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

[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 Overview," in Stephen Wilks and Maurice Wright (eds.), *Comparative Government-Industry Relations* (Oxford, UK: Clarendon Press, 1987), ch. 5.

[4] See Charles C. Ashley, "IVANS: 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 initiative 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. RINET will work with IVANS in the United States to implement these standards. See Kathrine Huelster, "EDI 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. 143, 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,

[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

[16]Wil Lepkowski, "NIST Accelerates Its New Mission Under First Woman Director," *Chemical and Engineering News*, Sept. 6, 1993, p. 20.

[17]See Jonathan A. Morell 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 when all interested parties 1) prefer the same standards, 2) have something positive to gain from standardization; and 3) have 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 will emerge at the right time through the process of supply and demand Producers will 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 will 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 will 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-

[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 llnklng, 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

Layers	Function	Layers
User Program	Application Programs (not part of the 0SI model)	User Program
Layer 7 Application	Provides all services directly comprehensible to application programs	Layer 7 Application
Layer 6 Presentation	Transforms data to and from negotiated standardized formats	Layer 6 Presentation
Layer 5 Session	Synchronizes and manages dialogues	Layer 5 Session
Layer 4 Transport	Provides transparent reliable data transfer from end-node to end-node	Layer 4 Transport
Layer 3 Network	Performs message routing for data transfer between nodes	Layer 3 Network
Layer 2 Data Link	Detects errors for messages moved between nodes	Layer 2 Data Link
Layer 1 Physical	Electrically encodes and physically transfers messages between nodes	Layer 1 Physical
	Physical link	

SOURCE National Institute of Standards and Technology (formerly National Bureau of Standards)

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-

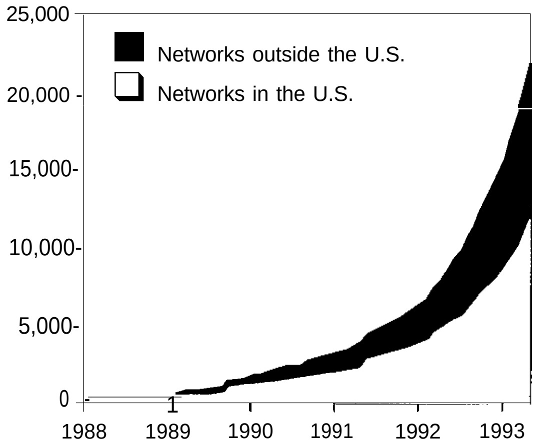
[29] Id, For a full description of the standards process, see also A.L. Chapin, ""The Internet Standards Process " RFC131 (). Internic (AT&T) (admin@ds internic.net), March 1992.

[30] Ibid.

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 IP 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)

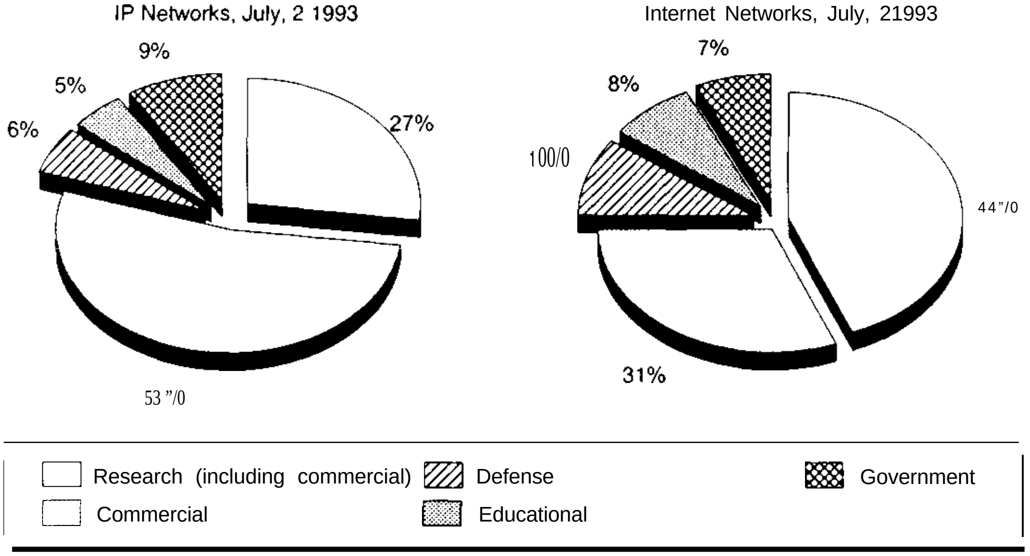
(continued)

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 process 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 likely 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

[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.

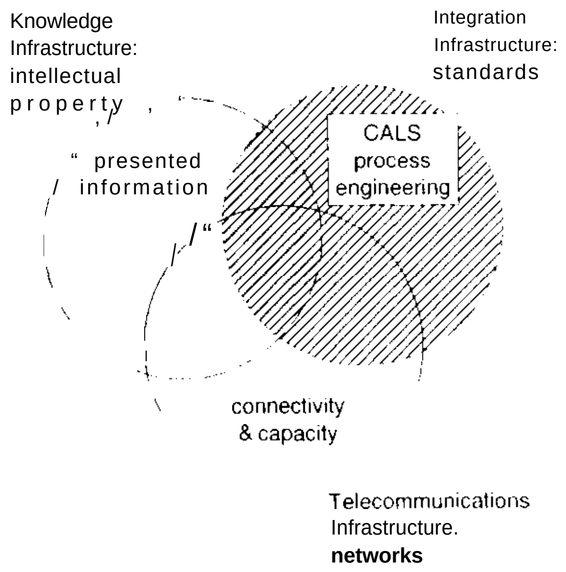
Broad-Based Standards Efforts

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 support 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

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



[1]Continuous Acquisition and Life Cycle Support

As depicted in this figure, CALS 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

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

[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

[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.[%]

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," *California 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] The magnitude of these spillovers 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]

[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

[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 Robinson: "[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. I-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.