project matches small companies with researchers from universities, federally funded R&D companies, and other nonprofit research organizations, including federal laboratories. Inspired, in part, by the success of the Small Business Innovation Research (SBIR) grants program, this new program will receive $24 million in 1994, to be increased to $72 million in 1996.[68]

The social payoff from federal investments in cooperative research may be further enhanced to the extent that these programs can be networked together, allowing them to build on one another.[69] A number of federally funded programs take advantage of the Internet, which owes its existence to federal support. For example, CommerceNet, a 3-year pilot project funded by a grant under the Technology Reinvestment Program,[70] will develop software applications for use over the Internet to electronically link companies with their customers, suppliers, and development partners.[71] Similarly, Microelectronics and Computer Technology Corp. (MCC), a government-supported consortium made up of approximately 80 companies, is in the process of developing the Enterprise Integration Network (EINet), a business network that will run applications over the Internet.[72] The high-speed data networking services will be provided by Sprint; directory and encryption, and eventually electronic funds transfer, services will also be available .73 In like fashion, the Technologies for Effective Cooperation Network (TECnet) will use the Internet to link and provide business information support to the Manufacturing Technology Centers (MTCs) (see box 6-1 in ch. 6).

[68]Ibid.

[69]See, for one discussion, Brian Kahin, "CALS in Context," *Cals Journal*, spring 1993, pp. 27-29.

[70]This interagency program is jointly sponsored by the Advanced Research Projects Agency (ARPA) of the Department of Defense, the Department of Energy Defense Programs (DOE DP), the Department of Commerce's National Institute of Standards and Technology (NIST), the National Science Foundation (NSF), and the National Aeronautics and Space Administration (NASA). Its mission is "to stimulate the transition to a growing, integrated, national industrial capability which provides the most advanced, affordable, military systems and the most competitive commercial products. This will be accomplished through the application of defense and commercial resources to develop dual-use technologies, manufacturing and technology assistance to small firms, and education and training programs that enhance U.S. manufacturing skills and target displaced defense industry workers." ARPA, "Program Information Package for Defense Technology Conversion, Reinvestment and Transition Assistance," Mar. 10, 1993, p. 1-1.

[71]This effort will be administered by Enterprise Integration Technologies with support from WestRen, the operator of the Bay Area Regional Research Network (BARRNET), and Stanford University's Center for Information Technologies. The federal government will provide $4 million in funding, which will be matched by the State of California's Trade and Commerce Agency and 20 participating companies, including Apple Computer, Hewlett-Packard, Lockheed, National Semiconductor, Pacific Bell, and Sun Microsystems. Local communities, although involved, will not contribute funds.

[72]MCC was established in 1982 in response to Japan's Fifth Generation Computer effort. Ten million dollars of the Department of Defense appropriation for fiscal year 1993 have been earmarked for EINet. A number of pilot programs to test applications are presently underway. These include, for example, Electronet, a concurrent-engineering effort to develop printed wiring boards for avionics equipment, an electronic bidding network to link U.S. auto manufacturers and their suppliers, and a utility network to link the 800 member companies of the Electric Power Research Institute (EPRI). The network is intended to provide fully encrypted electronic data interchange services at a cost of approximately $20,000, plus operating expenses.

[73]See Gary Anthes, "Internet Commercial Uses Bloom," *Computerworld*, June 28, 1993, pp. 71, 73; Bill Burch, "Sprint To Resell EDI, E-Mail Business Service," *Network World*, June 28, 1993, p. 29, and "Expanding the Horizons of Electronic Commerce," *Industry Week*, Apr. 18, 1993, p 46.

Promoting Technology/ Industry Developments

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If innovation or commercial activity are lacking in an area that is important for the public, the government can promote such activities itself. For example, the government might: 1) provide tax-related incentives to stimulate private sector activity; 2) provide private sector grants and loans; 3) stimulate the market by leveraging government procurement powers; and 4) directly fund, develop, and/or provide needed technologies and technology-related services.

Although government has always played a role in promoting technology development. its actions have sometimes been controversial. Conflicts surrounding government promotion of technology and economic development are as old as the Republic itself, providing fuel to fire the political debates between the Jeffersonians and Hamiltonians and the Jacksonians and the Whigs for almost 100 years.[1] Avoiding such controversy for the most part, the government has generally reserved the role of technology promoter to one of last resort. It has assumed a major role only when—as required in basic research, defense, and mission-oriented objectives such as space exploration—it was clear that the

Policies promoting information networks will need to reflect a greater understanding of, and appreciation for, the complex and iterative nature of both diffusion and innovation processes.

[1]Jeffersonians and Jacks{ onians, for example, rejected plans put forward by Secretary of the Treasury, A lexander Hamilton, to build a national banking system and other infrastructure believing that it would favor the gentry class. Later they opposed national devel-(opment plans put forward by Whig party leader, Henry Clay, Speaker of the House. Clay wanted to construct national roads and canals and, ultimately, national railroads as well. Jefferson and Jackson, in denying these initiatives, encouraged state and local governments to undet-take this development; thus state and local governments assumed the critical role. See Don Hadwiger, "A History of Rural Economic Development and Telecommunications Policy,"" contractor paper prepared for the Office of Technology Assessment, January 1990, p. 7.

private sector would not do so.[2] Even when providing the funding and setting the research priorities, the government has generally delegated the task of actually performing the work to private sector organizations.[3]

Today, the federal government invests more than $70 billion in research and development. This investment is comparable to, and sometimes higher than, the amounts spent by other countries.[4] Most other governments, however, conduct R&D to achieve commercial goals; in the United States, approximately two-thirds of all government-sponsored R&D is for military purposes.[5] In a knowledge-based, global economy, this difference in emphasis may greatly disadvantage the United States. As a result, efforts are now underway to shift the R&D orientation from defense to economic growth and competitiveness, from basic to applied research, and from public to private sector involvement.[6]

Moving toward more commercially oriented R&D will present a number of challenges, however.[7] Better criteria will be required for determining why some technologies merit greater support than others.[8] Decisions must also be made about the appropriate amounts of funding and how funds can be most effective1y deployed. These quest ions will likely be difficult to answer because the relationships between R&D, technology diffusion, and innovation are not well understood.[9] More often than not, choices about the type and amount

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[2] Road-building is an example. During President Truman's Administration, road-building failed to keep paCe with increased road use. There was no consensus about the federal role. Rural Senators Milton Young (ND) and John Stennis (MS) sponsored increases inroad appropriations, including $100 million for farm highways. However, at the same time, the U.S. Chamber of Commerce opposed farm highways, characterizing them as "national socialism." President Truman cutback on road construction during the Korean War, even as road use was sharpl y rising. It was only after President Eisenhower justified federal support for highway construction on national defense grounds that a federal road-building program really took off. See Mark H. Rose, *Interstate Express Highway Politics, 1941-1956* (Lawrence, KS: The Regents Press of Kansas, 1979).

[3] David Mowery and Nathan Rosenberg, *Technology and the Pursuit of Economic Growth* (Cambridge: Cambridge University Press, 1989), p. 128.

[4] According to Cohen and Noll: "Government now accounts for about 45 percent of total R&D in the United States; in most other advanced, industrialized economies the share of government in total R&D varies from 36 percent (Germany) to 54 percent (Italy). The primary exception is Japan, where only 20 percent of national R&D is paid for by government; however, this figure is misleading because of the coordinating function of the government." Linda R. Cohen and Roger G. Nell, "R&D Policy," Center for Economic Policy Research, Publication No. 298, Stanford, CA, August 1992, p. 11.

[5] See Harioff Grupp, "Efficiency of Government [intervention in Technical Change in Telecommunications: Ten National Economies Compared," *Technovation*, vol. 13, No. 4, 1993, pp. 192-193.

[6] See Lewis M. Branscomb *(cd.), Empowering Technology: Implementing a U.S. Strategy* (Cambridge, MA: The MIT Press, 1993), p. 8. See also, Linda R. Cohen and Roger G. Nell, "Privatizing Public Research: The New Competitiveness Strategy," *Scientific America,* forthcoming, 1994. With respect to the need for such a policy shift, see John Alic et al., *Beyond Spinoff: Military and Commercial Technologies in a Changing World* (Boston, MA: Harvard University Press, 1992); and Nathan Rosenberg and W. Edward Steinmueller, "Can Americans Learn To Become Better Imitators," Center for Economic Policy Research, CEPR Publication No. 117, Stanford University, Stanford, CA, January 1988.

[7] For an in-depth discussion, see U.S. Congress, Office of Technology Assessment, *Defense Conversion: Redirecting R&D*, OTA-ITE-552 (Washington, DC: U.S. Government Printing Office, May 1993).

[8] Responding, in part, to these problems, the National Competitiveness Act of 1993 includes a title, called "Critical Technologies," which authorizes the Department of Commerce to develop a formal process of technology 'benchmarking' whereby the scientific and technological capabilities of American firms would be compared to those of other nations. Branscomb, op. cit., footnote 6, p. 20.

[9] As noted by Cohen and Noll: ". . designing efficient R&D policies is quite difficult and requires trading off several conflicting objectives. There is a relatively strong case for supporting fundamental R&D that broadens society's broad technological base and widely disseminating the results to maximize their spillover value; however, one must guard against policies that are too disconnected from technical application or that, due to lack of profitability to the innovator, are not attractive to those who might apply the results. Likewise, substantial efficiencies are theoretically possible from targeting particular types of technologies for assistance; however, as a practical matter, the government may not be able to identify them to confine support to the most promising areas and to manage them efficiently.'" op. cit., footnote 4, p. 8.

of R&D and support for technology diffusion will need to be determined on a case-by-case basis.[10] In these circumstances, there is a danger that such choices will be based on political rather than economic rationales. [11]

Communication and information technologies have genrally been high on the list of technologies meriting government promotion. Viewed as essential to defense efforts, these technologies have benefited from consistent Department of Defense (DOD) support since World War II. Recognizing that communication and information technologies constitute a national infrastructure, the government has also backed their development, providing venture capital and other incentives when private capital was unavailable. When required, the government has even done the job itself. [12]

In the past, the government fostered the building of canals, railroads, and highways. Today, many people believe it should more aggressively promote the information networks required to support economic commerce.[13] Policies designed to meet such objectives should not necessarily be modeled on the past, however. Today, such policies will need to take into account the many technological, economic, and social changes that have taken place - in particular, the advances in and convergence of communication and information technologies, the conversion from a defense economy to a peacetime one, the privatization of the infrastructure, the globalization of the economy, and the rise of multinational networking providers. Policies promoting information networks will also need to reflect a greater understanding of, and appreciation for, the complex and iterative nature of both diffusion and innovation processes.

OPTION A: Use Tax Incentives To Foster Private Sector Developments

The government can stimulate electronic commerce by encouraging the development and diffusion of innovative technologies and business processes through the use of tax incentives such as tax credits, tax writeoffs, and/or accelerated depreciation schedules. By lowering the costs of technology research, development, and deployment, such mechanisms are intended to stimulate private sector activity.

Unlike technology-push strategies, which rely on government promotion of technology to create a market, tax-related incentives are designed to work indirectly through the marketplace. These measures allow private firms to control their own investment decisions. Because they are relatively simple to administer, they require little government bureaucracy.[14] In a market-oriented society

10 See Nathan Rosenberg, *Inside the Black Box--Technology and Economics (New York, NY:* Cambridge University Press, 1983).

11 As Roger Nell and Linda Cohen pointout:". . most programs are not clearly a waste of money, especially in early exploratory research. The problems arise because mid-project managerial decisions are directed from matters of economic efficiency by a host of political factors; impatience to show commercial progress, distributive politics, the inability to commit to long-term, stable programs, and a mismatch between the types of industries that are most likely to underinvest in research and those that are most attractive politically to subsidize. "Roger G. Nell and Linda Cohen. "Economics, Politics and Government Research and Development,"' Working Papers in Economics, E-87-55, The Hoover Institute/Stanford University. Stanford, CA, December 1987.

12 Highway promotion illustrates the flexibility of the government's approach and rationale. The federal government became involved in highway building as early as 1932. when Congress enacted a penny-per-gallon gas tax. The rationale and the means of financing the nation's highway system were distinct from other infrastructure projects. Presidents Hoover and Roosevelt both believed that massive spending for road construction would provide jobs during the depression. President Eisenhower justified federal support for highway construction on national defense grounds. To finance this road building program, he set up a Highway Trust Fund to be replenished from increased highway user taxes. See Rose, op. cit., footnote 2.

13 The Clinton Aministration, for example, has singled out communication technologies, automobiles, and high-speed rail for special attention.

14 Branscomb, op. cit., footnote 6, p. 18.

such as the United States, this approach has proven especially popular. In some other countries, however, it is much less in vogue. [15]

Preferential tax treatment to subsidize private sector R&D was first provided for in 1981 with the passage of the Economic Recovery Tax Act of 1981.16 As described in the 1981 House Report 4242, this tax credit was intended to "reverse [a] decline in research spending by industry" as well as "to overcome the reluctance of many ongoing companies to bear the significant costs of staffing and supplies, and certain expenses such as computer charges, which must be incurred to initiate or expand research programs in trade or business."[17] In addition to the tax credit, the Economic Recovery Tax Act also created an accelerated cost recovery system for capital expenditures. Unlike tax credits, which are applicable to all aspects of R&D, accelerated cost recovery is limited to capital expenses alone. [18]

Today, firms can receive a credit of 13.2 percent (or a 20-percent credit, 50 percent of which is treated as taxable) for the excess of R&D over the base amount for that year. [19] The cost to government constitutes a relatively small proportion of total federal R&D funding. (For one estimate of this cost see table 5-1.) Few begrudge these expenditures, and many have called for an increase in the amount.[20] Tax incentives also have the support of the Clinton Administration, which has announced that it plans to implement a permanent R&D tax credit, selective investment-tax credits, modification of capital gains taxation, and similar macroeconomic incentives.[21]

Notwithstanding the popularity of tax incentives, there is no definitive evidence to show that they have had their intended effect.[22] Although most analysts agree that R&D spending increased after 1981, this increase is not necessarily attributable to tax incentives alone.[23] For example, some analysts have argued that, instead of undertaking new areas of research and development, businesses merely shifted their focus to take better advantage of government incentives. Measuring the impact of tax incentives on innovation itself is also extremely difficult. Innovation is multidimensional, depending for its success on a wide range of inputs such as management structure, quality control, marketing strategy, and the level of employee creativity. [24] Weighing any benefits against the cost of employing this approach is also

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15 See Dennis Patrick Leyden and Albert N. Link, "Tax Policies Affecting R&D: An International Comparison," *Technovation*, vol.13, No. 1, 1993, pp. 17-25.

16 Cohen and Nell, op. cit., footnote 4, p. 12.

17 See U.S. Department of Commerce, Office of Technology Policy, "Analysis of the Research Tax Credit," Mimeo., Apr. 6, 1990.

18 See Leyden and Link, op. cit., footnote 15.

19 Committee on Technology Policy Options in a Global Economy, *Prospering in a Global Economy: Mastering a New Role* (Washington, *DC:* National Academy Press, 1993).

20 Committee on Technology Policy Options in a Global Economy, *Mastering a New Role: Shaping Technology Policy for National Economic Performance* (Washington, DC: National Academy Press, 1993).

21 Ibid.

22 The four major time series studies that have examined the impact of tax incentives conclude that there has been a significant benefit. "n the other hand, this conclusion is at odds with studies that focus at the microeconomic level. Ibid., p. 20.

23 Ibid,

24 Innovation is not a linear process; rather, it is an (ingoing process that entails a number of feedback loops. As described by Dominique Foray: ". . . the diffusion process itself is fundamentally dynamic and will generate, via a series of mechanisms, the continual improvement of the given technology." Dominique Foray and Christopher Freeman, *Technology and the Wealth of Nations: The Dynamics of Constructed Advantage* (London, UK. Pinter Publishers, 1993), p. 3. See also, OECD, The Technology/Economic Program, *Technology and the Economy:* The *Key Relationships* (Paris, France: OECD, 1992). esp. ch. 2, "Technology Diffusion."

problematic because the total cost of such programs is similarly subject to debate.[25]

Tax incentives to encourage the diffusion of networking technologies for electronic commerce might well be designed to play a more decisive and definitive role. Whether or not diffusion and innovative changes occur depends as much on the ability of an organization to '*absorb" change as it does on the nature and quality of the technology to be deployed. Firms are likely to absorb more if investments in intangibles—such as in-house R&D, worker training, patents, and software development—match investments in capital equipment.[26] Thus, the government might enhance the overall benefits to be derived from tax credits if it were to incorporate intangible investments in its tax-related provisions to a greater extent.[27]

Such a policy would be particularly beneficial to small firms that generally are less able to respond positively to technology change. Over the long term, the national economy will also benefit from increased productivity. American firms are often less apt to invest in intangibles, especially workforce training, than are firms in other countries. Thus, in a comprehensive survey of the use of computerized automation in metal-working industries, it was found that, in 84 percent of the cases examined, workers were not given any training to upgrade their skills.[28] Yet studies show that such investments can yield five times the benefits from deploying new technology.[29]

TABLE 5-1: The Federal R&D Tax Credit (in millions of 1982 dollars)

Year	Outlay equivalent of federal tax credit	Revenue loss
1981	220	16
982	640	415
983	696	590
984	3106	,276
985	2,179	,493
986	2004	594
1987	2,300	1 580
1988	1,020	740
1989	1,255	903
1990	1,233	846
1991	1,220	839

SOURCE Science and Engineering indicators–1991 p 334

OPTION B: Encourage Private Sector Activity by Providing Grants and Loans

The government can also provide financial incentives through grants and loans to the private sector. This option is very much in keeping with the recent shift in technology policy to favor research and development that aims to support commercial

[25] For some of these differences, see U.S. General Accounting Office, *Tax Policy and Administration: The Research Tax Credit Has Stimulated Some Additional Research Spending (* Washington, DC: The U.S. Government Printing Office, 1989), as compared with J.J. Cordes, "Tax Incentives and R&D Spending A Review of the Evidence, Research Policy, vol. 19, 1989, pp. 119-133.

[26] As described in a recent OECD analysis "If the full value of investments in new equipment is to be gained, then physical and intangible investment should be closely linked. In-firm training and investments in the reorganization of work and in software should accompany physical investment at the firm level, to ensure that equipment is used effectively and that the productivity potential of the equipment is reaped." OECD, op. cit., footnote 24, p. 119.

[27] According to the OECD ". . . a number of countries are now looking carefully at training incentives and incentives to improve human resource management. In some cases, incentives have been introduced to widen firm-based training. Most other expenditures on intangibles (organizational costs, engineering, and marketing) can be deducted from taxable income as they are Incurred, and they are now favored [over physical investment. However, as firm strategies give more emphasis to a whole range of intangibles, the question of whether the balance of government policy investment incentives and disincentives is correct must be addressed" Ibid., p. 133.

[28] M. R. Kelly and H. Brooks, *The State of Computerized Automation in U.S. Manufacturing* (Cambridge, MA: Harvard University Press, 1988).

[29] OECD, op. cit., footnote 24, p. 129.

needs. Like tax incentives, it relies for the most part on "demand-pull" rather than "technology-push" to achieve its ends; in many cases, it is the private sector that initiates, and the government that responds to, funding proposals.[30] To assure an appropriate balance between public and private sector goals, financing is provided on a matching basis.

The Advanced Technologies Program (ATP), administered through the National Institute for Standards and Technology (NIST), provides a good example of this type of research arrangement. ATP, which was established by the 1988 Omnibus Trade and Competitiveness Act, provides small grants to companies or groups of companies to undertake "high-risk, high-return research on precompetitive, generic technologies" that have a good chance of being commercialized. Proposals are generated by the private sector. In evaluating proposals, NIST favors neither specific industries nor technologies; instead, it evaluates projects on the basis of whether or not they are technically superior and show business promise.[31] However, in the projects funded to date, there has been a clear bias in support of proposals from "high-tech" industries such a microelectronics, superconducting materials, and biotechnology .32

The ATP has had a promising start. However, it has not yet demonstrated whether or not the high-risk projects will have enough upstream support to successfully make it to market. One possible constraint may be a lack of funding.[33] To date, ATP funding has been increased from $10 mill ion in fiscal year 1990 to $68.9 million in fiscal year 1993.34 However, had Congress enacted the NIST authorization bill for fiscal year 1994, the program would have received $1.5 billion over a 5-year period.[35]

The Technology Reinvestment Program (TRP), while similar to ATP, is more technology directed. Its aim is to ● 'stimulate the transition to a growing, integrated national industrial capability which provides the most advanced, affordable, military systems and the most competitive commercial products." Although supported by five departments and agencies, TRP is administered through the Advanced Research Projects Agency (ARPA), formerly the Defense Advanced Research Projects Agency (DARPA).[36] TRP's focus is dual-use technologies, but the criteria for project selection

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30 Describing this rationale, Branscomb and Parker note: "In a well-designed program there should be an industry role in choosing, executing and funding projects. Since it is industry that has the ultimate responsibil ity to bring a technical product to fruition, any program that is to succeed in helping industry must be oriented toward industry needs. There is no more effective way to do this than to have industry's input into the decisions that determine the choice of projects." See Lewis M. Branscomb and George Parker, "'Funding Civilian and Dual-Use Industrial Technology," in Branscomb, op. cit., footnote 6, p. 79.

31 Ibid., pp. 82-84.

32 Cohen and Noll, op. cit., footnote 6, p. 2.

33 As assessed by the Committee on Science, Engineering, and Public Policy: "The ATP program has had a promising start. It is not possible, at this early stage, to determine the program's success; nor should congressional or executive branch pol icymakers expect to see immediate, dramatic results. The panel has concluded, however, that the ATP's budget in the past has been insufficient to have a significant impact on U.S. technology commercialization efforts." Committee on Science, Engineering, and Public Policy, *The Government Role in Civilian Technology: Building a New Alliance* (Washington, DC: National Academy Press, 1992).

34 Committee on Technology Policy Options in a Global Economy, *Mastering a New Role: Shaping Technology Policy for National Economic Performance*, op. cit., footnote 20, p. I 06.

35 Ibid., p. 107.

36 These agencies include the Departments of Defense, Commerce, and Energy, as well as the National Science Foundation and the National Aeronautics and Space Administration. In addition to the technology development programs within TRP (which receive 45 percent of all funds), there are programs for technology deployment (which receive 45 percent of all funds), and manufacturing education and training (which receive 10 percent of all funds).

are flexible and in keeping with DARPA's well known and highly commended style of project management.[37] Projects may be joint commercial-military in nature, or they may focus on private technology development and/or engineering education. In all cases, participants are required to contribute 50 percent of the costs. In fiscal year 1993, the TRP received funds totaling $472 million. President Clinton has announced his intention to increase funding to $600 million for fiscal year 1994.

There are a number of advantages to programs that encourage greater private sector participation in the funding, selection, and execution of research and development tasks. Studies have shown, for example, that research and development is more likely to enhance economic growth and productivity when businesses, themselves, play a major role.[38] This is not surprising because R&D is an intangible investment; when businesses conduct R&D, they have greater capacity to innovate and absorb technological advances.[39] A greater role for business is also called for, insofar as R&D is intended primarily to achieve a commercial goal. As the history of U.S. government technology policy makes clear, the federal government has a poor record of anticipating which technologies are 1ikel y to become commercial Successes .x)

One aspect of these programs that merits greater scrutiny, however, are the provisions for intellectual property rights. Unlike previous government R&D programs, which provided that the results remain in the public domain, many new programs transfer all of the intellectual property rights to the participating businesses.[41] This trend may be counterproductive. One of the reasons why government invests in R&D is to reap the gains that result from "knowledge spillovers." The gains may be less, however, if the knowledge generated by R&D is kept proprietary.[42] Establishing intellectual property rights is especially important in the development of networking technologies. These rules will not only have an impact on firms doing research; they may also have a negative affect on standardization and network interoperability.[43]

OPTION C: Stimulate the Market by Leveraging Procurement Powers

Government procurement combines the effects of "technology push" and "demand pull." Because the federal government is one of the largest purchasers of both communication and information technologies, it has considerable leverage in these markets. Using this leverage, the government can influence the design, development, and deployment of technologies to support electronic com-

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[37] DARPA was established within the Department of Defense in 1958 in response to the Sputnik Crisis. Its goal was to foster "advanced projects essential to the Defense Department's responsibilities in the field of basic and applied research and development which pertains to weapons systems and military projects." As described by John Alic et al,: "DARPA is unique within the Defense Department in that it has a minimum of administrative layering and gives its program managers wide discretion to support technologies they consider promising. It operates no laboratories of its own, and until 1987 did not even have the ability to execute its own contracts, relying instead on the services to act as its contracting agents." Alic et al., op. cit., footnote 6, p. 138.

[38] See OECD, op. cit., footnote 24, p. 127.

[39] Ibid. see also Mowery and Rosenberg, op. cit., footnote 3.

[40] Cohen and Noll, op. cit., footnote 4.

[41] Using the Advanced Technology Program as an example, Cohen and Noll point out: "ATP originally emphasized 'generic Pre-competitive' research. however, the emphasis is now on 'high risk' research. In line with its competitiveness angle, ATP keeps the details of its projects proprietary. Any resulting patents are owned by participating companies, although the government retains 'march-in rights'" (i.e., It can take away patents if the contractor fails to commercialize the technology within a specified period of time) and can require the contractor to license its new technology." Cohen and Noll, op. cit., footnote 6, p. 3.

[42] Ibid.

[43] Joseph Farrell, "Standardization and Intellectual Property," Hoover Institute Working Paper No. ED-89-25, August 1989.

merce, The government's demand can have an impact either directly, through the creation of new products and industries, or indirectly, through the knowledge spillovers that occur when new products and processes are more widely diffused throughout the economy.[44]

The impact of government procurement on the development and evolution of communication and information technologies has been greatest in the area of defense. It was, in fact, to meet its wartime needs that the federal government first turned to the private sector to develop technology.[45] Mirroring defense needs, funding was concentrated in specific industries, such as aircraft and missiles (50 percent) and electrical equipment (25 percent). This allocation favored communication and information technologies, which account for almost the entire electrical equipment category.[%]

Leveraging DOD's procurement power has proved especially effective in the case of new and rapidly advancing communication technologies.[47] *Had emerging businesses not been able to* count on the DOD for a large, guaranteed market, many industries would have been unable to rally the sizable investments required to develop such state-of-the-art technologies as early satellites, computers, and semiconductor chips. 48 Having a large market in the early stages of product development may also have helped to lower the barriers to entry, increasing competition and allowing many small and innovative companies to share in the defense contracting market.[49] Knowledge spillovers were also greatest in the earliest stages of technology development when military and civilian needs overlapped.

With the shift in the focus of national priorities from security to economic competitiveness, defense procurement has become an increasingly inadequate mechanism for promoting communication and information technologies. As these technologies have matured, civil and defense applications have diverged. Greater tradeoffs between them are now required and there are fewer knowledge spillovers. Moreover, high-risk, advanced technologies—the area of development in which DOD has excelled the most-do not constitute a major barrier to the evolution of electronic commerce. There is, however, a need for more

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44 Cohen and Noll, op. cit., footnote 4, p. 16.

45 As Mowery and Rosenberg point out, until 1940, most government research and development was carried out by the civil service in agencies such as the National Bureau of Standards, the Department of Health Services, or by state institutions financed by federal grants such as agricultural experiment stations. Op. cit., footnote 3, p. I 23.

46 Recently, however, there has been a shift from public sector funding to private sector funding of these technologies. Ibid., p. 137.

47 See Alic et al., op. cit., footnote 6.

48 Describing the case of integrated circuitry, Mowery and Rosenberg note: "'The large procurement needs of the military and NASA and the increasing concern with the importance of miniaturization were vital in the early years of new product development in electronics. The Signal Corps was the largest military purchaser of semiconductors in the early and mid 1950s. . . . In the first year of integrated circuit production, the federal government purchased the entire $4 million of output. It remained the largest buyer for the first 5 years, although the government share declined rapidly. . . . By the end of the I %0s, the rapidly growing computer industry displaced the military as the largest end user market for integrated circuits. " Mowery and Rosenberg, op. cit., footnote 3, p. 145. See also, Richard R. Nelson (cd.), *Government and Technical Progress: A ~'rc~,~.s-ltl~lli.sir? Analysis* (Elmsford, NY: Pergamon Press, 1982); and Kenneth Flamm, *Creating the Computer: Government, Industry, and High Technology* (Washington, DC: Brookings Institution, 1988).

49 Ibid.

rapid and effective technology diffusion within commercial settings. In this area, DOD's record is not particularly strong.[50]

This is not to say that DOD has no role to play in the promotion of electronic commerce. As a major government buyer, DOD can lead the way in using networking technologies for both product development and commercial exchange. Within DOD, efforts are already underway to promote a commercial infrastructure to support electronic commerce through the Continuous Acquisition and Life-Cycle Support (CALS) initiative. Originally fashioned to provide DOD computer-aided logistical support, this effort has recently been expanded and reconceived as a technical, standards-based platform to support enterprise integration and electronic commerce.[51] Linking DOD to its suppliers and its suppliers to one another, CALS fits well into the technology policy shift from defense to dual-use technologies.[52]

In like fashion, the General Services Administration (GSA), which is responsible for $10 billion in annual purchases, can take advantage of networking technologies to enhance its procurement process. Network technologies for electronic commerce are coming on line at the precise moment when many people are proposing new ways to restructure GSA's procurement operations. Just as many businesses are using networking technologies to help them reengineer for higher performance, GSA could employ these technologies as a catalyst for organizational change,[53]

OPTION D: Directly Fund, Develop, and/or Provide Needed Technologies and Technology-Related Services

Government can also help to stimulate electronic commerce using a "technology-push" strategy. Although such an approach was common in the past, it is likely to be less applicable in the future. There is no longer a single communication "network" to support. Instead, networks are comprised of a variety of converging digital technologies that are being unbundled and repackaged for sale by a wide variety of competing industry players. As past experience indicates, when widespread diffusion and continuing innovation are the goal, a technology-push strategy will not suffice. However, with these limitations in mind, such an

[50] As described by John Alic "Defense's way of doing business provides little guidance for coping with the pressures of the new international economy. Defense technologies take their cues from government "requirements, not from a competitive market. DoD emphasizes functional performance objectives over schedule and cost; one consequence is that it spends five times more on R&D, as a fraction of total system costs, than commercial firms do. Major defense projects extend over a decade or more, much longer than in civilian industry. Defense programs tend to follow a 'pipeline' progression, in which a separately funded and managed R&D phase precedes production. In contrast, commercial businesses are constantly improving their products, pursuing R&D in parallel with production and feed in new technology incrementally." Alic et al., op. cit., footnote 6, p. 17.

[51] As described in the CALS Strategic Plan: "... official definitions of CALS have had a difficult time keeping up with 'CALS, the concept.' Initially, about 1985, CALS focused on *logistics* as computer-aided logistics support." Over time, CALS technologies were extended to include weapons acquisition systems, so that by 1988 CALS came to be defined as a "computer-aided acquisition and logistics support." Later, when design processes were included together with weapon systems production and support processes, giving rise to the discipline of concurrent engineering, CALS was renamed CALS CE. Most recently, CALS has been redefined as "computer-aided acquisition and logistics support" to take into account advances in other information technologies, such as electronic data interchange. DOD, "CALS Strategic Plan," Final Coordination Draft, Oct. 28, 1993.

[52] As described by Brian Kahin "CALS encompasses a broad set of standards development activities undertaken in conjunction with NIST and the private sector. CALS seeks to develop dual-use standards that will enable DOD to build on the civilian technology base while implementing a DOD-wide platform for automating weapons design, procurement, deployment, and maintenance. Thus CALS supports integration between the defense economy and the civilian economy, between DOD and its contractors (and subcontractors), and among the fragmented and bureaucratized procurement and logistics offices within the different services of the United States military." Brian Kahin, "Information Technology and Information Infrastructure," in Branscomb, op. cit., footnote 6, pp. 141-142.

[53] For a discussion of GSA's role in procurement and its use of information technologies, see U.S. Congress, Office of Technology Assessment, *Making Government Work: Electronic Delivery (Federal Services*, OTA-TCT-578 (Washington. DC U.S. Government Printing office, September 1993).

approach can serve to "prime" the development and deployment processes at the outset, demonstrate the viability of new technologies and applications, and meet social needs for which a market is unlikely to develop.

Technology-push strategies are generally mission oriented and often closely linked to the agencies charged with executing a specific goal. Thus, the goal of fuel efficiency is associated with the Department of Energy, space exploration with the National Aeronautical and Space Administration (NASA), and weapons production with DOD. In contrast, because communication and information technologies are used to support so many different kinds of activities, a number of agencies have supported their development. These include NIST, the National Science Foundation (NSF), NASA, ARPA, several government laboratories, the National Library of Medicine (NLM), and more recently the National Telecommunications and Information Administration. With the recent emphasis on competitiveness issues and defense conversion, however, many now look to ARPA to play a lead role.[54] This tendency will likely be even more pronounced in the case of electronic commerce because ARPA has strong programs to support the development of both networking and manufacturing technologies.

One ARPA-originated program that is often held up as a model for "technology-push" strategies is the Internet (previously ARPANET). Although government provided the initial funding, the private sector will be able to assume more of this responsibility as the network gains critical mass. While clearly a model of success, the case of the Internet also points to some policy issues that can be associated with technology-push strategies.

The Internet is a global computer network that provides technical compatibility and transparent connectivity based on a widely used suite of protocols-TCP/IP[55] (see box 4-5 in chapter 4). It is currently comprised of approximately 5,000 networks to which 500,000" computers are connected. [56] Originally funded through ARPA, and later NSF, to support defense communication and research, the Internet today serves as a worldwide communication network that provides a platform for the del ivery of a wide range of services, a number of which are now being provided on a commercial basis.

As the only nonproprietary global network capable of providing technical compatibility and transparent connectivity, the Internet rapidly grew in size. By the late 1980s, the university market had reached a saturation level and commercial de-

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[54] For a detailed description of the history and activities of ARPA, see "ARPA: A Dual-Use Agency," in OTA, *Defense Conversion*, op. cit., footnote 7. Describing ARPA's growing popularity, the OTA report notes: "ARPA's reputation for successfully identifying and supporting risky technologies with significant king-term benefits has led some people to suggest that the agency be given broader purview over technology development, While some proposals have called for removing ARPA from DOD and giving it a civilian mission, most have pushed for a more explicit broadening of ARPA's dual-use responsibility while keeping it within DOD. . . . The 1993 Defense Authorization Act also expressed a sense of the Congress that DARPA be renamed ARPA, with responsibility for researching innovative technologies applicable to both dual-use and military missions, and for supporting development of a national technology base. President Clinton implemented the first portion of this recommendation, renaming the agency ARPA in March 1993." p. 142.

[55] As described by Brian Kahln: "The Internet is defined functionally rather than institutionally. It Is the set of interconnected networks that support the interoperation of three basic functions: remote log-in, electronic mail, and file transfer. It is not limited to TCP1P networks; networks supporting 0S1 or other protocols are part of the Internet if they interoperate with the predominant TCP 1P Internet through protocol conversion." Brian Kahin, "In nformation Technology and Information Infrastructure," ch. 5, in Branscomb, op. cit., footnote 6, pp. 135-167.

[56] See Toni Valovic, *Corporate Networks: The Strategic Use (~' Telecommunications* (Boston, MA ArtechHouse, Inc., 1992), pp. 116-165. The Internet is organized hierarchically. At the top are the backbone networks, the largest of which is NSFNET. At the next let'el down are the mid-level network, which support regional connectivity. At the bottom are local networks, based in specific institutions. The Internet authority structure is very loosely coupled. Although each network is responsible for connectivity to the next higher level, administrative decisions are decentralized and individual networks are therefore highly diverse. See Hay Habegger, "Understanding the Technical and Ad]] inistrative Organization of the Internet," *Telecommunications*, February 1992, pp. 12-13.

mand was on the rise .57 Once demand had reached this critical mass, firms entered the market to meet it.[58] one key player, for example, was Advanced Network Services (ANS)—a nonprofit joint venture between IBM, MCI, and Merit Networks—which was established in 1990 to operate the NSF backbone. In May 1991, ANS spun off a for-profit subsidiary, ANS CO+RE Inc., to develop a T3 Internet backbone. The subsidiary would be allowed to sell the excess capacity to commercial users. Equally important, in 1991, Performance Systems International (PSI), BARRNET, CERFnet, and UUNET Technologies (later followed by Sprint) joined together to form the Commercial Internet Exchange Association (CIX) to provide interconnect ion between their commercially oriented services. Today, 60 percent of all registration domain names on the Internet are those of commercial organ izat ions .[59]

While allowing the government to reduce the level of its financial support, commercialization of the Internet also raises a number of issues. For example, some people in the research community began to protest that their networking costs were likel y to increase. Others were alarmed that the decentralized, collegial structure. which has characterized the administration of the Internet, could not survive in a commercial environment. They questioned how researchers' needs for openness and accessibility would be traded off against business needs for data security, and whether—in a cost-based, commercial environment—significant emphasis would be placed on deploying the most advanced, cutting-edge technologies.[60]

The commercialization of the Internet also raises a number of regulatory issues. Because the Internet now functions as a ubiquitous worldwide data network, decisions must be made about its relationship to other aspects of national communication policy.[61] Issues will also need to be resolved with respect to the providers of services. Because of ANS's early role in managing the Internet, some have accused NSF of favoritism in its selection of providers.[62] As commercialization makes Internet traffic increasingly more lucrative, competition—and the debate over the rules that govern it—will also become more and more intense.

The Internet experience may prove to be much less transferable than many have surmised. Its rapid growth was due not only to common standards and government support, but also to the

[57] Alton Hoover, "Scenarios for Internet Commercialization," *Tele({~nln]l~nil{lt/ens,* February 1992, p. 19.

[58] See, for discussions, William Schrader anti Mitch Kapor, "The Significance and Impact of the Commercial Internet," *Telecommunications,* February 1992, pp. 16-17, Hoover, op. cit., footnote 57, pp. 18-19; Gary H. Anthes, "Commercial Users Move (into Internet," *Computerworld,* Nov. *2.5, 1991,* p. 50. and Ellen Messmer, "Industry Asks for NREN To Support Commercial Needs," *Network World,* Oct. *9, 1991,* pp. 4, 43.

[59] Schrader and Kapor, op. cit., footnote 58, p. 17.

[60] See Susan M. Eldred and Michael McGill, "Commercialization of the Internet/NREN: Introduction," *Electronic Networking: Research, Application \ and Policy, v{)],* 2, No. 3, fall 1992, pp. 1-2.

[61] As described by Kozel "How the more commercialized Internet will be regulated is itself being debated. The Internet has evolved with little regulation other than the good manners implicit m peer pressure and self-policing among equals. This system may not hold up in an era when commercial users paying for service inevitably have problems that need to be arbitrated. Closely monitored FCC-type regulation is not likely, yet the need for an authority to resolve such problems is already at hand.'" Edward R. Kozel, "Commercializing the Internet: Impact on Corporate Users," *Telecommunications,* January 1992, p. I I.

[62] Sharon Fisher, "Access Providers: ANS Has Unfair Edge," *Communications Week, Dec. 23, 1991,* p. 5. As Branscomb and Parker have pointed out, fairness is especially important in mission-oriented research and development. As they note: "In these cases the assumption is usually made that the desired activities will ultimately he carried out by the private sector. The justification for such R&D is compensation for externalities the market does not adequately address. The constraint on the appropriateness of federal R&D investments, once Congress has authorized the program, is supplied by standards of effectiveness and fairness."' Lewis Branscomb and George Parker, "Funding Civilian and Dual-Use Industrial Technology, In Branscomb, op. cit., footnote 6, p. 68.

unique environment in which it blossomed.[63] The first community of users were highly skilled, technical people who tend to be early adopters of new technologies. These users were also contributors to the design and development of the Internet, an ongoing and innovative process that continues today. Although this factor was probably essential to the Internet's success, it may also be the most difficult aspect of the Internet model to replicate.

Building on its past efforts to promote the Internet, the government is now supporting a number of projects that are designed to develop applications that will run over the Internet or other value--added networks. Many of these relate to electronic commerce. For example, in 1991, the Air Force initiated a program to develop an electronic procurement system called Government Acquisition Through Electronic Commerce (GATEC). This project is part of a larger ongoing joint effort started in 1989 by DOD and Lawrence Livermore National Laboratory (LLNL) entitled "Electronic Commerce through Electronic Data Interchange (EC/EDI)."[64]

GATEC capitalizes on LLNL's complex systems integration and computer security expertise and successful technology transfer. The technology, now fully deployed and in use with hundreds of vendors at Wright-Patterson Air Force Base, is wholly government-owned and employs the services of seven value-added networks (VANS). It is interesting to note that VANS were used for the convenience of small suppliers who could neither afford the cost of direct Internet access nor handle its complexity. GATEC's innovative design with off-the-shelf gateways and personal computers permits the exchange of e-mail-based electronic data interchange without regard to the specific hardware and software systems used.

Government may also choose to develop products and services that meet specific social goals to which the market is unlikely to respond. One such project, for example, is the Visible Human Project. This project is funded through the federal High Performance Computing and Communications Program as one of its Grand Challenges. Participants will create an electronic "image library" consisting of three-dimensional images of the male and female body, which will be accessible through computers and computer networks.[65] Over the longer term, it will link the structural-anatomical data depicted by images to the functional-physiological knowledge that exists in text-based databases.

The designers of the Visible Human Project deliberately chose to have the government fund the database development costs in their entirety. Four principles governed this decision: 1) medical information is a public good and should be readily accessible; 2) the quality and integrity of NLM's data must be protected at all times; 3) American health professionals should have equal access at equal prices to this information; and 4) to the degree possible, the costs of gaining access should be shared appropriately by the biomedical community.[66] To assure Widespread availability, users

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63 Hoover, op. cit., footnote 57.

64 DOD has invested about $15 million in the EC/EDI projects over 4 years, with about 20 percent of it having ken spent on the GATEC pilot site.

65 In the first phase, the University of Colorado, under contract, will supply Computerized Tomography (CT), Magnetic Resonance Imaging (MRI), and cryosection images of a representative male and female cadaver at an average of one millimeter intervals. This data will occupy about 70 to 80 CD-ROMs and will likely be made available via the Internet. National Library of Medicine, "The Visible Human Project," Fact Sheet, April 1993.

66 National Library of Medicine, "NLM Policy on Database Pricing," January 1993.

will be charged an access fee that is set at "the lowest feasible price."[67]

Even when serving the interests of the public-at-large, government funding of these kinds of information services can create problems with the private sector, especially if the information has economic value. Although the government has met with little resistance in the case of the Visible Human Project, it has encountered problems in developing other medically related databases that contain information about medical devices or drugs that might be considered proprietary. Concerns about proprietary rights in information have, for example, forestalled efforts by the NLM to begin a clinical trials database. Many of these trials are sponsored by drug companies who consider even general knowledge about the existence of the trial to be proprietary.

When funding social programs, issues will necessarily arise with respect to making choices between social goals. Because there are no formally agreed-upon criteria, decisions are often politically based, depending on which constituencies have the most financial resources and political power. As a result, some groups have been underfunded compared with others. Among them are small businesses, nonprofit organizations, and labor. Although NTIA has recently established a grant program to help nonprofits establish interconnection through the national information highway, this program calls for matching funds of 50 percent. This requirement may well be beyond the means of many organizations, and may defeat the program's purpose.

[67] In 1989 the Board of Regents, the civilian oversight body for NLM, put together a blue-ribbon panel on electronic imaging. This panel recommended that the project be completely funded by government on the grounds that medical information should be readily accessible to all. National Library of Medicine, Board of Regents. "Electronic imaging: Report of the Board of Regents," U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, NIH Publication 90-2197, 1990.

Educating for Technology Transfer

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The federal government's role in promoting information dissemination, science and technology, and education has its origins in the Constitution: the first amendment guarantees freedom of speech and press; article I, section 8, authorizes the federal government to grant intellectual property rights: and article I, section 8, paragraph 7, permits the government to build postal roads. [1] The federal government used the postal provisions to subsidize the distribution of news in the late 1700s. [2] After the Civil War, the federal government played a major role in the development of libraries and the American public

Just as the government helped American farmers adjust to the industrial revolution, so, today, many call on it to better prepare American businesses to compete in a knowledge-based global economy.

[1] The American attitude toward information dissemination differed radically from that in Europe w here the ruling monarchs regarded it with considerable alarm. However, building a nation required the establishment of communication l inks, the development of a unified market, the forging of a common culture, and the bu i lding of a democratic polity. The w idespread flow of information was considered essential to accomplish these tasks.

[2] See Richard B. Kielbowicz, "'New slathering by Printers' Exchanges Before the Telegraph," *Journalism History*, vol. 9, summer 1982, pp. 42-48, and Samuel Kernell, "The Early Nationalization of Political News in America," *Studies in American Political Development (New* Haven, CT Yale University Press, 1986), pp. 255-278.

[3] In the United States. libraries have always been regarded as popular educational institutions. Like the public schools, they derived their support from the public education and reform movements that developed after the Civil War. Traveling libraries were founded to bring news and reading materials to rural areas where book deposit stations were set up in grange ha] ls, neighborhood stores, fire stations, and women clubs. In ci - ties, libraries were established not only to provide access to books, but also—like the settlement houses—to provide a haven and adult education programs for a growing number of working class immigrants. These libraries developed rapidly during the post-Civ II War period, and c\ en continued to thrive in the depression years. See V. H. Mathews, *Libraries for Today and Tomorrow* (Garden City. NY: Hippocrene Books, 1976).

school system.[4] Toward the turn of the century, "t became more active in promoting science and technology, especially through the university sys-(em.[5]

These overriding values helped to structure the federal government's response to the agricultural crisis that followed the Civil War and the challenges posed by industrialization.[6] To help farmers adjust to the structural changes in the economy, the government began to develop and transfer modem technology to agriculture.[7] Working through the Department of Agriculture, the federal government established four complementary programs:

1. land grant colleges;
2. support of agricultural research at agricultural experiment stations;
3. making basic information on farm and home problems available to people through extension services: and
4. providing vocational training on agricultural problems, home economics, and industrial subjects.

Just as the government helped American farmers adjust to the industrial revolution, so, today, many call on it to better prepare American businesses to compete in a knowledge-based global economy.[8] Drawing on the success of the government past experience, there are a number of options that might be pursued today.

OPTION A: Expand the Program for Extension Services

Federal extension services have a long history in the United States, dating to 1914 with the passage of the Smith-Lever Act.[9] This act, inspired in part by the Country Life Commission, focused on agriculture and the problems of rural areas. It authorized partial federal funding for a nationwide extension program modeled after private, state, and

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[4] The American commitment to public schooling" grew in the wake of the Civil War. This commitment was so intense that it gave rise to a national crusade to establish public schools. Concerned about the problems of reconstruction in the South, the influx of Catholic immigrants, and the advent of industrialization in the North, Americans saw pub] ic schooling as a way of preserving the social, economic, and political order. See Rush Welter, *Popular Education and Democratic Thought in America (New* York, NY: Columbia University Press, 1962); and David Tyack and El izabeth Hanson, "Confl ict and Consensus in American Public Education," *America's Schools: Public and Private, Daedalus*, summer 1981.

[5] See Edward Shils, "The Order of Learning in the United States from 1865- 1920: The Ascendance of the Universities," *Miner\ 'a,* vol. 18, No. 2, summer 1978.

[6] As Wayne Rasmussen has described it: "The revolution generated by the Civil War catapulted the nation's farmers not only into a new era of mechanization but also into a world of complex social and economic forces that were too volatile and powerful for individual farmers to confront by themselves. It seemed that the appearance of more complex and productive tools intended to guarantee the farmer's survival had made that survival more complex." Wayne D. Rasmussen and Paul S. Stone, "Toward a Third Agricultural Revolution," in Don F. Hadwiger and Ross B. Talbot (eds.), *Food Policy and Farm Programs,* Proceedings of the Academy of Political Science (New York, NY: The Academy of Political Science, 1982), p. 179.

[7] The idea that knowledge could i$_{mprove}$ agriculture was first put forward by agricultural societies composed Of well-to-do gentlemen farmers, farm journalists, and some educators. Such citizen advocacy was bolstered by public agencies and private agricultural interests that acted in mutually supportive ways. These public agencies included the U.S. Department of Agriculture and the land-grant colleges. The private interests Included general farm organizations as well as commodity groups. Wayne D. Rasmussen, *Taking the University to the Peep/e: Seventy-Five Years o/ Cooperative Extension* (Ames, 1A: Iowa State University Press, 1989), pp. 8-22. See also David E. Hamilton, "Building the Associative State: The Department of Agriculture and American State-B uilding," *Agricultural History, vol. 64,* pp. 209-218.

[8] See, for a discussion, U.S. Congress, Office of Technology Assessment, *Making Things Better: Competing in Manufacturing*, OTA-ITE-443 (Washington, DC: U.S. Government Printing Office, February 1990). See also, Joe Janmesurak, "priority #1: Fix Industrial Infrastructure," *Appliance Manufacturer*, vol. 40, No. 10, October 1992, p. 92.

[9] Among extension services, for example, were Deaman Knapp's "demonstration farms," on which farmers could learn by watching and doing, and 'movable schools' such as George Washington Carver's Tuskegee mule-driven wagons full of new seeds, farm machinery, and dairy equipment, as well as boys' and girls' clubs through which it was hoped parents could be educated. See Hadwiger and Talbot, op. cit., footnote 6.

local efforts that provided education and information to rural communities.

Building on these ongoing efforts, the Cooperative Extension Service (CES) brought together a wide range of players and encouraged cooperation among them. The U.S. Department of Agriculture (USDA) and the land-grant agricultural colleges were charged with management of the program, while the costs were shared by the states, counties, and county organizations of innovative farmers, called farm bureaus. In addition, partnerships were established between university extension and experiment stations, and between county extension agencies and county farm bureaus. [10] Later on, extension people helped to start other farm organizations called commodity organizations. The experiment stations also formed links with the farm bureau and with the commodity groups so they could better understand the research needs of producers. Leadership for this public-private network was recruited from graduates of the agricultural colleges. Within a few decades, this elaborate network of players had achieved its goal of farm modernization. The quality of farm life had also been improved through access to home economics and farmer information services. [11]

Industrial extension, like agriculture extension. originated at the state level.] [2]However, it did not receive national focus until 1989 when Congress established three Manufacturing Technology Centers (MTCs)[13] and a State Technology Extension Program (STEP) [14] to be administered by the Department of Commerce's National Institute of Standards and Technology (NIST). [15] Today there are seven MTCs located throughout the United

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[10]The county agencies organized the farm bureaus, which in turn formed state and national farm organizations, thereafter becoming the Extension Service's link with political supporters as well as farmers.

[11]At present, the Cooperative Extension Service (CES) provides education, information, and technology transfer on numerous topics relevant to fanning and agriculture generally. The scope extends to many topics that are germane to rural development. CES has the advantage of many extensive state and county networks of land-grant colleges, extension agents, and field experiment stations to disseminate information and education. CES has interpreted its statutory mandate as extending to the general health of rural America, and has now developed its own rural development strategy in coordination with the U.S. Department of Agriculture and government-wide rural revitalization initiatives. See OTA, *Rural America at the Crossroads: Networking for the Future*, OTA-CIT-471 (Washington, DC U.S. Government Printing Office, April 1991), and Robert E. Chapman. Marianne K. ('lark. and Eric Dobson, "Technology-Based Economic Development A Study of State and Federal Technical Extension Services," National Institute of Standards and Technology, Special Publication #786, June 1990, p. 7.

[12]One of the largest of these efforts is the Industrial Extension Service established in 1956 at Georgia Institute of Technology)". Only in 1964 did the federal government become involved on a very limited basis, disseminating technical information to manufacturers through programs operated by individual states. Other programs were run independently of universities through state development agencies. See Chine R. Simons, "Industrial Extension and Innovation," in Lewis M. Branscomb (cd.), *Empowering Technology: Implementing a U.S. .! rategy* (Cambridge, MA The MIT Press, 1993), pp. 171-172.

[13]Today these include: 1) the Northeast Manufacturing Technology Center, located in Troy, NY; 2) the Southeast Manufacturing Technology Center in Columbia, SC; 3) the Great Lakes Manufacturing Technology Center in Cleveland, OH; 4) the Midwest Manufacturing Technology Center in Ann Arbor, MI; 5) the Mid-America Manufacturing Technology Center in Overland Park, KS; 6) the California Manufacturing Technology Center in Torrance, CA; and 7) the Upper Midwest Manufacturing Technology Center in Minneapolis, MN. U.S. Department of Commerce, Technology Administration, National Institute of Standards and Technology, "Helping Manufacturers Build a Technological Advantage," March 1993.

[14]The State Technology Extension Program (STEP) helps states to develop industrial extension programs and a modern infrastructure to serve the needs of small and medium-sized businesses. It also funds planning grants for states, and follows up with support for implementation. In addition, the STEP program develops tools that state programs can use to provide client services.

[15]The manufacturing technology centers were established under the Omnibus Trade and Competitiveness Act of 1988. As described by Simons, "Congressional interest in implementing a federal technology policy during the Bush administration resulted in several small programs under the Department of Commerce. or-w of these, the Manufacturing Technology Centers (MTC) program, is based on the premise that smaller manufacturers are the foundation of (1. S. industry. The designers of the MTC program defined the technological improvement of the smaller manufacturers a\ a necessary precursor to the resurgence of U. S, manufacturing " S imons, "Industrial Extension and Innovation," in Branscomb, op. cit., footnote I 2, p. 167,

States. Their task is to enhance productivity and technology performance in U.S. manufacturing through the transfer of manufacturing technologies and techniques. However, each employs a somewhat different approach to meet its own area's special needs. For example, the Midwest MTC, located at the Industrial Technology Institute in Michigan, has a strong industry focus, reflecting the presence of the automobile industry. The Southeast Manufacturing Technology Center, which is situated on the campus of the University of South Carolina, caters more to the needs of small, rural manufacturers. [16]

Although modeled after the CES, the industrial extension program does not have comparable federal funding. In 1992, for example, the CES was budgeted at $1 billion, $400 million of which was provided by the federal government. In contrast, industrial extension was budgeted at $80 million, with the federal government providing only $17 million.[17] Thus, it is not surprising that the CES has 3,140 offices located throughout the country, whereas industrial extension has offices in only 20 states.[18]

Federal funding might increase in the future, however, given the growing popularity and bipartisan support for technology transfer programs.[19] This support was most recently confirmed in March 1993 when the Advanced Research Projects Agency (ARPA) announced the Technology Reinvestment Program (TRP), which will receive $472 million of reprogrammed fiscal year 1993 Department of Defense (DOD) funds .20 The MTC program is now incorporated in the TRP and budgeted at $87 million.[21]

Despite their limited resources, the MTCs have received considerable praise for their accomplishments during their first 4 years.[22] Using a variety of outreach mechanisms, they have provided support to more than 6,500 small manufacturers, who claim to have received $250 million in added benefits.[23] Among the many programs they provide are individual project engineering, [raining courses, demonstrations, and assistance in selecting and using software and equipment. Some MTCs have also conpiled large databases of computer-aided design and computer-aided manufacturing software, which can be run for business c1ients using MTC hardware. A number of demonstration facilities display how automated machining processes-such as automated metalworking equipment, robotics, and state-of-the-art

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[16]National Institute of Standards and Technology, "A Collection of Successful Interactions Between the MTCs and Client Firms," U S. Department of Commerce, Technology Administration, NIST SP 848, March 1993.

[17]Most federal funding is used to support the MTC program, administered through NIST. Jim Treece, "Observing Production," *Production*, October 1993, p. 32. As noted by Gene Simons". .compared to similar programs in other countries, such as Japan's program funded at $500 million per year, the U.S. federal role was quite small." In Branscomb, op. cit., footnote 12, p. 170.

[18]Ibid.

[19]As Simons points out: "The Bush Administration's position on technology for industrial policy appeared to shift in 1992, when the Undersecretary for Technology, Robert White, issued the Technology Administration's 'Strategic View.' This report proposed expanding the MTC program to 30 large centers and 100 small centers over the next 8 years. Bipartisan support developed when Governor Clinton promised in his platform to expand the MTC program to 170 ""n~iirkcl driven" centers and to provide support for improving state extension operations. In October 1992, Senator Bingaman proposed in the Department of Defense budget revisions to spend $540 million in fiscal year 1993 on state and federal initiatives." I bid., p. 169.

[20]For a description of this program, see ch. 5.

[21]If passed, the National Competitiveness Act (HR 5757/S4) would provide an additional $150 million to the Department of Commerce in support of NIST extension services. The amount targeted for 1996-97 is $500 million.

[22]Marianne K. Clark and Eric N. Dobson, "'Increasing the Competitiveness of America's Manufacturers A Review of State Industrial Extension Programs," Center for Policy Research, National Governors' Association, Washington, DC, 1991

[23]Ibid.

coordinate-measuring machines-can be used. Two of the centers have mobile demonstration facilities[24] (see box 6-1).

With additional funding, MTCs will be able to expand their in-house capabilities; they will also be better able to link up with, and leverage the expertise of, other federal, state, local, and private sector organizations that are involved in similar activities.[25] Recent legislative proposals would facilitate this kind of interaction because the concept of extension is now much more broadly defined.[26] This would allow for greater sharing of resources and expertise. This kind of cross-fertilization proved critical for agricultural extension, and it will be a major factor in assuring the success of industrial extension.[27]

New types of nonprofit and professional organizations are already emerging to fill this need. The Modernization Forum, for example, generates interactions among the MTCs and refers them to other experts and organizations with relevant interests and needs.[28] Similarly, the National Center for Manufacturing Sciences, which promotes technology adoption through "teaching factories," hopes to partner with the MTCs, providing services as needed on a nationwide basis. [29]

Much of this interorganizational, interagency cooperation could occur electronically, online. This could greatly reduce the costs of providing extension services. The expenses entailed in establishing such a network would be small because many agencies are already investing in networking. A networked extension program might also facilitate the dissemination and integration of agency research, allowing it to be more rapidly diffused and effectively employed in the exten-

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[24]Ibid., pp. I -3.

[25]For a discussion of one such plan, see U.S. Department of Commerce, Technology Administration, National Institute of Standards and Technology, "Manufacturing Extension Partnership," summer 1993.

[26]As Simons pints out: "For example, the DOD authorization bill defines manufacturing extension as any 'public or private nonprofit program for the improvement of the quality, productivity, and performance of small manufacturing firms.' And the proposed National Competitiveness Act includes federal, state, and local agencies as well as universities, schools, laboratories, small business development centers, professional society programs, and industrial organization, as qualifying outreach centers. . . .

As this broad range suggests, industrial extension within the federal lexicon now refers not (rely to the more traditional concept of agents making in-plant visits as consultants and trouble shooters, but also institutions such as community and technical colleges and worker training Institutes to which manufacturing firms could send their employees. Hundreds of these institutions are already operating across the country, and with federal backing, could be the nucleus of the expanded national network of industrial extension. " In Branscomb, op. cit., footnote 12.

[27]As described by Clark and Dobson, with reference to agriculture extension services" "The development of linkages to other service providers and sources of technical expertise is critical to success. Although the programs differ in terms of how narrowly or broadly defined their services, all indicated the need to work with and provide access to other service providers. Extension programs often refer firms to SBA-supported Small Business De\ elopment Centers for help with marketing or management, to community colleges for training. and to universities for research and development." Op. cit., footnote 22.

[28]The Modernization Forum was established by the MTC directors to support their collaborative projects and learning and to give them a common voice in working with others.

[29]Ibid. The National Center for Manufacturing Science (NC MS) is a membership research and development consortium that serves both large and small firms in a broad range of Industries. Its only mandate is to aid U.S. member firms to become internationally competitive in manufacturing. Under its 50 I (c)(3) status, NCMS must make its research results reasonably a\ ail able to the public. Member firms define research projects and develop the research. Member firms also have first call on research results. Member firms will be 1 icensed to use the technology developed at lower fees than nonmember firms in order to offset their in-kind par-t icipation in the research process and their membership fees that help to fund the research.

BOX 6-1: NIST's MTCs Respond to the Needs of Small Manufacturers

Rapid changes in manufacturing and Information technologies and business practices have left many small manufacturers struggling to keep up Without the cushions of large capital and human resources, they are frequently left to make do with shoestring budgets and seat-of-the-pants decisionmaking The NIST Manufacturing Technology Centers (MTCs) are responding to specific business needs with a variety of assistance services such as Implementing total quality standards, pooling demand for expensive resources, and helping small businesses grow

For example, to help suppliers meet competitive demands for higher quality, the MTCs are working with client firms to register and qualify for the new European IS0-9000 standards [1] Manufacturing Development, Inc (MDI), of Cheney, Kansas, a small company with 25 employees and $1 5 million in annual sales, worked with the Mld-America Manufacturing Technology Center (MAMTC) to Implement the D1-9000 quality standard [2] An MAMTC field engineer and the company's president and vice-president together arranged for incorporation of statistical process control (SPC) techniques Training for all employees was arranged through classes taught by an MAMTC quality coordinator and the cost of training was offset through a Kansas Industrial Retraining (KIR) grant provided by the Kansas Department of Commerce and coordinated through the MAMTC Through this effort MDI was approved as a D1-9000 supplier, and subsequently realized savings of $132,000 for the year

Currently, thousands of Industrial sales in Europe, compared with a few hundred in the United States. are registered under ISO 9000, which is predicted to become a de facto prerequisite for doing business in Europe In Troy, NY, the Northeast Manufacturing Technology Center (NEMTC) established a pilot ISO 9000 registration program which Includes seminars, workshops, onsite visits to manufacturing facilities, and step-by-step training modules In 10 sessions over the course of a year, client firms, in collaboration with each other and the Quality Systems Resource Facility (QSRF) at NEMTC, prepare for the third-party registration audit This pilot program is anticipated to serve as a model for other MTCs

Another small business need that MTCs help provide is access to expensive specialized equipment or services that small businesses can only afford on a fee-per-use basis Frequently, as was the case for Fortitech, Inc of Schenectady, NY, this is for experimenting with or consulting for new computer systems Fortitech is a business that blends minerals, vitamins, and other food additives After rapidly growing from its Incorporation in 1986 to 1992, its turnaround time Increased to longer than a month Fortitech's chemists were spending too much time doing hand calculations for the blends and could not attend to analysis of the final products After consulting with NEMTC for several weeks, Fortitech computerized most of its chemists' practices using off-the-shelf database programs that run on personal computers In addition, Fortitech found further ways to improve their process by networking the computers with the analysis equipment and feeding the analysis Information into the newly established enterprise-wide recordkeeping system And the databases have contributed to inventory control. Most importantly, the turnaround time dropped to 2 weeks and Fortitech's founder estimates that the system has saved the company several million dollars that would have resulted from lost business

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[1] 'While the ISO 9000/Q90 series is only a minimum set of requirements for a quality management system, itprovides the foundation for total quality management Organizations that do not meet the requirements of ISO 9000/Q90 are unlikely to be able to meet more comprehensive requirements such as GMs Targets for Excellence' or Fords 01 program ""'ACollectlonof Successful Interactions Between the MTCs and Client Firms, " NIST SP 848, U S Department of Commerce, March 1993, p 5

[2] Boeing, one of MDIs customers, is requiring its vendors to be approved as D 1-9000 (Advanced Quality Systems) suppliers by 1996 Ibid p 24

SOURCE 'A Collection of Successful Interactions Between the MTCs and Client Firms, " NIST SP 848. U S Department of Commerce March 1993

sion process. However, to develop such a program it would be necessary to establish an organizational mechanism for synthesizing and packaging the information to be delivered.[30]

A prototype electronic network for manufacturing extension service providers, TECnet, has already been funded through the Technology Reinvestment Program. This network links NIST's MTCs, state technology extension projects, federal technology sources, and other technology reinvestment projects. TECnet will facilitate communication and collaboration among industrial extension services providers, their client firms, national laboratories, and other government programs. It will be accessible through the Internet and employ a state-of-the-art graphical user interface incorporating electronic mail. public and private electronic conferences, business software applications, databases, remittance services, directory services, context-sensitive help, security and access control, file transfer capability, and gateways to other information sources. In addi(ion, a wide variety of business-related information services will be made available to the MTCs and their clients free of charge[31] (see table 6-1).

TABLE 6–1: Information Services, Databases, and Conferences on TECnet

Databases and information	Public conferences
Computer-aided design (CAD) file transfer	Business news briefs from United Press International
CAD selection tool	CAD software support conference
CAD utility software	Database software support conference
Chemical safety data	IBM- PC support conference
Commerce Business Daily	Newsletter on manufacturing networks
Directory of Business & Financial Assistance	Spreadsheet software support conference
Federal procurement leads	**Private Conferences for NIST MTCs**
Federal Register	Defense conversion
Internet mail	Defining CAD terminology
ISO 9000 reference materials	Human resources group
Military Specifications Index	Director's conference
MTC and NIST service briefs	Field agents' conference
NASA technology transfer Information	National Staff Conference planning group
Quick View assessment tool	
U S Library of Congress database	
Used Industrial equipment directory	
Virus protection software	

SOURCE ProductIon Technology Inc Arlington VA unpublished paper, 1993

[30] As noted by NIST "The Federal government has a variety of approaches to serving the needs of small-and medium-sized manufacturers, incorporating centers and programs with in the National Aeronautics and Space Admin istration (NASA), DOD, the Department of Energy (DOE), USDA, the Department of Labor (DOL), the Small Business Administration (SBA), and a number of other departments and agencies. For the target set of manufacturers. this threatens to present a confusing diversity of services from which it is difficult for these companies to choose. These programs will continue to represent a major portion of the resources which the Federal go\ ernment applies for this purpose." NIST, op. cit., footnote 25.

[31] TECnet is being developed at Tufts University in collaboration with Production Technology, Inc., and the Microelectronics and Computer Technology Corp. (MCC)

More recently, TECnet—in conjunction with EINet,[32] Production Technology, Inc. (PTI),[33] and some of the national R&D labs—has proposed an even more elaborate prototype network under the auspices of the Manufacturing Outreach System to Achieve International Competitiveness (MOSAIC) program.[34] This network would link the MTCs and TECnet into a national information network providing access to one another; to their small- and medium-sized business clients; to the national laboratories and other technology sources; to electronic commerce networks; and to the defense sector. Given the positive externalities that are associated with networking, the benefits of such a network should be considerable. How much value might be added becomes clear when one considers the full range of networked services being offered throughout the country that can be linked to this network in support of electronic commerce (see box 6-2).

No matter how extensive electronic networks are, however, they cannot meet all extension needs. Many types of manufacturing equipment are immobile, requiring the development of demonstration centers that can replicate the factory floor. Moreover, successful technology transfer requires much more than technology; it also requires organizational and social change. To bring these kinds of changes about, onsite visits are critical.[35] Extension agency staff members will not only have to be expert and up to date in their knowledge of manufacturing technology; they will also need to understand, and be able to mediate, the relationship between technology and organizational change.

Even with increased funding and electronic interconnection, providing industrial extension to meet business needs in a knowledge-based global economy will be an extremely difficult task. In the United States, there are 360,000 manufacturing companies that have less than 500 employees. They represent a broad range of industries with distinct activities, production methods, and products. Given limited resources, they need to set priorities in meeting their diverse needs. Care will be needed to assure that some groups and some types of businesses are not pitted against one another. Questions will also arise with respect to how and on what basis services are to be made available. If, as is now the case, services are intended to be self-supporting and provided on a fee basis, firms with few resources may be excluded, regardless of their prospects for success.[36]

Labor has had very little role in industrial extension. At present, the only formal connection between labor and the MTCs is through the recently established Office of the American Workplace (OAW) in the Department of Labor. This agency is charged with developing concrete initiatives for promoting innovative workplace practices and cooperative labor-management practices. To this end, OAW is working with the MTCs, as well as

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[32]EINet is a business network being developed by MCC.

[33]PTI is the technical and management support agent for the Navy's Best Manufacturing Practices programs and the DOD Manufacturing Science and Technology Program.

[34]"Manufacturing Outreach System To Achieve International Competitiveness: A Proposal for Extension Enabling Services Under the Defense Dual-Use Assistance Extension Program," Production Technology, Inc., Arlington, VA, unpublished paper, 1993. The name has recently been changed from MOSAIC to MEPnet (Manufacturing Extension Partnership Network).

[35]Clark and Dobson, op. cit., footnote 22, p. 88.

[36]As described by Clark and Dobson: "As programs become more successful and visible, it is likely that there will be a greater demand for services. Thus, there will be a greater need to screen clients and target resources. States may want to target assistance to firms with the greatest potential for economic growth or to [hose industries thought to be of critical importance to the state's future economic health. Efforts arc underway to develop tools to assess a firm's competitive position." Ibid., pp. 88-89.

BOX 6-2: A Sampling of Statewide and Regional Network Programs

Aeronet Electronic sharing of mechanical specification and process information to drive flexible manufacturing cells for metal fabrication in the aerospace Industry

MADE Manufacturing Automation and Design Engineering program to develop both enabling and application technology sponsored by Advanced Research Projects Agency (ARPA)

AMTEX Electronically connecting textile supply chains from retail back through manufacturers to raw material suppliers

AUTO-NET An agile manufacturing pilot demonstration of the benefits of networking, electronic commerce, and distributed team management in the auto supplier chain

TEXAS ONE The Texas Open Network Enterprise is sponsored by the Texas Department of Commerce to provide a statewide communication network for manufacturers and technical assistance providers

Alaska University of Alaska Small Business Development Center's Alaska Technology Transfer Assistance Center wiII provide network access to their client firms

OTNET The State of Ohio, in coordination with its Edison Program and the Great Lakes Manufacturing Technology Center proposes to establish the Ohio Technology Network (OTNET), a statewide network of technology deployment agencies to support small and medium-sized companies

Rensselaer Polytechnic Institute/Northeast MTC (RPI/NEMTC) RPI/NEMTC wiII use the network to link suppliers provide access to Quickview—a business assessment tool—and train extension providers

New York Public Library The NY Public Library wiII provide manufacturers with access to a number of library-held databases

Michigan State University (MSU) Technology Transfer Network (TTN) MSU TTN IS a statewide communication network for technical assistance providers and small businesses in Michigan

California ACORN ACORN proposes to build a full-scale prototype of a National Information Infrastructure for engineering and agile manufacturing

New Hampshire Manufacturing Extension Program New Hampshire Department of Postsecondary Technical Education and New Hampshire Governor's Technology Partnership are creating a statewide electronic network to deploy available technologies to small and medium-sized manufacturing enterprises

Best North America Best North America is a commercial network providing access to a database of publicly and privately generated technical articles

New Jersey Institute of Technology This Institute wiII provide mail, database, and scheduling services via an electronic network to five Manufacturing Outreach Centers in New Jersey

Kansas/Sprint Kansas/Sprint wiII provide capability to transfer computer aided design files and conduct video training programs

Teltech Teltech wiII provide assistance to service providers in accessing federal and commercial technical Information

NTTC National Technology Transfer Center wlll facilitate and provide access to federal technology for small manufacturers assist in identifyng dual-use technology, assist defense-dependent firms with diversification and provide customized access to procurement opportunities

Oak Ridge Associated Universities (ORAU)/Oak Ridge National Laboratory (ORNL)/Production Technology, Inc ORAU/ORNL/JPTI will develop a training course for universities based on the Navy's Best Manufacturing Practices Program and the Program Managers Workstation developed by DOD

SOURCE ProductIon Technology Inc Arlington, VA, unpublished paper 1993

state and local offices, to develop ways in which firms can integrate innovative work systems and human resource practices with new technologies and production methods .37

The lack of direct input of labor groups into extension could be a serious mistake. Excluding labor from the extension process will not only affect workers and their quality of life; it may also limit the benefits to be gained by business from industrial extension. If businesses are to benefit from new modes of production, organizational as well as technological restructuring will be required. Changes in job content and skill levels, as well as in work patterns and authority structures, will also be necessary.[38] For this kind of workplace redesign to succeed, workers must be active participants.

One way of providing for greater worker representation would be to recognize labor as a constituent of the MTCs in its own right. Organized labor or some other agreed-upon worker representative might be included on any policy committee that directs the work of an MTC. To the extent that labor representatives have the appropriate abilities for design, assessment, and outreach, the MTCs might solicit their input and advice as they do from their client firms. MTCs could also encourage the concept of participatory design by offering both management and workers' assistance and training on group process methods, problem-solving, and best practices in this area.[39]

Organized labor could also serve as a target of outreach efforts by MTCs as well as a part of their process. Unions might be encouraged to contact MTCs with questions about new technologies and modem manufacturing methods. In turn, local and regional AFL-CIO bodies might be used to link firms represented by affiliates, encouraging them to participate in the work of the MTCs. In this event, MTC staff would need to maintain contact with appropriate union bodies to explain MTC's work, make information about the MTCs available, and solicit union support in contacting employers.

Bringing labor representation into the MTC process may not be welcomed by all. Many of the businesses that are likely to use MTC resources are small businesses that have had few dealings with organized labor. They may view labor participation as a disruptive element, if not an intrusion into their affairs. Business may not be fully aware of the potential benefits that can result from such interaction. Often when businesses have decided to partner with labor they have done so not on the basis of principle, but rather for the sake of survival.@ For this option to be viable, therefore, greater efforts will be needed to demonstrate the advantages that can be gained by all.

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[37]U S Department of Labor, "industrial Extension/Technology Integration," *American Workplace, vol. 2, No. 2,* March 1994, p. 2. This office was established in the fall of 1993. According to Martin Manley, its director, the OAW has three top priorities. These are to: 1) build a clearinghouse to help companies and employees learn from the experience of America's most successful companies; 2) develop partnerships with business and labor organizations to identify and promote high-performance work practices, employee ownership, and new roles for labor unions; and 3) promote the use of new measurements of workplace practices to allow investors, managers, and board members to better determine the economic impact of high performance work practices. See U.S. Department of Labor, '-Martin Manley Confirmed as Assistant Secretary for the American Workplace," *American Workplace,* vol. *2, No. 1,* January 1994.

[38]See Barry Mac, and H iroaki Izumi, "'Organizational Change, Design, and Work Innovation: A Meta Analysis of 13 I North American Field Studies—1 96 I -199 1," in R. Woodman and W. Pasmore (eds.), *Research in Organizational Change and Development* (JAI Press, forthcoming).

[39]The gains from these kinds of activities can be significant. One study that analyzed the use of computer-controlled technology in over 1,000" sites found that production time decreased considerably when shopfloor workers wrote their own control programs. See, for a description, Maryellen Kelley, "'productivity y and Information Technology," working paper 92-2, School of Urban and Public Affairs, Carnegie-Mellon University, January 1992.

[40]For an overview of the type of labor-management issues that need to be overcome, as well as some of the benefits of working them through, see Proceedings, *Conference on the Future of the American Workplace*, Department of Labor and Department of Commerce, Chicago, IL, July 25-26, 1993. As was emphasized throughout the conference, businesses often resisted change, except when their survival was at stake.

OPTION B: Promote the Dissemination of Business-Related Information

To assist American businesses in a knowledge-based global economy, the government might also promote the dissemination of business-related information. This is not a new role for government. Because of the critical role that information plays in economic transactions, the government has also acted to ensure its widespread and equitable distribution.[41] Taking advantage Of the advanced communication and information technologies that are available today. the government will be able to provide more information, which will be better packaged to meet business needs; delivering this information electronically can also serve to promote networking and electronic commerce.[42] A number of such efforts are already underway.

The Small Business Administration (SBA), for example, has developed a national bulletin board (SBA On-line) that provides free information about the SBA loan programs, financial management services, government procurement services, publications, and training.[43] This system allows users to download information that can then be processed and incorporated into spreadsheets at the desktop. Within the next year, small businesses will also be able to access the network from persona] computers in Business Information Centers to be established in each of the agency's 10 regions. These PCs, equipped with databases of their own, can be used to develop business plans, do financial planning, and conduct cost-benefit analyses. Eventually, these centers will provide gateways to other bulletin boards as well as government and commercial databases. If capacity permits, E-mail services will also be available. allowing businesses to contact SBA counselors or members of its service corporation of retired executives.

The benefits of this kind of effort can far exceed the costs. The SBA On-Line system, for example, cost less than $50,000 to establish. It is comprised of a PC, 20 modems, and telephone lines fed by two 800 circuits provided free to the government by Sprint. The SBA centers will also receive donations of hardware and software from vendors such as Microsoft Corp., Lotus Development Corp., Apple Computer, Inc., and Sony Corp. of America.[44]

The Department of Commerce also provides online information through BISNIS, a network that helps companies identify business opportunities in the newly independent states of the former Soviet Union. This network offers information about upcoming trade missions, potential customers and partners, sources of financing, trade and investment laws, market research, advertising opportunities, and the status of trade and investment treaties. The network was inspired by the recent Commerce Department report, "Obstacles to Trade and Investment in the Newly Independent States of the Former Soviet Union." Funding is provided by the U.S. Agency for International De-

~ I Before the telegraph, newspapers provided the basic means of obtaining business-related news. Newspapers devoted between 75 to 90 percent of their space to hrsinc~s-related topics, and they provided the fastest and cheapest way of gathering information. To promote the dissemination of news, the government permitted the postage-free exchange of newspapers among printers. Long before the advent of press associations, editors obtained nonlocal in formation by culling out-of-town newspapers, their so-called exchanges. I n an arrangement that today's journalists might find foreign and offensive, the government, in essence, operated the nation's news-gathering services. These printers' exchanges furnished most nonlocal news throughout the first half of the 19th century. See Richard B. K ielbowicz, "The Press, Post Office, and the Flow of News in the Early Republic," *Journal of the Early Republic*, vol. 3, fall 1983, pp. 255-280; and Richard B. Kielbowicz, "Modernization, Communication Policy, and the Geopolitics of News, 1820- 1860," *Critical Studies in Mass Communications*, vol. 3, March 1986, pp. 21-35

[42] For a discussion of the issues involved in electronic dissemination of federal information, see OTA, *Informing the Nation: Federal Information Dissemination in an Electronic Age*, OTA-CIT-396 (Washington, DC: U.S. Government Printing Office, October 1988).

[43] See G. Anthes, "Feds Set Up BBS for Small Businesses," *Computerworld*, Oct. 26, I 992.

[44] Ibid.

velopment. The Export-Import Bank of the United States and the Overseas Private Investment Corp. are also involved.[45]

The Internet is also a source of government-provided business information.[46] The Economic Bulletin Board (EBB), for example, is a "one-stop source of current economic information." It houses 2,000 information files provided by federal agencies such as the Federal Reserve Board, the Bureau of Labor Statistics, the U.S. Census, and the Treasury Department. Included in these files are current business statistics, economic indicators, employment statistics, energy statistics, foreign trade data, monetary statistics, price and productivity statistics, regional economic statistics, and summaries of current economic conditions. Also provided are regular updates on key economic and business indicators, including Treasury rate quotations, foreign exchange rates, bond rates, consumer price index, producer price index, advance retail sales, manufacturing and trade inventories, and employment and unemployment statistics. In addition, Trade Opportunity files (TOPS) and International Marketing Insights (IMI), which are compiled by American embassies and consulates, are made available on a weekly basis.[47] As more and more files are added, issues of financing and pricing will need to be dealt with. It is likely that regular institutional users will be required to pay an annual flat fee, while infrequent users will pay according to use.[48]

Federal agency information useful to business can also be accessed through the Library of Congress Information System (LOCIS). Using the new search tool LC Marvel (Machine-Assisted Realization of the Virtual Electronic Library), businesses can retrieve Presidential documents, speeches, and White House press releases; portions of the Federal Register and the Federal Information Exchange (FEDIX); as well as files from key federal agencies such as the Departments of Agriculture, Commerce, and Energy; the Food and Drug Administration; NIST; the National Institutes of Health, the Patent and Trademark Office; and the Office of Management and Budget (OMB).[49]

Government provision of economic data can clearly help businesses identify new opportunities and reduce overall transaction costs. However, this practice, if carried out extensively, may also give rise to a number of policy issues. For example, there is a rapidly growing industry comprised of commercial firms that repackage and add value to federal information for sale. While benefiting from access to government information provided in an electronic format, many firms in this industry are concerned about the possible adverse affects from government competition. Efforts by OMB to establish policy in this area have proven to be controversial .50 The advent of electronic dissemination of federal information also raises equity concerns. To the extent that electronic formats have distinct advantages (for example, in terms of timeliness and searchability), those without electronic access will likely be disadvantaged.[51] Thus, if equity is the goal, policies that aim to pro-

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[45]Eric Bruder, "Commerce Department Opens a 'B ISNIS' Center for Newly Independent States of Ex-U. S. S.R.," *Business America*, June 29, 1992, p. 17.

[46]For a discussion of how this information can be accessed, see Mary J. Cronin, "Internet Business Resources," *Database*, December 1993, pp. 47-50.

[47]Ibid. See also Rosalind Resnick, "Log on to Trade Leads," *International Business*, vol. 4, No. 3, November 1991, pp. 63-64.

[48]Ibid.

[49]Ibid See also, "How to Use the Freedom of Information Act to Benefit Your Business: This We]] -Known Act Is Little Used by Business, But It Should Be," *Agency Sales Magazine*, June 1993.

[50]OTA, op. cit., footote 42, p. 9.

[51]Ibid.

mole information dissemination will need to be closely linked to policies that affect technology access and technological literacy.

OPTION C: Provide Greater Support for Business and Business-Related Education

In its efforts to help rural Americans make the adjustment from an agricultural to an industrial-based economy, the federal government did not limit itself to promoting technology transfer through extension services. Equally important were its efforts to train people in the new ways of doing business. The land grant colleges, provided under the Morrill Act of 1862, played a key role. Responding to the major structural changes taking place in the economy, these universities were called on to expand beyond their traditional role of training gentlemen as preachers. lawyers, and doctors. Using applied research, universities were asked to develop the more practical applications of education in fields such as agriculture, engineering, home economics, and business administration.[52]

The impact of the Merrill Act was very evident in the field of engineering. Before the act wits passed, state legislatures had been reluctant to invest in technical education. Responding to the offer of federal grants, however, they quickly sought to establish new types of schools; private colleges. caught up in the movement, also established departments of engineering.[53] Schools of engineering expanded rapidly thereafter, numbering 110 by 1886. The number of engineering students similarly increased from 1,000 in 1890 to 10,000 in 1900.[54] As more and more engineers were educated in formal institutions, there was a greater emphasis on engineering in science. With the establishment and growth of these institutions, a profession was developed and with it a means of preserving, transmitting, and increasing an evolving body of engineering knowledge.[55]

Today, the government is engaged in a number of similar efforts to ease the transition from an industrial to a knowledge-based global economy. However, most of these undertakings are focused on technology development and technology transfer alone; much less attention has been paid to the problems of organizational barriers, and the need to help businesses reconceptualize and redefine the way they think about and carry out their activities. This gap needs to be filled. If businesses fail to adapt their thinking and their organizational culture to the structural changes taking place in their environment, both they and the nation will fail to reap the full benefits that communication and information technologies afford. Just as the government turned to the land grant colleges to help farmers adapt to the industrial era, it might now look to universities to develop and widely disseminate a business curriculum that is more appropriate to a changed economy.

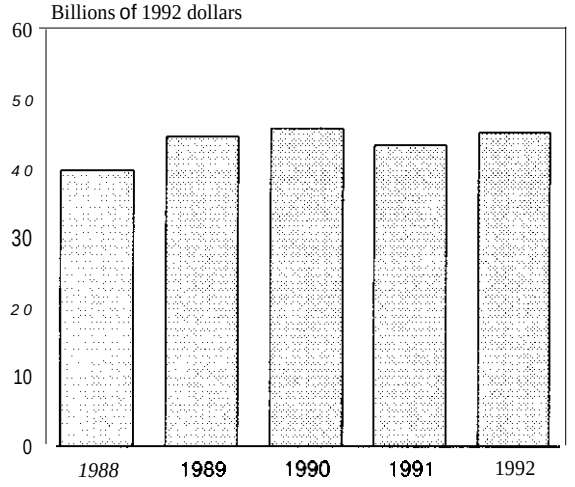
Recognizing that organizational culture and organizational change are critical factors for success, many large firms are already spending con-

52 This law provided land to the states, the proceeds of which were to be used to teach in the fields of agriculture and mechanical arts. Subsequent legislation provided federal financial support for research and the operation of the land-grant colleges. Democratic and populist in origin. these universities were open to children of all backgrounds. Moreover, unlike the traditional colleges, the land-gram colleges were not isolated communities. Through then agricultural expcriment stations and their service bureaus, their activities were designed to serve the states. See, for a discussion, Clark Kerr, The Uses of the University (Cambridge, MA: Harvard University Press, 1972).

53 David Noble, *America by Design: Science, Technology and the Rise of Corporate Capitalism* (New York, NY: Alfred A. Knopf, 1977), pp. 38 39.

54 Edwin T. Layton, Jr., *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession* (Cleveland, OH: The Press of Case Western Reserve University, 1971).

FIGURE 6-1: Total Training Budgets for U.S. Corporations (billions of 1992 dollars)



SOURCE *Training* October 1992 p 32

siderable amounts of money to reeducate themselves[56] (see figure 6-1). To do so, they are importing some of the best faculty members from the top business schools to lecture on their premises. The cost of this kind of in-house training is high, ranging between $5,000 to $20,000 per day. Although expensive, this approach not only allows businesses to stay up to date in their understanding of successful corporate strategies; it also allows them to apply these lessons to their company's specific problems and goals.[57]

Drawing on faculty from both business and engineering, some of these programs are highly innovative. Ford Motor Co. and Wayne State University, for example, have recently established a joint venture to create a program offering a Master's Degree in Engineering to be offered to employees on Ford Motor Co. premises. This is an interdisciplinary program with courses and faculty drawn from both the Schools of Business and Engineering at Wayne State University. Taking into account both the organizational and technological problems entailed in technology deployment, this program provides both depth in engineering and breadth in business management. The Massachusetts Institute of Technology (MIT) is currently putting together an innovative interdisciplinary program that also involves both business and engineering (see box 6-3). Unlike Wayne State's program, it will be delivered by interactive video technologies. Both Wayne State and MIT's programs are full degree programs.

Smaller companies can hardly afford such services, however. Operating with minimal staff and narrow time constraints, they rarely have the time or resources that full degree programs require. One way to meet their educational needs, however, is through targeted distance learning classes. The development costs of programming and other training materials can be shared among many users, and participants can schedule the viewing of such courses at their own convenience.

In England, a distance learning educational program for small-business managers is now being offered through the Open University.[58] This program was jointly developed by the Cranfield School of Management, the Open University, and the British Broadcasting Corp. The course materials, which draw on the experience of over 200 entrepreneurs, are designed to teach the principles of good management. In addition to video programming, students are also provided with audio cassettes and workbooks. A number of workshops have been set up to allow face-to-face interactions. Initial financial support for this program, totaling 1.5 million pounds, was provided by the Training Agency (formerly the Manpower Services Commission). Over the long run, however, the program is intended to be self-supporting.[59]

[56] See Paul Froiland, "Who's Getting Trained," *Training*, October 1993, pp. 59-65.

[57] See Lori Bongiorno, "The Professor Is In," *Business Week*, Oct. 25, 1993, p. 105.

[58] David Oates, "Switched onto Distance Learning," *Director*, June 1990, p. 127.

[59] Ibid.

BOX 6-3: MIT's Engineering-Management Distance Learning Project: Filling a New Educational Gap

After engineers have been in Industry for several years, they frequently move into project leadership positlons and must then expand their knowledge base to Include not only more of the engineering systems with which they work, but also more of the business and Industrial systems Only with knowledge of the "big picture" can such leaders and managers take products efficiently and effectively from design to manufacturing to sales Today, practicing engineers who are formally trained in both technology and business and able to run large-scale design projects are rare Rarer still are educational programs geared toward filling this professional gap in the workplace

The Massachusetts Institute of Technology (MIT) is currently designing a new engineering/management curriculum to address this gap through distance learning The project, still under development, proposes to grant engineers a "second professional degree " Because of MIT's firm belief that the best education is interactive, it wiIl likely utilize interactive video between professors at MIT and on-premise company locations The on-premise arrangement is Important because industry generally does not want to do without valuable engineers for more than a few months In addition to combining traditionally separated engineering and management courses, the project is further driven by two other themes First is the need to bridge MIT's strengths in basic technical and management knowledge and industry's strengths in applications Yet another strong driver is to better educate America's professional workforce, which necessarily entails learning from and working with industry

This project builds on the experience of MIT's successful Leaders for Manufacturing (LFM) program that also combines engineering and management Now in its sixth year, the LFM program is a partnership between MIT and about a dozen large U S manufacturers Students in the program get practical experience by doing a term-long internship in a manufacturing company Participants get two master's degrees one from MIT's School of Management and one from the School of Engineering MIT's new distance learning program differs from the LFM program in two respects it emphasizes engineering design rather than manufacturing, and introduces remote delivery Both programs are intended to give students an understanding of the whole company Also, the successful LFM program model of university-industry interaction and cooperation wiIl likely be duplicated in the distance learning project

wiIl graduates of this new program be a new breed of upskilled managers? Perhaps wiIl this model of distant education be emulated by other universities that have strong engineering and business programs? Perhaps Importantly the new curriculum has strong interest by both MIT and industry Since industry is under competitive pressure, they need engineer-managers trained in both the newest technology and management practices And MIT's engineering and management professors wiIl benefit by their exposure to Industrys present concerns Ultimately, both MIT's engineering and business courses can be made more effective by addressing real world problems

Government, as the promoter of both education and a National Information Infrastructure has a stake in supporting pilot projects, such as M IT's, that combine elements of industry-relevant workforce education technology and business knowledge diffusion both ways between industry and academia and demonstration of state-of-the-art "information Infrastructure" such as interactive video technologies

SOURCE Private communication John D C Little Institute Professor and Professor of Management Science and Joel Moses Dean of Engineering Massachusetts Institute of Technology, March 1994

Similar types of programming could be provided in the United States, either via public broadcasting or the public switched network. In states that already have a vast educational infrastructure in place, programming and delivery mechanisms could be provided as part of the overall educational system. In the State of Maine, for example, the University of Maine system has created a network that is comprised of an extensive interactive television system reaching 77 sites, an electronic library catalogue database including the holdings of the state's major libraries, and other data and information technologies. Efforts are now underway to greatly enhance the network's potential for use by the citizens of Maine. The university and its partners are forming the Maine Information Technology Users Consortium (MITUC), a new nonprofit membership organization that will consist of Maine schools, not-for-profits, state agencies and departments, municipalities, businesses, labor organizations, professional and trade associations, and educational and cultural institutions. This consortium will foster education and training, professional development, access to information databases, teleconferences, legislative and other public policy briefings and hearings, and cultural and other programs. The anticipated startup costs of such a program are between $400,000 and $500,000.[60]

To support new developments in business education, the federal government might also pursue an approach similar to the one it took to promote science education following World War II. Recognizing that advanced technology was critical for both the nation's economic growth and its defense, the government established the National Science Foundation (NSF) to improve the nation's potential in scientific research and science education.[61] Provoked by the successful launching of the Soviet spacecraft Sputnik, defense considerations also motivated the passage of the National Defense Education Act of 1958 (NDEA), whose goal was to improve instruction in mathematics, science, and foreign languages. Under this law, funds were provided on a matching basis to public schools and as long-term loans to private institutions. Funds could be used for needed equipment in these instructional fields, curriculum development, guidance counseling, vocational education in defense-related fields, and teacher training in foreign language instruction.[62]

With the nation's shift from defense to national and economic issues, government could complement its efforts to promote technology and technology deployment with steps to prepare its citizens to make the most productive use of these technologies. In recognition of the complex relationship between technology and organizational social change, the government might support the development of new centers of research and new curricula that would extend beyond the realms of engineering and business to incorporate disci-

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60 The consortium is presently seeking a federal grant of $400,000 to pay for startup costs, which the University of Maine will match with $100,000 cash and in-kind investments.

61 The philosophical basis for establishing NSF, and the rationale for including the development of scientific manpower within its organizational mission, was explained by Vannevar Bush in *Science-The Endless Frontier*, his report to the President on a program for postwar scientific research. About the need for scientific manpower, he said: "Today, it is truer than ever that basic research is the pacemaker of technology progress. In the 19th century, Yankee mechanical ingenuity, building largely on the basic discoveries of European scientists, could greatly advance (he technical arts. Now the situation is different.

A nation that depends on others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill." *The National Science Foundation and Pre-College Science Education: 19S0-/975,* report prepared for the Subcommittee on Science and Technology, U.S. House of Representatives, 94th Cong., 2d sess., by the Congressional Research Service, Library of Congress, January 1976, p. 19.

62 The passage of the NDEA resulted i, substantial increases in federal aid to education. Since federal dollars had to be matched by state and local funds under provision of the act, the overall investment in NDEA programs was large. Between 1958 and 1961, $163.2 million in federal funds were disbursed. Approximately 75 percent of these funds were directed to the development of science curricula. See OTA, *Information Technology R&D: Critical Trends and Issues*, OTA-CIT-268 (Washington, DC: U.S. Government Printing Office, February 1985), ch. 5, "Education and Human Resources for Research and Development."

plines such as anthropology, psychology, sociology, and technology assessment. In addition, as in the case of the NDEA, financial incentives in the form of loans might be provided to encourage students and faculty to pursue these interdisciplinary areas of research. To enhance the benefits of such a program. students might be provided the option of repaying their loans, in part, by working with small businesses, perhaps in the context of an organization such as an MTC. Matching funds might also be provided by state and local entities.

Implementing such an option might be difficult because any curriculum that deals with business will likely have political overtones. On the other hand, faced with the need to explain differing patterns of growth across countries, many in academia recognize the need for a more interdisciplinary approach to understanding economic phenomena.[63]

OPTION D: Provide Greater Support for Worker Training

Given the constitutional limitations on the federal government's role in education, the responsibility for developing human resources has always been shared by a number of different social institutions ranging from the family to the business communi - t y. As American society has become more technologically advanced, however, the federal government has been increasingly called on to play a more significant role. The pressure on the government to be more active in this area is particularly strong today as the nation seeks to maintain its place in a highly technical and competitive world environment.

Although Americans were aware of the economic benefits associated with having a skilled labor force, the nation did not original] y adopt a formal system for transmitting vocational and technical skills when agriculture was the dominant mode of production.[64] It was only with the rapid industrialization of society at the end of the 19th century that education came to be valued in economic and technical terms.[65] As Americans learned that special technical knowledge was the key to prosperity in the modern age, secondary educational institutions were restructured to prepare American youth for an increasing] y differentiated set of economic roles. Not only were vocational courses added to the educational curriculum, but the schools themselves were remodeled to conform to the prevailing business standards of efficiency. The business community played a major role in bringing about these changes, Concerned about strikes, labor turnover. and increasing worker absenteeism, they hoped that schooling would socialize a growing number of immigrant youths for the workplace.[66]

The educational and training strategies for an industrial era are increasingly less relevant today. given the changing nature of the American workplace and the structural changes in the economy.[67] Yet the quality of the U.S. workforce matters now more than ever before. In today international

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6 {See for instance, Joseph E. Stiglitz, "Social Absorption Capability and Innovation," CEPR Publication No. 292, Center For Economic Policy Research, Stanford University, November 1991, and Douglas Cecil North, *Institutions, Institutional Change, and Economic Performance* (Cambridge, UK: Cambridge University Press, 1990).

[64]Instead, most formal educational institutions were designed to serve general social and political functions, while general vocational skills were left to be passed on more or less informally by family members or through apprenticeship systems. See, for discussions, Bernard Bailyn, *Education in the Forming of American Society* (New York, NY: W.W. North, 1980); and Lawrence Cremin, *Traditions in American Education* (New York, NY: Basic Books, Harper, 1976).

[65]David K. Cohen and Barbara Newfeld, "The Failure of High Schools and the Progress of Education," *America's Schools: Public and Private, Daedalus*, spring 1981.

[66]David Tyack and Elizabeth Hansot, "Conflict and Consensus in American Education," *America's Schools: Public and Private*, ibid.

[67]This section of the report is drawn extensively from OTA, *Worker Training: Competing in the New International Economy*, OTA-ITE-457 (Washington, DC: U.S. Government Printing Office, September 1990).

economy, motivated workers who can produce high quality goods and services at low cost can enhance industrial productivity and competitiveness and keep American living standards high. Workers must be trained, however, to change the way they do their jobs in order to capture the benefits from rapidly evolving technology. Well-trained workers go hand-in-hand with productivity, quality, flexibility, and automation in firms that perform well.

Unfortunately, most American workers are not well trained, especially when measured by international standards. Foreign countries place much greater emphasis on developing workforce skills at all levels (see table 6-2). Experienced production workers at Japanese auto assembly plants, for example, get three times as much training each year as their American counterparts. American workers are so mobile, especially when they are young, that most U.S. companies offer training only sporadically. Workers in many smaller firms, in fact, may receive no formal training at all. Although larger firms provide more formal training, most of it is for professionals, technicians, managers, and executives. Rarely do American workers voluntarily upgrade their skills for job advancement (see figure 6-2).

The need for better training is clear in both manufacturing and service industries where skills and responsibilities are broadening. Work reorganization forces employees to take more responsibility, cooperate more with one another, understand their roles in the production system, and act on that knowledge. Competitive manufacturing and service firms are increasingly relying on employees with good higher-order skills such as reasoning and problem-solving.

TABLE 6-2: Comparison of Workforce Training

	United States	Germany	Japan	Korea
School-to-work transition	Left mostly to chance, some employers have ties with local schools	Apprenticeship for most noncollege-bound youth	Personal relationships between employers and local schools	Employers recruit from vocational and academic high schools
Vocational education				
Extent	Available in most urban areas	Universally available	Limited, mostly assumed by employers	Universally available
Quality	Wide range, poor to excellent	Uniformly good	Fair to good	Vocational high schools uniformly good
Employer-provided training				
Extent	Largely limited to managers and technicians	Widespread at entry level and to qualify for promotion	Widespread	Limited, employers rely on public vocational Institutes
Quality	Wide range, some excellent, but more often weak or unstructured	Very good	Very good	Generally poor
Public policies	Federal role very limited, state aid to employers growing	Govern apprenticeship, encourage continuing training	Subsidies encourage training by small firms	Directive-some employers resist policies

SOURCE Off Ice of Technology Assessment, *Worker Training Competing in the New Internatinoal Economy, OTA- ITE-457* (Washington DC U S Government Printing Off Ice, September 1990)

Demographic changes are also shaping training needs. Over the next few years, the labor force will expand more slowly than at any time since the 1930s. In the year 2000, the average worker will be nearly 40 years old compared with 36 today. Keeping this slowly aging workforce up to date and flexible will require ongoing training. New entrants in general will need better basic skills, including reading, writing, arithmetic, and oral communication. Americans already in the labor force will require better skills as well.

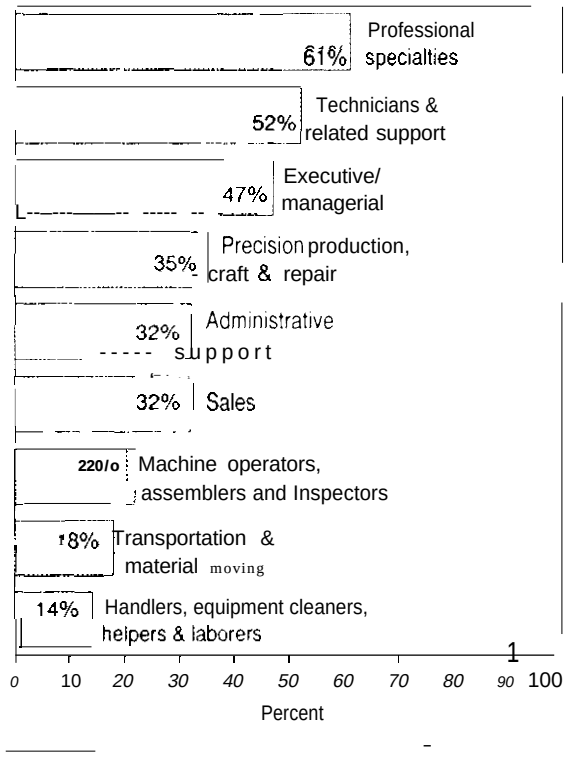
Simply providing more training will not be enough, however. If work is not organized to tap employees ' skills, the firm's investment will be wasted. In addition, training must not only be focused on workplace problems, but it must also be delivered effectively. Efforts to employ more innovative and effective training approaches are still rare outside of sophisticated firms with large training budgets. Instead, most programs lag far behind state-of-the-art training.

If training is to be made available to businesses and other firms with 1imited resources, new institutional structures will be needed to make affordable training available to employees of small businesses and other firms with limited resources. A variety of approaches. including industry training consortia, involvement of employer organizations in training. state assistance programs, and joint labor-management programs promise to enhance the scope and quality of training. While such efforts are currently limited, government can act to foster these developments in a number of ways.

One approach the government might take, for example, is to reduce the barriers to company training. These barriers include 1imited funds, an inadequate awareness of training needs, a lack of knowledge about good training pract ices, and a reluctance to train young and older workers. To address these problems, the government could encourage the establishment of training consortia through government startup grants. Such a program would allow companies to share the costs and risks of training. A related possibility would be to expand technical assistance to trade associations, other industry groups, and joint labor-management organizations to aid in the development of training programs for their members.

The federal government could also use financial inducements, such as tax credits, to make training investments more attractive. It would be important, however, to ensure that the revenue loss is matched by an increase in the desired train-

FIGURE 6–2: Upgrade Training by Occupation (percent of workers reporting upgrade training in their current job)[a]



a NOT E:On average 35percent of all workers reported skill improvement training for their current job

SOURCE Max Carey and Alan [ck How *Workers Get Their Training* (Washington DCUS Department It of Labor Bureau of Labor Statistics 1985) pp 18 19

ing activities. This could be done by establishing a national payroll levy. [68] Congress could also expand assistance available to firms for certain activities, such as basic skills training and vocational skills upgrading, that would make it easier for employees to participate in training activities.

Over the long term, federal support for work and learning research, and for the development and dissemination of new training technologies, could also improve worker training at a relatively low cost. The quality of training varies greatly. Although some U.S. firms are world leaders in training, others know little about best practices. Moreover, research about how adults learn often fails to be integrated into training practices. To address this problem, Congress could direct federal agencies that have education and training programs (e.g., Defense, Education, Labor, Commerce, Health and Human Services) to develop and disseminate information about new educational technology and best practices. In addition, the government could support the periodic updating and dissemination of information on workplace training.

[68] Under such an option, companies would choose between either spending a specified percentage of their payroll on particular types of training or contributing that percentage to a national fund for training initiatives. Several countries (including France, West Germany, Ireland, and South Korea) use such levies to encourage worker training. In the United states, four States now raise training funds through this type of levy. For a more detailed discussion, see ibid,

Government and Markets

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Markets are generally viewed as the "web of relationships between buyers, sellers, and products that are involved in an exchange."] They can be defined in several ways according to a number of criteria. For example, markets can be local, regional, national, or global. They may be relatively open or closed to entry. They may be more or less competitive, and they may be restricted or not in the kinds of products and services exchanged. Finally, markets can encompass exchange relationships that are momentary or that endure over time and space.

A market's form affects the way it functions and how it meets national economic and social needs. In capitalist societies, the market system, for the most part, manages economic activity, coordinating supply and demand and allocating goods and services. To the extent that market structure reflects perfect competi - tion—i.e., each producer selects the factors of production that will maximize profits; each consumer maximizes preferences; and perfect information is available to all—the market system will distribute goods and services in the most economically efficient fashion.

Rarely, however, are all these conditions met. Producers and consumers are limited in their abilities to find, process, and use information in their decisionmaking processes.[2] Few markets are

True electronic commerce is in its in fancy, but the government may need to take steps to further assess its market implications.

[1] Peter Steiner, "Markets and Industries," *International Encyclopedia of Social Science* (New York, NY: Macmillan, 1968), vol. 9, pp. 571-581.

[2] As a result, individual actions will, according to Herbert Simon, "be intendedly rational but only I imitedly so." Herbert A. Simon, *Administrative Behavior (New* York, NY: Macmillan, 1961).

competitive in the classic sense; that is, comprised of buyers and sellers who are unable to influence market events. Most large modern corporations have considerable leverage in the marketplace. They can structure market relationships through their competitive strategies; influence preferences and tastes through marketing and advertising; determine the nature and quality of labor through their work organization and labor management; and help to define the economic rules of the game through lobbying and political activities.[3]

Markets diverge from the theoretical ideal because of economic, social, and political factors; they do not exist independent of their circumstances. Markets are historical phenomena, having emerged and evolved at a particular time and under a set of social and economic circumstances.[4] Markets are embedded in cultural, social, and institutional environments and operate in the context of these environments.[5]

The government helps to establish markets in a number of ways. At a fundamental level, it determines the social activities of the marketplace, as well as which commodities are bought and sold. Government also defines economic actors—proprietors, workers, and corporations-by establishing and enforcing their rights and obligations, the rules by which they interact, and the means they use for exchange.[6] These decisions are of major importance; they determine the economic opportunities for business, as well as the efficiency and performance of the economy as a whole.[7]

Government decisions about the market are not cast in stone, however. They need to be reevaluated to accommodate the changing business environment. Communication and information tech-

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[3] See Fred Block, *Post industrial Possibilities: A Critique of Economic Discourse* (Berkeley, CA: University of California Press, 1990); and Charles E. Lindblom, *Politics and Markets: The World's Political-Economic Systems (New* York, NY: Basic Books, 1977).

[4] For the market system to emerge and predominate required the secularization of society, the establishment of property rights that 'ere 'ree from feudal obligations, and the division of society into groups and rankings that, while based on economic interest, permitted social mobility. States and other ruling powers played a major role in establishing these conditions. They were responsible for breaking down the feudal system and bringing large territories under physical control. In addition, they established property rights; a common currency; and a reliable system of banking, investment, and contracts. They also eliminated internal market barriers. For discussions, see Karl Polanyi, *The Great Transformation: The Political and Economic Origins of Our Time* (Cambridge, MA: Harvard University Press, 1986); Femand Braudel, *The Wheels of Commerce, Civilization and Capitalism 15th-18th Century, vol. 2* (Berkeley, CA: University of California Press, 1992); Albert O. Hirschman, *The Passions and the Interests: Political Arguments for Capitalism Before Its Triumph* (Princeton, NJ: Princeton University Press, 1977); and Randall Collins, "Weber's Last Theory of Capitalism: A Systematization," m Mark Granovetter and Richard Swedberg (eds.), *The Sociology of Economic Life* (Boulder, CO: Westview Press, 1992).

[5] Every economic transaction—however fleeting< ntails interaction and, therefore, requires a contextual basis for its interpretation. Thus, if the market itself is to function, economic participants must act in accordance with some agreed-upon norms of behavior such as honesty and fairness. See, for discussions, Talcott parsons, *7'he Structure of Social Action*, vol. 1 (New York, NY: The Free Press, 1949), and Emile Durkheim, trans. by W.D. Halls, *The Division of Labor in Society (New* York, NY: The Free Press, 1984).

6As described by Friedland and Robertson: "The contest over property rights is not one that is played out in the market, but in regulatory agencies, law courts, and legislatures. To understand how individuals work to maximize utility—the hostile takeover, dual classes of stock, 'golden parachutes' granting executives certain benefits in the event of a takeover, due process rights for employees, prenotification of workers in the event of plant closings, requirements that developers absorb public infrastructural costs, or environmental impact statements- requires that we bring power, and hence the state, from the margins of economic analysis to the very center. Because property rights attach to categories of actors and actions, some of the most important exercises of power involve the defense of transformation of systems of economic classification, the ways in which people construe, categorize, and measure economic activity." Roger Friedland and A.F. Robertson, "Beyond the Marketplace," in Roger Friedland and A.F. Robertson, *Beyond the Marketplace: Rethinking Economy and Society (New* York, NY: Aldine de Gruyter, 1992), p. 10.

[7] See Douglas C. North, *Institutions, Institutional Change, and Economic Performance* (Cambridge, UK: Cambridge University Press, 1990). See also, Joseph Stiglitz, "Social Absorption Capability and Innovation," CEPR Publication No. 292, Center for Economic Policy Research, Stanford, CA, November 1991.

nologies define relationships among economic actors and the ways the market is structured to conduct businesse[8]

In the past, when contacts and communications were limited, manufacturers produced on a small scale and out-sourced their marketing operations to middlemen—such as shippers, financiers, jobbers, transporters, insurers, brokers, and retailers—who brokered information as well as goods. There was little need for market regulation to preserve competition. Only at the end of the 19th century—with the development of transportation, the growth of interstate commerce, and the rise of the vertically integrated firm-was the federal government called on to establish national market rules and regulations (see box 7-1).

Today, communication and information networks are again reconfiguring the business environment. Serving as the infrastructure for electronic commerce, these technologies are already an integral part of many businesses. When networked for business, these technologies contribute to economic growth by reducing transaction costs, By channeling the flow of information and structuring economic interaction and exchange, they will partially determine who will reap the benefits.

True electronic commerce is in its infancy, but the government may need to take steps to further assess its market implications. Like electronic networks, social and economic institutions follow a set course, making it difficult to reorganize relationships after the fact.[9] The government could: 1) establish a commission that will investigate the implications of electronic commerce for future market rules and regulations; and 2) restructure the organization for communications decisionmaking to ensure that the economic and market implications of communication and information technologies are adequately considered.

OPTION A: Establish a Congressional Commission To Investigate the Implications of Electronic Commerce for Future Market Rules and Regulations

Building on the tradition of common law. U.S. laws and the legal system that acts to interpret them have proven to be remarkably resilient over time and in dealing with major social and economic change. For example, the intellectual property provisions provided in the Constitution, although originally for print media, have been extended over two centuries to incorporate an array of new communication and information technologies[10] (see box 7-2). Similarly, the Communications Act of 1934, which established national goals for radio and telephone, has survived despite technology convergence and a rash of new communication and information products and services (see box 7-3),

Incremental legal and institutional adjustments have provided acceptable responses to evolutionary changes in technology and the economy in the

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[8]See Richard DuBoff, "The Telegraph in Nineteenth Century America. Technology and Monopoly," *Comparative Studies in Society find History*, vol.26, October 1984, pp. *57 I -586,* and JoAnne Yates, "The Telegraph's Effect on Nineteenth Century Markets and Firms," *Business and Economic History*, 2d *ser.* 15 *(1986),* pp. 149-163.

[9]As described by Powell and DiMaggio: "Institutional arrangements are reproduced because individuals often cannot even conceive of appropriate alternatives (or because they regard as unrealistic the alternatives (hey can imagine). Institutions do not just constrain options; they establish the very criteria by which people discover their preferences. In other words, strew of the most important sunk costs are cognitive." See Walter W. Powell and Paul J. DiMaggio (eds.). *The New Institutionalism in Organizational Analysis* (Chicago, IL The University of Chicago Press, 199 I), pp. 1 ()- I 1. See also North, op. cit., footnote 7.

[10]See Ray Patterson, *Copyright in Historical Perspective* (Nashville, TN: Vanderbilt University Press, 1969); and Nicholas Henry, *Copyright, Information Technology, Public Policy* (New York, NY: Marcel Dekker, 1967).

BOX 7–1: The Role of Government in Structuring the American Marketplace

In the early years of the American republic, business activities were regulated by the states With the growth of interstate commerce, the federal government was increasingly called on to establish national rules and regulations to govern business activities The federal government had the Constitutional authority to assume this role under the interstate commerce clause and the 14th amendment, which was broadly interpreted to include corporations within its due process provisions Despite its clear authority, however, the federal government was somewhat reluctant to act, it neither wanted to offend state governments nor to undermine the institution of private property [1]

Under these circumstances, businesses were relatively free to fend for themselves And fend they did The exceptional growth that characterized the period from the end of the Civil War to the turn of the century was accompanied by fierce competition, Growth in economic activity gave rise to overproduction, which led in turn to three severe economic downturns, from 1873 to 1877, 1885 to 1887, and 1893 to 1897 In this economic climate, the rate of business failure was exceedingly high To survive, businesses employed whatever measures they could—including cartels and other pooling arrangements, predatory pricing, or direct control through horizontal mergers-despite their blatantly anticompetitive nature [2]

It was in this context that the federal government came under strong pressure to Intervene Middle-class reformers, describing themselves as "progressives, " opposed the concentration of economic power, and called on government to control corporate abuses and to take posit we steps to reduce the negative Impacts of rapid industrialization and urbanization. Farmers and others living in the West accused big business, especially the oil companies and railroads, of price gouging In addition, labor, now emerging as a movement in its own right, became increasingly critical of business[3]

The political climate, which once provided unquestioned support for business, had clearly changed But despite the public outcry against big business, few people were certain about what the role of government, in relationship to business and the marketplace, should be This issue, which dominated American politics from the turn of the century until World War II, continues to reverberate today

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[1] Neil Fligstein, *The Transformation of Corporate Control* (Cambridge, MA Harvard University Press, 1990)

[2] Louis Galambos and Joseph Pratt, *The Rise of the Corporate Commonwealth L/ S Business and Public Policy in the Twentieth Century (New* York, NY Basic Books, 1989)

[3] Ibid

SOURCE Off Ice of Technology Assessment, 1994

BOX 7–2: Intellectual Property Law

To provide an incentive for the creation and dissemination of scientific information and creative works, the Founding Fathers Included a specific clause in the Constitution (Section 1, Article 8, clause 8) authorizing Congress to establish Intellectual property rights Rights granted under the first copyright act of 1790 corresponded to the capabilities of the printing press, these were the rights to print, reprint, publish, and vend a writing During the 19th and 20th centuries intellectual property rights were gradually extended and expanded to take into account the development of new kinds of information technologies The "right to perform" was first granted in 1856 for dramatic compositions, and in 1897 it was applied to musical compositions In 1909, Congress granted musical compositions a "mechanical recording right, " at which time the duration of copyright was also lengthened from 14 to 28 years, and on renewal, to 56 years In 1976, the term of copyright was extended to the life of the author plus 50 years, in 1980, copyright was extended to cover computer software and in 1984 chip masks were provided protection under the Semiconductor Chip Protection Act

As Intellectual property rights were extended to Incorporate new technologies, the issue of how to bound these rights repeatedly reemerged Although one of the primary purposes of Intellectual property rights was to promote free and competitive markets the continual expansion of rights has sometimes had the opposite effect Striking the appropriate balance between Intellectual property protection and the need for information access is a difficult task that continues to challenge policymakers today

SOURCE Off Ice Of Technology Assessment 1994

BOX 7–3: The Communications Act of 1934

The flexibility of the law and role of the courts in Interpreting it is well Illustrated in the case of the Radio Acts of 1912 and 1927 and the Communications Act of 1934, which—incorporating the radio acts—formally established national communication goals for broadcasting and telephony The standard set for broadcasting to serve the public interest convenience or necessity" was stated so vaguely as to leave room for compromise So too was the goal for prowding "so far as possible, to all the people of the United State, a rapid efficient Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges" for this definition did not provide criteria for defining adequacy and reasonableness Although from 1976 to 1980 Congress did reevaluate communication policy goals these efforts to revise the 1934 Communications Act failed for lack of consensus As a result, in recent years—in the absence of clearly defined and consistent goals—-natlonal communication policy is often set by the courts

SOURCE Office of Technology Assessment 1994

past. But this approach may not be suitable today, given the structural changes taking place in the world economy.[11] In fact, if small adaptive changes merely provide temporary relief to U.S. economic problems, they could mask the need for the more radical adjustments needed to sustain economic performance over the long term.[12] In this regard, the rules and regulations governing market structure and market interactions will be critical, as well as the cost and availability of information. These arrangements determine transaction costs and, hence, the incentive structure that drives economic behavior; they also define the scope and form that markets take.[13]

Many of the rules and regulations for economic interactions in the United States were established in the last half of the 19th century for a national market that prompted the growth of large, vertically integrated firms.[14] The policies that the government then selected to cope with those developments, however, stem as much from U.S. political culture as from the events themselves.[15] Americans are fierce supporters of a free-market, competitive economy.[16] At the turn of the century, when the government acted against the abuses of large businesses, it did so in a uniquely American, pro-market fashion.[17] America's preference 'or competitive market solutions is demonstrated in

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[11] As Andrew Schotter has pointed out: "Economic and social systems evolve the way species do. To ensure their survival and growth, they must solve a whole set of problems that arise as the systems evolve. Each problem creates the need for some adaptive feature, that is, a social institution. Every evolutionary economic problem requires a social institution to solve it. . . . Those societies that create the proper set of social institutions survive and flourish; those that do not, falter and die. The distressing fact is that what is functional to meet today's problems may be totally inadequate in meeting the tests our society faces tomorrow." Andrew Schotter, *The Theory of Social Institutions* (Cambridge, UK: Cambridge University Press, 1981), pp. 1-2.

[12] As described by Polanyi: "A nation may be handicapped in its struggle for survival by the fact that its institutions, or some of them, belong to a type that happens to be on the downgrade-the gold standard in World War 11 was an instance of such an antiquated outfit. Countries, on the other hand, which, for reasons of their own are opposed to the *status quo,* would be quick to discover the weaknesses of the existing institutional order and anticipate the creation of institutions better adapted to their interests." Karl Polanyi, *The Great Transformation: The Political and Economic Origins of Our Time* (Boston, MA: Beacon Press, 1957), p. 28.

[13] As described by North: "Institutions provide the structure for exchange that (together with the technology employed) determines the cost of transacting and the cost of transformation. How well institutions solve the problems of coordination and production is determined by the motivation of the players (their utility functions), the complexity of the environment, and the ability of the players to decipher and order the environment (measurement and enforcement)." North, op. cit., footnote *7,* p. 34.

[14] See Alfred Chandler, *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, MA: Harvard University Press, 1977); and James Beniger, *7-he Control Resolution: Technology and the Economic Origins of the Information Society* (Cambridge, MA: Harvard University Press, 1986).

[15] See for discussions of the effects of culture on institutions and organizations, John W. Meyer and Brian Rowan, "Institutionalized Organizations: Formal Structure as Myth and Ceremony," in Powell and DiMaggio (eds.), op. cit., footnote 9; Fred Block, *Postindustrial Possibilities: A Critique of Economic Discourse* (Berkeley, CA: University of California Press, 1990); and Neil Fligstein, *The Transformation of Corporare Control* (Cambridge, MA: Harvard University Press, 1990), pp. 53-55.

[16] As Galambos and Pratt describe: "What did vibrate through America was praise for the creator of new Ventures, whether on the farm, in transportation, or in manufacturing and commerce. The materialistic culture was translated into specific political improvements when the states and localities supported internal improvements, encouraged resource use, eased the route to incorporation, and carefully protected property rights. The entrepreneurs of that day could expect few threats and much support from government." Louis Galambos and Joseph Pratt, *The Rise o/ the Corporate Commonwealth: U.S. Business and Public Policy in the Twentieth Century (New* York, NY: Basic Books, 1989), p. 23.

[17] Although these values were often supported more by rhetoric than practice, they were greatly popularized by the progressive movement, which had its heyday in the late 1800s. Members of the progressive movement helped to expose a number of scandals that linked politicians and business, reinforcing American suspicions of government. Ironically, the reputation of big business was actually improved. As Walsh notes, "Laissez-faire economic theory seemed newly justified by the record of great corporate successes between 1889 and 1929. The role of Government in that development was discounted and its reputation tarnished." Annemarie Hauch Walsh, *The Public's Business: The Politics and Practices q/Government Corporations* (Cambridge, MA: The MIT Press, 1978), pp. 25-26. See also, David Vogel, "Giwemment-industry Relationships in the United States. An Overview," in Stephen Wilks and Maurice Wright (eds.), *Comparative Government-Industry Re/a/ions* (Oxford Clarendon Press, 1987), ch. 5.

four areas where the government intervened to channel market activities—antitrust law, regulatory policy, information policy, and trade policy.

Antitrust law, for example, was codified with the passage of the Sherman Act of 1890. Building on common law prescriptions that dated from the 1840s, this act sought "to protect trade and commerce against unlawful restraints and monopolies." The Sherman Act was somewhat ambiguous. however, because it did not describe which particular practices constituted either "a restraint on trade" or "an attempt to monopolize. " Nor did the act provide an institutional mechanism to undertake investigations or enforce the law. [18] Instead, responsibility for implementation was left to the courts, and notification of violations was made the responsibility of the damaged parties. Given such ambivalence, it is clear that the Sherman Act was not meant to be anti business nor anticapitalist. On the contrary, the act opposed trusts and other forms of big business precisely because they were anticompetitive and their behavior precluded other businesses from fully participating in the market economy. It was widely believed that if the monopolistic practices of business could be curbed, there would be less reason for government to intervene in the economy. [19]

Regulatory policy created a similar dilemma for government. The railroads were the first in line for regulation because of their central role in the nation's economy. [20] When overbuilding and cutthroat competition at the turn of the century led railroad owners to resort to anticompetitive practices, such as pooling arrangements and discriminatory pricing, the public called for reform. As in the case of antitrust, there was little agreement on how to proceed. Some favored cartelization, and called on government to enforce pooling arrangements. Such an approach, however, would not have been politically acceptable. At the other extreme was nationalization, which was out of the question, given American political culture and the costs involved. [21] After much debate, Congress adopted a hybrid solution-the independent regulatory commission. This approach left business in private hands, while limiting the potential for monopoly abuse (see box 7-4).

In contrast to antitrust and regulatory policy, which were inspired by turn-of-the-century events, the government's use of information policy to structure markets dates back to the founding of the nation itself. [22] Operating as a common carrier, the government used its postal monopoly not only to disseminate information, but also to assure that there would be equitable access to it. Policies relating to the distribution of newspapers were key to early commerce. Newspapers carried most of the business news, and also

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[18] Such powers were only provided in 1914 under the Clayton Antitrust Act, which established the Federal Trade Commission.

[19] Because the Sherman Act was vague, it was open to liberal interpretation. Thus, with few exceptions, it was not applied against existing business arrangements. Although it outlawed cartels, trusts, and pooling, it permitted mergers through holding companies and vertically integrated corporations. In the period that followed the passage of the Sherman Act, there was a rash of horizontal mergers. Several years later, when this approach proved unsuccessful, these holding companies were replaced by vertically integrated firms. See Galambos and Pratt, op. cit.. footnote 16; and Fligstein, op. cit., footnote 15.

[20] The railroads presented government with a special case. Although the railroad magnates were considered to be guilty of some of the worst market-related abuses, most people recognized that a national rail system was critical for economic growth and development. The railroads, c\eryone recognized, had made it possible to open up the West, a fact that had led the government to subsidize their development through huge land grants and other financial benefits. The Union Pacific Railroad, for example, was given 12 million acres of land, while the Central Pacific recen Cd 11 million. Railroad performance continued to affect all other aspects of economic life. The nation's financial markets, for example, were greatly influenced by railroad financing, and commodity prices were directly linked to railroad rates. See L.C. A. Knowles, *Economic Development in Nineteenth Century: France, Germany, Russia and the United States* (New York, NY. Augustus M. Kelley Pub] ishers, Reprints of Economic Classics, 1 967), pp. 91-93.

[21] Galambos and Pratt, op. cit.. footnote 16, pp. 91-93,

[22] See Gordon Hook, *The Creation Of the American Republic, 1776-1787* (Chapel Hill, NC: University of North Carolina Press, 1959).

BOX 7–4: The Interstate Commerce Cc

To regulate the railroads, the Interstate Commerce Commission (ICC) was established in 1887 with the passage of the Interstate Commerce Act. Its overall mission was to assure that rates were "just and reasonable" In addition, price discrimination and pooling arrangements were prohibited To carry out this mandate, the President was to appoint five commissioners who were to serve for 6 years Although the ICC responded to the immediate call for government action, its impact on business practices was quite limited. Having little expertise, scanty information, and no investigative authority, the ICC lacked the wherewithal to effectively execute its role. [1]

The ICC'S impact over the long term was, however, much more significant. It not only set an important precedent for regulatory intervention, but it also helped to firmly establish the principles of common carriage and equal access to essential facilities Moreover, despite the ICC'S failings, it served as the organizational model for the regulation of a number of subsequent technologies.

[1] Louis Galambos and Joseph Pratt, *The Rise of the Corporate Commonwealth U S Business and Public Policy in the Twentieth Century (New* York, NY Basic Books, 1989), pp 57-59

SOURCE Off Ice of Technology Assessment, 1994

provided the fastest and cheapest way of gathering information. [23] In 1836, the Post Office also inaugurated postal express services to speed information-especially market intelligence—in advance of the regular stagecoach mails.[24]

The laws to protect intellectual property rights, also authorized by the Constitution, were designed to foster information dissemination. James Madison—the principal author of the intellectual property clause—was aware of the monopolistic connotations of such a governmentally granted, exclusive right. However, he distinguished the American system of intellectual property rights from previous ones that he believed to be more

23 Perhaps the clearest expression of the government policy to promote the widespread dissemination of news was the postage-free exchange of newspapers among printers. Long before the advent of press associations, editors obtained nonlocal information by culling out-of-town newspapers, their so-called exchanges. In an arrangement that today's journalists might find foreign and offensive, the government in essence operated the nation's news-gathering services. These printers' exchanges furnished most nonlocal news throughout the first half of the 19th century. See, for a discussion, Richard B. Kielbowicz, "The Press, Post Office, and the Flow of News in the Earl y Republic," *Journal of the Early Republic, vol.* 3, fall 1983, pp. 255-280.

24 Newspapers could send slips postage-free; other mailers paid triple the regular rates. Policymakers assumed that newspapers could thereby obtain timely market intelligence through the government-subsidized service, making it available to all readers and thereby counteracting the advantages enjoyed by speculators who had access to private communication channels. Public support for such policies intensified as the nation expanded westward. Postal debates reflected a concern about the issue of equitable access to information. See Richard B. Kielbowicz, '"Modernization, Communication Policy, and the Geopolitics Of News, 1820- 1860," *Critical Studies in Mass Communications, vol.* 3, March 1986, pp. 21-35.

pernicious.[25] To avoid the evils of monopoly, Madison intended that the exclusive rights afforded by copyright be narrowly circumscribed; owned by "many" and "granted for only limited periods of time."[26] The role of the government was also confined to that of registrar; it was up to the holders of intellectual property rights themselves to monitor infringements and enforce their own rights .27 Despite the Founding Fathers' intentions, however, the issue of how to bound these rights, and the role of the government with respect to them, has repeatedly reemerged as intellectual property rights were extended to incorporate new technologies.[28]

The government's inconsistency with respect to market rules and regulations was most apparent in the case of trade and tariff policy. Although Americans strongly supported free market competition in the domestic marketplace, this was not true with respect to foreign trade. Until World War II, the United States was the most protectionist industrialized country in the world.[29] This protectionist stance was justified on a number of grounds—the need to raise revenues, protect infant industries, and defend against cheap foreign labor.[30] However, the country position on tariffs also needs to be understood in terms of the overriding concern at the time about integrating the nation and developing a national market. It is likely that the economic costs of high tariffs were difficult to perceive. Consumers enjoyed an ever-increasing number of products at increasing y lower prices, as a result of a national market that could support mass production.[31] It was much later, after the U.S. economy had grown sufficiently to be integrated into the world economy, that the United

[25] In a letter to Jefferson, Madison wrote: "Monopolies are sacrifices of the many to the few. Where the power is in the few it is natural for them to sacrifice the many to their own partialities and corruptions. When the power is in the many not in the few the danger cannot be very great that the few will be thus favored." Letter from James Madison to Thomas Jefferson, dated Oct. 17, 1788, as quoted in Bruce Bugbee, *The Genesis of American Patent and Copyright Law* (Washington, DC: Public Affairs Press, 1967), pp. 84-125.

[26] Numerous other features of the first copyright law ensured that the bargain struck between the author and the public would not constitute a monopoly. For example, the term of copyright protection was limited to 14 years, after which the work would return to the public domain and anyone would be free to print it. The copyright term ended with the lifetime of both the author and his reading public, so that, even if copyright were a monopoly, it was one that could not last long. Moreover, copyright was initially vested in the author, although he could thereafter assign his copyright to others. By creating as many copyrights as there were authors, the law avoided the concentration of market power. See Patterson, op. cit., footnote 10.

[27] Henry, op. cit., footnote 10, pp. 56-57.

[28] See OTA, *Intellectual Property Rights in an Age of Electronics and Information*, OTA-CIT-302 (Washington, DC: U.S. Government Printing Office, April 1986); and OTA, *Finding a Balance: Computer Software, Intellectual Property and the Challenge of Technological Change*, OTA-TCT-527 (Washington, DC: U.S. Government Printing Office, May 1992).

[29] Knowles, op. cit., footnote 20, p. 304.

[30] It should be noted that tariff policy was a major issue in American politics, which greatly contributed to the breach between the North and the South. Dependent on European markets to sell its cotton, the South consistently opposed high tariffs. The North, on the other hand, looked to tariffs to protect their newly emerging manufacturing concerns.

[31] In no other country was there a geographic market large enough to absorb the output of a single standardized commodity or stable enough to sustain continual large-scale production. Nor was there anywhere else a labor or consumer market equivalent to that in the United States that could take advantage of an ever-expanding volume of mass-produced capital and consumer goods. See, for discussions, Harold Williamson (ed.), *The Growth of the American Economy* (New York, NY: Prentice Hall, 1951), p. 722; and Michael J. Piore and Charles F. Sabel, *The Second Great Industrial Divide: Possibilities for Prosperity* (New York, NY: Basic Books, 1984).

States became the leading advocate for free trade.[32]

Today, these four market-related policy mechanisms are overlapping because of the convergence of information and communication technologies and the shift to a knowledge-based, global economy. For example, trade policy can no longer be considered apart from information, regulatory, and antitrust policies. Increasingly, it is not tariffs per se, but rather nontariff barriers— such as data protection laws, regulatory rules of interconnection, and domestic cooperative business relationships—that serve as constraints on trade. Similarly, the resolution of antitrust disputes increasingly revolves around issues having to do with intellectual property rights, regulatory policies, and whether or not there is a global consensus on antitrust rules. For example, whether an electronic business network constitutes an antitrust infringement might depend on the way that standards are set, and/or the way that intellectual property rights and privacy laws are applied to commercial networked information systems.

Determining how to apply traditional market rules and regulations is also likely to be problematic in the future. Electronic business networks fall somewhere between the classical notions of markets and firms. While serving to enhance efficiency and effectiveness, they can shape the structure and functioning of the marketplace in profound ways. Because of the many interdependencies entailed in networks (whether social or technological), their mode of operation often conflicts with the prerequisites for competitive markets.[33] Members of business networks, for example, are not "price-takers" as classical theory would dictate .34 At the turn of the century, economic actors sought to control future prices and reduce their transaction costs by vertically integrating their activities within a corporation; today, many businesses are hedging against the future by establishing long-term commitments through networking .35

In developing such networks, members are motivated by both social and economic factors.[36] Studies show, for example, that businesses will accept a cost disadvantage in selecting suppliers. Instead of seeking the lowest cost provider, they prefer to deal with suppliers with whom they have ongoing relationships. Similarly, in selecting partners for a strategic alliance, businesses often choose to work with people they have known and dealt with for a considerable period of time.[37]

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[32] See Robert Gilpin, *The Political Economy of International Relations* (Princeton, NJ: Princeton University Press, 1987). At the end of the 19th century, the debate about tariffs also became intertwined with the issue of antitrust. The debate took place along party lines. Republicans under the Roosevelt Administration pushed had for antitrust regulation, but favored high tariffs. Democrats, on the other hand, adamantly opposed the Sherman Act, arguing that it was high tariffs, not pooling and cartel arrangements, that gave rise to competitiveness problems. If tariffs were lowered, they contended, trusts would face enough competition from abroad. Many years later it was the Republican Administration, under president Reagan, that— in its effort to limit the scope of antitrust infringements-argued a very similar case.

[33] See Cristiano Antonelli "The Economic Theory of Information Networks, in Cristiano Antonelli (cd.), *The Economics of Information Networks* (Amsterdam, The Netherlands North Holland, 1992), pp. 5-29.

[34] As noted by Hirschman: "Under perfect competition there is no room for bargaining, negotiation, remonstrations or mutual adjustment and the various operators that contract together need not enter into recurrent or continuing relationships as a result of which they would get to know each other well.'" Albert 0. Hirschman, "'Rival Interpretations of Market Society: Civilizing, Destructive, or Feeble'?''./ourna/ o/ *Economic Literature*, vol. *4*, No. *20*, p. 1473.

[35] G. Hodgson, *Economics and Institutions* (Cambridge, UK: Polity Press, 1988), p. 209. See also Jay B. Barney and William G. Ouchi, "Basic Concepts," in Jay B. Barney and William G. Ouchi (eds.), *Organizational Economics* (San Francisco, CA, Jossey-Bass Publishers, 1986), pp. 24-25.

[36] See Mark Granovetter, "The Old and the New Sociology," in Friedland and Robertson, op. cit., footnote 6; and Mark Granovetter, "Economic Action and Social Structure: The Problem of Embeddedness," in Mark Granovetter and Richard Swedberg (eds.), The *Sociology of Economic Life* (Boulder, CO: Westview Press, 1992).

[37] See Mario Benassi, "Organizational perspectives of Strategic Alliances," in Gernot Grabher, *The Embedded Firm: On The Socioeconomics of Industrial Networks* (London, England Routeledge, 1993), p. 104.

Studies of innovation also show that innovation tends to be greater when the relationships between buyers and sellers is cooperative rather than competitive.[38] Labor markets likewise often exhibit these kinds of network characteristics.[39]

Business networks also violate the ideal condition for competitive markets that requires that market information be symmetrically available. Whereas in competitive markets the only information required is price, in business networks the amount of information that needs to be shared is much greater.[40] In some cases, this kind Of information exchange will be confined to the network, and thus can serve as a major competitive advantage and a formidable barrier to market entry.[41] In fact, it is clear that networks are often designed precisely to play such a role.[42]

Some market problems relating to networked information systems have already arisen—for example, multiple-listing services (MLSs) in the real estate business. These networks are designed not only to connect buyers and sellers, but also to share the cost of searching facilities across a broad base of users, Although such networks have existed for years, it is only recently that MLSs have been computerized, allowing real estate information to be updated on a daily basis.[43] Real estate listings for a given area are pooled in a computer database and distributed to realtors over an electronic network. Realtors use the system to preview houses for customers, allowing them to compare homes according to a variety of criteria without having to visit each one. Brokers are willing to share their listings because they reduce their costs and receive a commission on each property sold by another participating broker.[44] Multiple-listing services are often administered by the local Board of Realtors, which maintains and updates the computer register. However, these systems are not open to all brokers and a number of membership stipulations apply.[45] Restricted membership, it is said, is designed to provide quality control. On the other hand, those who are excluded from such services often argue—and at times with the courts' concurrence-that closed MLSs give rise to anticompetitive behavior.[46]

Multiple-party networking services not only reduce search costs; they also allow transactions and exchange to take place online. Computer reservation systems (CRSs) also provide such services. Travel agencies use these systems to select

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[38] E. Von Hippel, *The Sources of Innovation* (Oxford, UK: Oxford University Press, 1988).

[39] Mark Granovetter "The Sociology and Economic Approaches to Labor Market Analysis, " in Granovetter and Swedberg, op.cit., footnote 36, pp. 233-263.

[40] See T. Scitovsky, "Two Concepts of Network External Economies, "*Journal of Political Economy*, April 1954, p. 150.

[41] Bruce Kogut Weijian Shan, and Gordon Walker, "Knowledge in the Network and the Network as Know ledge," in Grabher, op.cit., footnote 37, p. 77,

[42] For a discussion, see Robin Mansell, "Information, Organization, and Competitiveness: Networking Strategies in the 1990s," in Antonelli, op. cit., footnote 33, pp. 217-227.

[43] As Lopatka and Simons point out, manually operated multiple-listing services date back to the early 1900s. Like many of the other industry wide organizational arrangements that came into existence about this time, multiple-listing services were designed to bring (waler, and thus greater efficiency, to the industry through the establishment of some agreed-upon standards and practices, See John E. Lopatka and Joseph J, Simon, "'Real Estate Multiple Listing Services and Antitrust Revisited, " in Steve S. Wildman and Margaret Guerin-Calvert, *Electronic Services Networks: A Business and Pub/it Policy Challenge (New* York, NY: Praeger, 1991), pp. 207-208.

[44] Ibid

[45] For example some MLSs require that only exclusive right-to-sell listings be placed in the system; others require that members place all properties for which they have an exclusive listing in the service; while others prohibit membership in competing multiple-llst]ng services. Ibid.. pp. 217-219.

[46] See ibid. for example, who defend (he use of MLSs on quality and efficiency grounds.

and book flights. These systems are so efficient that they have become essential for doing business.[47] Today, there are four national CRS providers that serve over 95 percent of all travel agents.[48] When deployment achieves such levels, the electronic network can truly be said to represent the market.

The first computer reservation systems—SABRE and APOLLO-were established by the two largest airline companies, American and United. Because these companies had already developed their own internal reservation systems and had large markets, they were able to use these systems to both increase efficiency and gain strategic competitive advantage.[49] S ince travel agents used CRS terminals and data that were provided by the airlines themselves, their selection of flights was often biased in favor of the provider's airline service. The airlines not only listed their own services first, but they also provided bonuses to agents on the basis of volume sales. In addition, the prices that American and United charged to allow others to post flights on their CRS systems discriminated against competitors. Antitrust actions led the Civil Aeronautics Board, in 1984, to establish rules prohibiting display bias; limiting the terms of CRS contracts with travel agents to 5 years; and prohibiting discriminatory pricing with respect to both booking fees and access charges. However, despite these rules, previous market patterns have persisted, suggesting that there are still significant barriers to entry .50

Although automated teller machine (ATM) networks are now operated on a relatively open and shared basis, they have, like other electronic markets, run into antitrust problems[51] (see box 7-5). In the case of ATMs, the problem is with pricing. ATM networks are operated as joint systems comprised of a networking service provider, who provides electronic funds transfer services; and ATM sponsors, such as banks or other financial service providers, who own and operate the ATMs. Whenever customers use an ATM to access the ATM of a different sponsor, the network provider receives a switching fee from the first ATM owner. That same owner also has to pay a service fee to the sponsor of the ATM accessed by the customer through the network. ATM owners may also pay the network provider a fixed fee for access to the network, as well as a royalty fee for each ATM card issued.[52] The ATM providers may, in turn, charge the customer a fee for the ATM card, a fee for each transaction, and a fee for accessing a foreign ATM sponsor. Whether or not ATM sponsors should be free to set rates independent y of the network service provider is an extremely controversial issue. Network providers argued that fixed, universal rates are necessary for the effective func -

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47 Estimates are that Using CRSs, airline companies have been able to reduce (he costs of making a reservation from $7.50 to $0.50, while travel agencies have increased their productivity by as much as 43 percent. See Margaret E. Guerin-Calvert and Roger G. Nell, "Computer Reservation Systems and Their Network Linkages to the Airline Industry, " in Wildman and Guerin-Calvert, ibid., p. 147.

48 Andrew, N. Kleit, "Computer Reservation Systems: Competition Misunderstood, "' *Antitrust Bulletin*, vol.32, winter 1992, pp. 833-861.

49 Ibid. See also D Copeland and J. McKenney, "Airline Reservation Systems: Lessons from History," MIS Quarterly, vol.12, No.3, September 1988, pp. 353-370; and U.S. Department of Transportation, *Study of Airline Computer Reservation Systems* (Washington, DC: U.S. Government Printing Office, May 1988).

50 Guerin-Calvert and Noll, op. cit, footnote 47, pp.144-187.

51 There were a number of reasons why ATM network providers found it in their interest to have compatible systems. Interconnection allowed banks to gain economies of scale, increasing the rate of usage while averaging operating costs. In addition, providers were able to offer services outside of [heir local marketing areas. Alan Gart, "How Technology 1s Changing Banking," *Journal of Retail Banking*, spring 1992, vol. xiv, No. 1.

52 Richard J. Gilbert, "on the Delegation of Pricing Authority in Shared Automatic Teller Machine Networks, "in Wildman and Guerin-Cal- \ ert, op. cit., footnote 43, pp. 114-144. As noted by Richard Mitchell, these fees can add up for multiregional banks that have to pay membership fees for a variety of networks. Richard Mitchell, "Electronic Payments Services: Watershed in EFT Consolidation," *Bank Management*, October 1992, pp. 73, 76.

BOX 7–5: Automated Teller Machine Netw

Automated teller machine networks (ATMs) also function as electronic markets, providing both automated and networked banking services These networks reduce the costs of executing transactions by allowing banks to shorten teller hours and build smaller and fewer branches At the same time, consume gain by having much more convenient banking services, with access 24 hours a day from a number of different providers across a wide geographic area

While initially slow to take off ATMs have greatly increased in popularity [1] By 1990, there were 45,0(ATMs deployed, as compared to only 2,000 in 19732 As usage Increased, so did the number and variety competitors seeking to provide ATM services Nonbank financial restitutions such as Visa, Mastercard, Plus, and Cirrus quickly entered the fray Being unregulated, these financial service providers had the advantage of being able to offer nationally based services More recently, providers of data-processing services a getting into the market In the fall of 1992, for example, EDS announced its intention to enter the electron funds transfer market, deploying 10000 ATM machines by 1995, while Affiliated Computer Systems noted its plans to Increase its ATM base during the same period from 800 to 5,0003 To maintain their market posi tion existing ATM owners are seeking to differentiate their services by adding value, and to establish a n tional platform and reduce their costs by entering into mergers and alliances Leading the way is Electron Payments Services (EPS), a joint venture of four major banking companies [4]

Today's enhanced ATM services attest to this growing competition ATMs are now available in almost any locale—bank premises urban streets, airports, shopping malls, gas stations, universities, and hospital Moreover the range of services offered is expanding all the time Customers can obtain cash, transfer funds across accounts make deposits, and obtain cash balances using the latest technology [5]In son cases they can communicate with bank personnel via interactive video, pay bills, and make nonbank pur chases of such things as stamps, subway cards, and even gift certificates.[6]ATM services can also be a cessed Internationally By negotiating across shared ATM networks, for example, Hong Kong Bank now allows customers to get cash at 120,000 ATMs in 50 countries Similarly, Citibank provides cash access from 150000 machines worldwide [7]

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[1] The slow pace of deployment was due not only to customer resistance According to Peter Keen even as late as 1982 ma banks were still skeptical about the profitability of ATMs Peter Keen, *Competing in Time* Using *Telecommunications for Competiti* ***Advantage*** (Cambridge MA Ballinger Publishing Co 1986)

[2] Alan Gart How Technology is Changing Banking, ' *Journal of Retail Banking* spring 1992, VOI xiv, No 1, p 42

[3] Richard Mitchell 'Electronic Payment Services Watershed in EFT Consolidation, ' *Bank Management,* October 19 p 76

[4] At the outset EPS will link 1 400 financial institutions with 13,000 ATMs in 16 states, processing an estimated 1 billion transactio per year This adds up to about 20 percent of the nation's switched ATM services Thomas Hoffman, "Regional Banks Form ATM N work *Computerworld* July 27 1993

[5] Lauri Green How Buck Rogers Is Bailing Out ATMs ' *Bank Management,* November 1992, pp 65-67, see also, Mark Arer High-Tech Banking Centers Add Value to Branches, *ABA Banking Journal,* November 1992, pp 39-46

[6] Ibid See also Joe Asher Seafirst Expands Card Delivery System, " *American Banking Journal, April* 1991 PP 76, 78

[7] Mark Clifford Touch an ATM for Money," *Far Eastern Economic Review,* Sept 24, 1992 pp 62-63

SOURCE Office of Technology Assessment 1994

tioning of the network and to promote ATM usage; others, in particular ATM sponsors, contend that rate-setting, when imposed by network providers, is anticompetitive. Court rulings on the issue to date have been inconsistent. However, these kinds of cases will likely increase in the future, given the increase in competition.[53]

Sorting out these issues in an environment of virtual corporations and electronic commerce will become extremely difficult, requiring concurrent expertise in such areas as antitrust law, regulatory policy, networking technology and standards development, intellectual property and privacy law, and trade policy. Given the complexity of the issues, the economic costs of institutional failure, and the tendency of people to continue to view situations through the lens of old paradigms, Congress might want to establish a Commission or authorize a major study to analyze the implications of conducting business via electronic networks and enterprises for market rules and regulations.

In the past, national commissions have been especially useful in focusing the nation's attention on issues, such as electronic commerce, that are likely to have a broad impact on everyone.[54] The costs of setting up a commission are relatively small. Because national commissions are generally established to deal with a specific set of problems and have a limited tenure, there is virtually no risk of generating an enduring, and eventually unnecessary, government organization. Moreover, because commissions are temporary and unique in nature, they can often attract outstanding individuals with broad experience who would not be available on a long-term basis. This would be especially important in understanding the long-term market implications of electronic commerce because the range of knowledge that is required is so broad, and experts in the field are unlikely to have a basis for association and interaction. By heightening the public's awareness of a problem and by engaging the public to debate its solution, a commission to examine electronic commerce could also serve an important legitimating function at a time when the economy is undergoing such fundamental change; when government and the private sector are reconsidering and reworking their relationships; and when firms need to rethink and revise how they conduct their businesses.[55]

One model that might be followed in setting up a commission is that of the National Commission on New Technological Uses of Copyrighted Works (CONTU). This commission was established as part of an effort to comprehensively revise U.S. copyright law in the light of technological change and the greatly enhanced value of information. Following 3 years of deliberation, the commission presented its recommendations to Congress; many were incorporated into the 1986 Copyright Act, thereby extending copyright protection to computer software.[56]

OPTION B: Restructure the Organizational Basis for Communication Decisionmaking

Decisions about the structure of the marketplace are not necessarily made deliberately. Often such choices result from decisions made in what might

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53 For an economic analysis of these issues, see Gilbert, ibid. For a discussion of the legal cases, see also, Karen L. Grimm and David A. Balto, "How the Antitrust Laws Limit Pricing Policies of Shared ATM Networks," *Banking Law Review*, *vol. 4*, winter 1992, pp. 15-24, In *National Bank Corporation v. Visa USA*, the court upheld the right of the network to fix credit card interexchange fees, whereas in *First Texas Savings Association v. the Court* held that, when an ATM network has market power, it could fix fees only if, at the same time, it allowed ATM owners to impose surcharges or rebates. In *Valley Bank v. Plus System*, Inc., the court concluded that it was not necessary to fix fees, since a number of ATM networks operated successfully without having to do so.

54 For one discussion of the role of commissions, see Frank Popper, *The President's Commission* (New York, NY: Twentieth Century Fund, April 1970).

55 Ibid.

56 See *Final Report of the National Commission on New Technological Uses of Copyrighted Works* (Washington, DC: Library of Congress, 1979).

appear to be a totally different arena. Because communication and information technologies undergird all social and economic activities, the "spillover effects" of regulatory policies can have far-reaching consequences. In a knowledge-based economy, special care will be needed to ensure that regulatory policies are responsive to, and consistent with, national economic and social goals. One major problem that has prevented such policy reconciliation in the past has been the extremely fractionated nature of the U.S. communication policy decisionmaking process. To avoid these problems in the future, a more coherent policymaking process will be needed.

The Clinton Administration has taken a number of steps in this direction. Acknowledging the critical importance of the national information infrastructure (NII) in a global knowledge-based economy, the Administration has recently laid out a vision for its development. To assist in articulating and implementing this vision, a National Information Infrastructure Task Force (IITF) has been established. Membership includes high-level representatives of all federal agencies having a major role to play in the development and application of information technologies. Input from the private sector will be channeled through an advisory council of key stakeholders including industry, labor, academia, public interest groups, and state and local governments. In addition, the IITF has established an electronic bulletin board system that will provide IITF schedules, committee reports, and public minutes of meetings.[57] The White House Office of Science and Technology Policy (OSTP), together with the National Economic Council, is responsible for directing the operations of the Task Force, with the Secretary of Commerce acting as Chair.[58] Much of the staff work will be carried out by the National Telecommunications and Information Administration (NTIA) of the Department of Commerce.

Although the IITF represents a major step forward in the development of a coherent communications policy, in keeping with other national policy goals, it is questionable whether such an ad hoc process can resolve the jurisdictional problems that traditionally have characterized U.S. communication policymaking over the long term.[59] These problems will only be exacerbated in the future, given the continued convergence of technology across industry and policymaking boundaries, the greatly enhanced value of information, and the globalization of the communication marketplace. A more permanent, organizational solution may be required in order to consider communication policy in terms of all of its social and economic ramifications.

One possible organizational option, for example, would be to formally designate NTIA as the lead agency to coordinate national communication policy. NTIA, in the Department of Commerce, is a likely candidate. In 1978, Executive Order 12046 established NTIA to "provide for the coordination of the telecommunication activities of the Executive Branch. '*Go NTIA has itself pro-

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57 *IITF Committee Report,* Dec. 9,1993.

58 Ibid. According to the Executive Order establishing *the* National Economic Council, its charge is to "advise the IITF on matters related to the development of the NI 1, such as: the appropriate roles of the private and public sectors in NII development; a vision for the evolution of the NII and its public and commercial applications; the impact of current and proposed regulatory regimes on the evolution of the NII privacy, security, and copyright issues, national strategies for maximizing interconnection and interoperability of communication networks; and universal access. " The Council is also expected to invite experts to submit information to the Council.

59 For a detailed discussion of these problems see OTA *Critical Connections: Communication for the Future,* OTA-CIT-407 *(Washington,* DC U.S. Government Printing Office, 1990), esp. ch. 13.

60 47 U.S.C. 151.

posed this option in its report, *NTIA Telecom 2000,*[61] arguing that the current organizational structure for communication policy suffers from an outlook that:

- often tends to be reactive and skewed toward achieving short-term objectives;
- focuses too much on the status quo; and
- is too concerned with balancing particular interests, rather than
- with long-range policy planning.[62]

According to NTIA, the present, fragmented decisionmaking process encourages stakeholders to shop around for the policy forum in which they are likely to receive the most sympathetic hearing.[63] An executive branch agency, it is argued, can be more proactive than an independent agency such as the Federal Communications Commission (FCC). Moreover, an executive branch agency can more successfully bring together a cross-disciplinary depth of skills and command greater acceptance and respect within both the government and the private sector than can the FCC, which has a narrowly conceived regulatory (and some would say deregulatory) role.[64]

The idea of transferring authority from independent agencies to the executive branch as a means of enhancing policy coordination is not a new idea. A number of Presidential commissions created to analyze the organization of government have recommended such a realignment of power.[65] One of the most recent was the Ash Council established by President Nixon in 1969. It criticized the independent regulatory commissions for being neither responsive to the public interest nor coordinated with national policy.[66] It is important to note, however, that in prescribing the integration of a number of independent agencies, the Ash Council made an exception of the FCC. It argued that FCC should remain independent, given the sensitive role that it has played with respect to the mass media.[67]

Were NTIA to play a greater role in policymaking, its staff and resources would clearly need to be upgraded. Only recently—with a strong Presidential vision of the NII and a Democratic majority in the Congress—has NTIA shown an ability to address a consistent national communication policy. Nor has the NTIA been successful in performing the former Office of Technology Policy (OTP) task of coordinating the U.S. communication policy position for presentation in international policy fora.

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61 According to NTIA: "The Executive Branch should have the authority to *establish* policy, while the FCC should remain the agency for *implementation of policy* [emphasis in the original]." It should be noted that, if this proposal were adopted, the executive branch and legislative agencies would, in effect, be reversing their traditional roles.

62 U.S. Department of Commerce, National Telecommunications and Information Administration, *NTIA Telecom 2000: Charting the Course for a New Century* (Washington, DC: U.S. Government Printing Office, 1988), p. 165.

63 Ibid.

64 Ibid., pp. 167-172.

65 For example, in its report to Congress, the Brownlow Commission, established under President Roosevelt, recommended that 100 independent agencies, administrations, boards, and commissions be integrated into 12 executive departments. The report was particularly critical of the independent regulatory agencies, characterizing them as the "headless fourth branch of Government." The first Hoover Commission, set up after World War 11, made similar recommendations, arguing that the executive branch ought to be reorganized to create an integrated, hierarchical structure with the President as an active manager. So, too, did the J.M. Landis *Report on Regulatory Agencies to the President Eleel,* U.S. Senate, 1960. See, for a discussion, "The Federal Executive Establishment: Evolution and Trends," Library of Congress, Congressional Research Service, prepared for the Senate Committee on Governmental Affairs, May 1980. See also Ronald C. Moe, "The Two Hoover Commissions in Retrospect," Library of Congress, Congressional Research Service, Nov. 4, 1981.

66 "A New Regulatory Framework: Report on Selected Independent Regulatory Agencies," The President Advisory Council (m Executive Organization, 1971. For a discussion, see Moe, op. cit., footnote 65; see also Harvey Mansfield, "Reorganizing the Federal Executive Branch: The Limits of institutionalization," *Law and Contemporary Problems*, vol. 35, summer 1970, pp. 460-495.

67 "A New Regulatory Framework," op. cit., footnote 66, pp. 31-46.

The FCC would most likely oppose a transfer of any authority to the executive branch. Members of congressional committees responsible for FCC oversight, who in the past have protected their jurisdictions in this regard, are also likely to oppose such a measure.[68] Given the historical litany of complaints against independent regulatory commissions, their continued longevity in the face of such criticism attests to the strength of congressional stakeholder opposition to any change.[69]

The FCC could also serve as the central locus of policymaking. Established by the Communications Act of 1934, FCC was designed, in part, to implement the act "by centralizing authority heretofore granted by law to several agencies. "[70] However, the mushrooming of other agencies and authorities to deal with burgeoning communication and communication-related issues has seriously challenged FCC's role in this regard.

Created as an independent agency, FCC is linked and responsible to the legislative, rather than to the executive, branch.[71] Because it is the job of the legislature to make policy, it can reasonably be argued that FCC should be assigned the task of reconciling national communication policy objectives and jurisdictional disputes on a day-to-day basis. This legislative connection might also serve to ensure that, when developing communication policy, a broad range of interests are taken into account. Because compromise is inherent in the congressional environment, the legislative perspective is often eclectic and inclusive of many minority points of view.[72]

This tendency to be all-embracing, however, is both a strength and a weakness of the FCC. The congressional focus on winning political favor and fashioning political compromises can serve to put the brakes on any major policy departures.[73] Some might also take issue with the option of transferring considerable policymaking authority to FCC on grounds of democratic theory, which requires that policy organizations be held directly accountable to the public for their actions.[74] Although shifting this authority to FCC would not shield the policymaking process from public influence, it might change the nature and process of the debate about policy issues.

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68 As Moe has pointed out: "Congress is not well organized to deal with abstract principles, such as a unified executive branch. The committee structure is more appropriate for dealing with specific problem areas and with distinct units w ithin the executive branch. .Given its constitutional power to establish units in the executive branch, and given its institutional tendency to seek influence in the making of agency policy, Congress increasingly has been inclined to create agencies which have a high degree of independence from Presidential supervision." Moe, op. cit., footnote 65, p. 12.

69 See Glen O. Robinson (cd.), *Communications j& Tomorrow: Policy Perspectives for the 1980s* (New York, N Y: Praeger, 1978)

70 47 U.S.C. 1 5 *I*.

71 Although independent regulatory agencies have traditionally performed a combination of legislative, administrative, and Judicial functions—and, in fact, this was one of the original justifications for their existence—they are, in theory, regarded as "arms of the Congress." For a general discussion of independent regulatory agencies, see U.S. Congress, Senate Committee on Governmental Affairs, *Study on Federal Regulation v. Regulatory Organization*, prepared Pursuant to S. Res. 7 I (Washington, DC: U.S. Government Printing Office, December 1977).

72 Although many scholars and administrators have taken issue with the concept of the independent regulatory commissions, a number have strongly defended it. Most early advocates focused on the role of such agencies as administrative expert, separate and untarnished by the political process. This rationale was not long in vogue, however, becoming over time a major source of criticism of independent regulatory agencies. More recently the argument has been made that, instead of being protected from abuse and invidious influences, the commission form helps to assure that different views will be taken into account at the highest agency level. See Glen Robinson, "Reorganizing the Independent Regulatory Agencies," *Virginia Law Review*, vol. 57, September 1991, pp. 947-995.

73 As Glen Robinson" has pointed out, this tendency of Congress to be conservative is considered by some to be a benefit. As he notes: "For landbound conservatives. . . Congress' incapacities are more of a virtue than a vice, they discourage facile legislative solutions to social and economic problems—solutions that often prove short-sighted and ultimately mischievous." Robinson, ibid., p. 358.

74 For this point, see Robert G. Dixon, Jr., "The Independent Commissions and Political Responsibility," *Administrative Law Review*, vol. 25, No. 1, winter 1975, **pp. I -16.**

If the FCC were assigned an enhanced role in developing and coordinating national communications policy, it would clearly need more resources. Congress' decision to deregulate the cable industry has put a tremendous drain on the commission's staff. With the mounting public interest in the NII, the commission is also being pressed to accept petitions and filings online. Although such a policy would clearly open the FCC to a broader range of inputs, given present resources, it will surely lead to information overload. Given a broader range of issues to deal with, the staff composition will also need to become more interdisciplinary. Designed primarily to perform traditional regulatory functions, the FCC has been dominated professionally by lawyers, engineers, and regulatory economists.

Over time, organizations develop a "mystique" of their own that affects how the public, other agencies, and Congress relate to them .75 Once established, the character of an organization is extremel y difficult to change, often requiring nonorganizational measures that expand an agency's constituency, the complete reconfiguration of administration systems, and a different mix of professional skills.[76] Keeping these factors in mind, it could be argued that—given the numerous problems experienced with the previous organizational arrangements for dealing with communication policy, and the growing national importance of communication issues—the time may be right to create an executive agency specifically designed to deal with communication policy. Depending on the degree of prominence that Congress wants to attach to such a mission, an agency might be structured as an independent executive agency (like the Environmental Protection Agency) or a Cabinet-level department.[77]

As noted above, the virtues of the executive branch form of organization have long been touted by a number of scholars and commissions on governmental organization. Among the advantages typically cited are: enhanced policy coordination; greater efficiencies in division of responsibility and the execution of tasks; greater accountability; and greater ability to attract high-quality personnel.

Regardless of the merits of this option, establishing an executive department is not simple. Historically, Congress has not been eager to create new departments, often requiring an agency to serve a period of apprenticeship before being promoted to the status of an executive department. This reluctance is not surprising, given the close interrelationships between the executive and legislative branches. Any major changes in the executive branch are likely to have considerable impacts on the distribution of power and responsibility in Congress. Thus, Congress has the ultimate say with respect to any significant organizational changes.

The states also might look askance at the creation of a Department of Communication. As early as 1789, they were concerned that the growth of the executive branch would take place at the expense of their own authority and policymaking prerogatives. It was for this reason, for example, that the states opposed the establishment of the Department of Education. Given this history, and

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75 As Harold Seidman has noted: "The quest for coordination is in many respects the twentieth century equivalent Of the medieval search 'or the philosopher's stone. If only we can find the right formula for coordination, we can reconcile the irreconcilable, harmonize compelling and wholly divergent interests, overcome irrationalities in our government structure and make hard policy choices to which no one will dissent." Harold Seidman, *Politics, Position, and Power: The Dynamics of Federal Organization (New* York, NY: Oxford University Press, 1980), p. 205.

76 Ibid.

77 Executive agencies residing outside the departmental structure were rare until the turn Of the 20th century, becoming increasingly prominent after World War II. Their growth parallels, in a sense, the growing complexity of society. Many independent agencies were established in response to the lobbying pressure of a particular constituency. Examples are the Departments of Agriculture, Labor, and Education. Others such as the Environmental Protection Agency were created, in part, as a symbolic gesture to give prominence to a particular national concern. I bid., pp. 29-3 1

the number and intensity of recent disagreements between the federal and state governments about communication policy, the states might be averse to setting up an executive agency for communication.

A number of other stakeholders are likely to be ambivalent about creating a new agency to deal with communication policy issues. Although many may be frustrated by the lack of consistency and coherence in the present situation, they have learned how to operate effectively within it. The establishment of a new agency would be fraught with uncertainty. Since federal agencies have often served to promote certain constituencies, many stakeholders would oppose or favor an executive branch agency for communication, depending on whether they thought it would enhance or detract from their particular interests.

In considering these options, however, it is important to remember that organizational change is not a panacea and cannot substitute for real policy agreement. Because of the connection between organizational structure and policy orientation, stakeholders' preferences concerning where the organizational responsibility for coordinating communication policy should 1ie are often colored more by their policy preferences than their views about public administration.[78]

[78] As described by one authority on pub] ic administration: "'As a rule, however, reorganization proposals should have as their objective the furtherance of some public policy. Indeed, reorganization appears to be a basic political process through which Individuals and groups gain power and influence over others in order to achieve the social and political change they consider desirable." See Ronald C. Moe, "Executiv e Branch Reorganization An oven iew," Library of Congress, Congressional Research Service, 1978, p. 6.

Appendix: Workshop Participants A

PLANNING WORKSHOP

Carl Cargill
Standards Strategist
Sun Microsystems, Inc.

Joan Clay brook
President
Publ ic Citizen

Derek Leebaert
Graduate School of Business
Georgetown University

Jonathan Morell
Principal Member of Technical Staff
Industrial Technology Institute

Michael Piore
Department of Economics
Massachusetts Institute of Technology

Ronald E. Rice
School of Communication, Information, and Library Studies
Rutgers University

Michael Schrage
Los Angeles *Times*

Arthur B. Shostak
Department of Psychology and Sociology
Drexel University

Jim Snider
Author

Arndt Serge
Faculty of Economics and Business Administration
University of Limburg, Netherlands

Tom Valovic
Editor
Telecommunications Magazine

BUSINESS APPLICATIONS WORKSHOP

Tim Daunch
Manager, Information Integration Services
Allen–Bradley Co.

Peter Grunwald
Vice President
Issue Dynamics

David Hartzband
Leaders for Manufacturing Program
Massachusetts Institute of Technology

Lawrence Hunter
National Library of Medicine

Leonard Kruk
Marketing Director, Workplace Research
Knoll/Westinghouse

Robert Langridge
Computer Graphics Laboratory
University of California San Francisco

Anne Lightburn
Director of Technology
Food Marketing Institute

Sean McLinden, M.D.
Health Field Consultant
GFN Healthcare, Inc.

Robert Mittman
Senior Research Fellow
Institute for the Future

Jonathan Morell
Principal Member of Technical Staff
Industrial Technology Institute

John Quarterman
Editor of *Matrix News*
Texas Internet Consulting

Ted Rybeck
Director of Research
Advanced Manufacturing Research

Patricia Sachs
Visiting Professor
Expert Systems Laboratory
NYNEX Science & Technology

Bruce Shriver
Professor
University of Southwestern Louisiana

Michael Spring
Professor
Department of Information Sciences
University of Pittsburgh

PRODUCTIVITY WORKSHOP

Daniel Appleton
President
D. Appleton Co., Inc.

Paul Attewell
Professor of Sociology
The City University of New York

Martin Baily
Senior Economist
Brookings Institution

Daniel Bell
Scholar–In–Residence
American Academy of Arts and Sciences

Lewis Branscomb
Professor
John F. Kennedy School of Government
Harvard University

Erik Brynjolfsson
Assistant Professor/Management Science
Massachusetts Institute of Technology

Jim Eichner
Executive Director
Expert Systems Laboratory
NYNEX

Meg Graham
Manager, Research Information and Infrastructure
Xerox PARC

Martin Hoffmann
Senior Visiting Fellow
Center for Technology, Policy and Industrial Development
Massachusetts Institute of Technology

Brian Kahin
Director, Information Infrastructure Project
Harvard University

Robert Kaplan
Professor
Harvard Business School
Harvard University

Jim Keller
Information Infrastructure Project
Harvard University

Thomas W. Malone
Professor
Sloan School of Management
Massachusetts Institute of Technology

Warren McFarlan
Professor
Harvard Business School
Harvard University

Patricia Sachs
Visiting Professor
Expert Systems Laboratory
NYNEX

Edward Steinmueller
Deputy Director
Center for Economic Policy Research

Bill Wittland
Williams Marketing Services, Inc.

Steven Wildman
Associate Professor
Department of Communications Studies
Northwestern University

LABOR MANAGEMENT WORKSHOP

Jim Berm
Executive Director
Federation for Industrial Retention and Renewal

Ron Blackwell
Assistant to the President for Economic Affairs
Amalgamated Clothing & Textile Workers Union

Charles Bofferding
Executive Director
SPEEA (Boeing Union)

Dennis Chamot
Executive Assistant to the President
Department of Professional Employees
AFL-CIO

Ken Edwards
Director, Technical Services
International Brotherhood of Electrical Workers

Frank Emspak
Assistant Professor
School for Workers
University of Wisconsin

Debbie Goldman
Research Economist
Communications Workers of America

Don Kennedy
Director and Educational Representative
international Association of Machinists and Aerospace Workers

Terry Rosen
Labor Economist
American Federation of State, County, and Municipal Employees

Randle Sutton
Assistant Director
American Postal Workers Union, AFL-CIO

B Appendix: Reviewers and Contributors

Dana I. Abrams
Director, Planning and Standards
Rockwell Int.

Leon L. Addison
Director of Personnel
John D. Hollingsworth on Wheels

Myron Aldrink
Senior Director of Marketing
Meridian Inc.

Herb Anderson
Vice President and General Manager
Northrop Information Services Center

John O. Anderson
Manager
Boeing Commercial Airplane Group

Gordon J. Arita
Regional Manager, Intermodal Sales
Southern Pacific Lines

Walter Baer
Deputy Vice President
RAND Corp.

Jerry Beasley
Executive Vice President
South Carolina Textile Manufacturing Assoc.

Robert Benjamin
Robert Benjamin Consultants

John L. Berg
President
Future Tee., Inc.

Dick Berreth
Vice President, Manufacturing
Haworth. Inc.

Stanley Besen
Vice President
Charles River Associates, Inc.

Sena Black
Director, Research and Communications
South Carolina State Development Board

Paul L. Borrill
Director
Sun Microsystems, Inc.

Tim Brennan
Professor
University of Maryland at Baltimore

Daniel Brenner
Vice President for Law & Regulatory Policy
National Cable Television Association

George Brett
Director
Microelectronics Center of North Carolina

Geoffrey Brook
Assistant Professor of Management Science
Sloan School of Management
Massachusetts Institute of Technology

L.E. Brown
MIS Systems Analyst
SUSPA Inc.

Lin Brown
Director
Ease of Use Programs
SunSoft Inc.

Richard Bruce
President
Group Communications/Xerox Document Con.
Xerox Palo Alto Research Center

Gary A. Burgess
General Manager
McDonnell Douglas

Peter N. Butenhoff
President
Textile/Clothing Technology Corp.

Pete Butkiewicz
Executive Secretary
Kent-lonia Labor Council, AFL-CIO

Dave Byrne
Senior Account Manager
Clemson Fabrics
Milliken & Co.

Linda A. Callon
Attorney at Law
Berliner and Cohen

Terri Carlton
Administrative Director
Institute of Business Designers

George Connick
President
University of Maine

Paul Cornell
Manager, Behavioral & Environment Research
Steelcase

Russell R. Coyner
Executive Director
BIFMA

Geri Cross
Econimic Development Manager
City of Sunnyvale, CA

Frank Degar
Associate Director
Extension Operations, Southeast Manufacturing Technology Center
University of South Carolina

Doug Dennis
Strategic Programs Manager
Computer Systems
Silicon Graphics

R.W. Dillon
Executive Vice President
Steel Heddle

Henriette T. Douglas
Management Information Systems
TRW Vehicle Safety Systems, Inc.

Charlotte S. DuBose
Director of Retail Partnership/VISA
Milliken & Co.

Manek Dustoor
Director for Technologies and Concepts
Haworth, Inc.

Judson H. Early
Director, Research and Development
Textile/Clothing Technology Corp.

Jay M. Engineer
Plant Manager
Fashion Fabrics of America

Fred Falk
Technical Manager
Project Engineering and Development
John D. Hollingsworth on Wheels

Richard Fazzone
Telecommunications Affairs Manager
GE Information Services Co.

Frank Fisher
Visiting Scholar
Lyndon B. Johnson School of Public Affairs

Richard Fry
Director, Management Information Services
American Seating

Jim Fulton
Technical Manager
Microelectronics Center of North Carolina

Francesco Garibaldo
Research Director
Institute for Economic and Social Research
Bologna, Italy

Henry Geller
Director
Washington Center for Policy Research

Arthur B. Goodwin
Manager of Transportation Projects
WORLDPORT LA

Charles E. Grantham
President
Institute for the Study of Distributed Work

John E. Gross
Group Leader
McDonnell Douglas

A mar Gupta
Sloan School of Management
Massachusetts Institute of Technology

Dale N. Hatfield
President
Hatfield Associates, Inc.

Ed Hill
Site Director
Clemson University

Arnold J. Hooton
Manager, Technology Assurance
The Knoll Group

Catherine Howells
Manager, External Standards
Boeing Computer Services

Ken Hubbell
Computer Graphics Designer
Textile/Clothing Technology Corp.

Robert Johnston
Corporate Liaison
Public Policy Department
Herman Miller Inc.

Mary Gardiner Jones
President
Consumer Interest Research Institute

Brian Kahin
Director, Information Infrastructure Project
Harvard University

Ted M. Kahn
Research Scientist & Director of Technology Development
Institute for Research on Learning

Richard Kennedy
President
Kennedy Research

Dan Keyes
Technical Specialist
Applied Technology Center

Birgit M. Klohs
Executive Director
Grand Rapids Area Chamber of Commerce

Robert Koplowitz
Director
Logistics Services
Port of Seattle

Ellee Koss
Associate
The Human Resources Management Group, Inc.

P.E. (Pat) Lanthier
Director, Public Policy and Technology
Pacific Bell

William Lehr
Professor
Columbia University School of Business

Harvey G. Lehtman
Strategic Technology, Planning & Quality
Apple Computer, Inc.

W. Douglas Lewis
Chief Information Officer
AT&T Network Systems

James L. Lemons
President
Center for Applied Textile Technology

Michael Liebhold
Senior Scientist
Apple Computer, Inc.

John D.C. Little
Institute Professor
Massachusetts Institute of Technology

Stuart E. Madnick
Professor of Management Science
Sloan School of Management
Massachusetts Institute of Technology

Thomas W. Malone
CEO
Milliken and Co.

Elliot Maxwell
Assistant Vice President
Policy and Issues Management
Pacific Telesis

Gloria Mayer
Chief Operating Officer
Friendly Hills Health Network

Bruce McConnell
Chief, Information Policy
Office of Management and Budget

Dennis James McIntosh
Executive Director
Center for Office Technology

Udo Mehlberg
Director, Technology and Research
Port of Tacoma

William L. Miller
Director, Research and Development
Steelcase

W.L. Mitchell
Administrative Manager
Project Engineering and Development
John D. Hollingsworth on Wheels

Jonathan Morell
Senior Member, Technical Staff
Industrial Technology Institute

Joel Moses
Dean, School of Engineering
Massachusetts Institute of Technology

Dennis Nagel
Ford Motor Co.

Jeff Newman
Fielding Institute

Eli Noam
Director
Columbia Institute for Tele–Information
Columbia University

Stephen Nobel
Vice President
The Right Place Program

AlexOsadzinski
Director
Markets & Product Strategy
Sun Microsystems Computer Corp.

John (Jack) Peck
Professor, Department of Computer Science
Clemson University

Ken Peterson
General Manager, Regulatory Affairs
McDonnell Douglas

Thomas M. Reardon
Manager, Research and Information
BIFMA

David Reiling
Southeast Manufacturing Technology Center

Andrea Riniker
Deputy Executive Director
Port of Seattle

Doug Rippy
Dean, School of Textiles
Clemson Apparel Research

James M. Robinson
Director of Operations
Science and Technology, Inc.
NYNEX

Kenneth Robinson
Telecommunication Policy Review

Kirk Rosener
Electronic Commerce Consultant
Technology Management Applications

George L. Roth
Research Associate
Organizational Learning Center
Massachusetts Institute of Technology

Fred E. Rutan
Director–Purchasing
Haworth, Inc.

Anthony Rutkowski
Executive Director
Internet Society

Jon Ryburg
Principal
Facility Performance Group

Allan M. Schiffman
Enterprise Integration Technologies

Arthur Schiller
Arthur D. Little, Inc.

Leslie Schneider
TECnet
Tufts University

John F. Sheeran
Manager
Architecture & Standards Management
Boeing Computer Services

Gene Simons
Director
Northeast Manufacturing Technology Center

Marvin Sirbu
Chairman
Information Networking Institute
Carnegie–Mellon University

Lewis Smith
Systems Coordinator
Wundaweve Carpets

Oliver Smoot
Executive Vice President
Computer Business Equipment Manufacturers Association

Michael B. Spring
Professor
Department of Information Science
University of Pittsburgh

Richard Solomon
Research Associate
Massachusetts Institute of Technology

Nancy J. Staples
Research Associate/Assistant Professor
Clemson University

Anne Strauss-Weider
Principal Transportation Economist
Port of Authority. NY

Susan U. Stucky
Associate Director
Institute for Research on Learning

Jim Sweeney
Manager, Electronic Data Interchange
Southern Pacific Lines

Paul Tang
Program Manager
Hewlett Packard Labs

Richard Thayer
Director of Government Affairs
AT&T

Thomas Valovic
Editor
Telecommunicate ions Magazine

Rex Visser
Manager, Engineering Information Technology
Haworth, Inc.

Janet M. Vratny
Information Specialist, Apple Library
Apple Computer, Inc.

Brian W. Warren
Vice President
Operations and Manufacturing
Wundaweve

Karen E. Wieckert
Research Affiliate
Institute for Research on Learning

Steven R. Wilcox
Manager, Technical Services
BIFMA

Frederick Williams
Chair in Communications
The University of Texas at Austin

Mark L. Williams
Manager
Existing Business and Industry Services
South Carolina State Development Board

Bill Wittland
Williams Marketing Services, Inc.

JoAnne Yates
Associate Professor and Coordinator of the Sloan Communication Program
Sloan School of Management
Massachusetts Institute of Technology

Diane Zandstra
President
Intersect Interiors

Lewis E. Zink
Senior Manager
Communication–VIP Relations, Everett Division
Boeing Commercial Airplane Group

Joseph L. Zobkiw
Director, Facilities Management
Manufacturing Services
Haworth, Inc.

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Appendix: Acronyms and Terms

E

ADA	After Date of Award (of contract)
AMIX	American Information Exchange Network
AMTEX	American Textile Partnership
ANSI	American National Standards Institute
ARPA	Advanced Research Projects Agency
ATM	Asynchronous Transfer Mode
ATM	Automated Teller Machine
ATP	Advanced Technology Program (NIST)
BARRNET	Bay Area Regional Research Network
B-ISDN	Broadband Integrated Services Digital Network
BISNIS	Department of Commerce network that helps companies identify business opportunities in the states of the former Soviet Union
CAD	computer–aided design
CAD/CAM	computer–aided design/computer-aided manufacturing
CALS	Continuous Acquisition and Life-Cycle Support (DOD)
CASE	Computer Aided Software Engineering
CES	Cooperative Extension Service
CIM	computer-integrated manufacturing
CIX	Commercial Internet Exchange Association
CNC	computerized numerically controlled (machines)
CNRI	Corporation for National Research Initiatives
COBOL	Common Business–Oriented Language
CONTU	National Commission on New Technological Uses of Copyrighted Works
COS	Corporation for Open Systems
CRADA	Cooperative Research and Development Agreement
CRS	Computer Reservation System

DAMA	Demand Activated Manufacturing Architecture
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
DOE	Department of Energy
DOL	Department of Labor
EBB	Economic Bulletin Board, a network of business and economic information operated by the Department of Commerce
EC/EDI	Electronic Commerce through Electronic Data Interchange
EDI	Electronic Data Interchange
EDIFACT	Electronic Data Interchange For Administration, Commerce and Transport
EINet	Enterprise Integration Network
EPRI	Electric Power Research Institute
FCC	Federal Communications Commission
FDDI	Fiber Distributed Data Interface
FEDIX	Federal Information Exchange
GSA	General Services Administration
HPCC	High Performance Computing and Communications
IETF	Internet Engineering Task Force
IITF	Information Infrastructure Task Force
ISDN	Integrated Services Digital Network
IVANS	Insurance Value Added Network Services
KIR	Kansas Industrial Retraining
LAN	local area network
LFM	Leadership for Manufacturing program at MIT
LLNL	Lawrence Livermore National Laboratory
LOCIS	Library of Congress Information System
MAP	Manufacturing Automation Protocol
MAN	metropolitan area network
MAMTC	Mid–America Manufacturing Technology Center
MCC	Microelectronics and Computer Technology Corp.
MFJ	Modified Final Judgment
MIT	Massachusetts Institute of Technology
MITUC	Maine Information Technology Users Consortium
MOSAIC	Manufacturing Outreach System to Achieve International Competitiveness
MTC	Manufacturing Technology Centers
MLS	multiple–listing service
NASA	National Aeronautical and Space Administration
NCMS	National Center for Manufacturing Science
NDEA	National Defense Education Act of 1958
NEMTC	Northeast Manufacturing Technology Center
NIST	National Institute for Standards and Technology
NII	National Information Infrastructure

NLM	National Library of Medicine
NSF	National Science Foundation
NTIA	National Telecommunications and Information Administration
OAW	Office of the American Workplace (Department of Labor)
OMB	Office of Management and Budget
ONA	Open Network Architecture
OSI	Open Systems Interconnection
OSTP	Office of Science and Technology Policy
QSRF	Quality Systems Resource Facility
RBOC	Regional Bell Operating Co.
REA	Rural Electrification Administration
RINET	Reinsurance and Insurance Network
RJV	Research Joint Venture
SBA	Small Business Administration
SEMATECH	a consortium of DOD (through ARPA) and 11 private semiconductor companies
SMDS	Switched Multimegabit Data Service
SPC	statistical process control
STEP	State Technology Extension Program
TCP/IP	Transmission Control Protocol/Internet Protocol—a standard developed for the Internet
TECnet	Technologies for Effective Cooperation Network
TOP	Technical Office Protocol
TQM	total quality management
TRP	Technology Reinvestment Program (administered by ARPA)
UNIX	an operating system standard developed at Bell Labs
VAN	value–added network
WAN	wide–area network

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