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INFORMATION INFRASTRUCTURE, NATIONAL POLICY, AND GLOBAL COMPETITIVENESS

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Abstract

Because of its economic and social significance, information technology (IT) is increasingly the focus of national policy aimed at carving out a niche for local industry in the global production system. Debate rages over government intervention versus private sector leadership, and over policies for production versus use, sometimes missing the fact that these dual aspects are interrelated and mutually reinforcing. This article discusses the dilemma of national policy formation for information technology (IT) in the context of the information superhighway initiative, or national information infrastructure (NII), in the United States. It reviews the technological forces shaping the convergence of computers and communications, describes current and future services on the information superhighway, outlines the major service providers and the markets at stake, and concludes with some implications for the information superhighway for national competitiveness. It notes that multinational corporations are moving ahead on NII whether governments do so or not. In order not to be left behind, governments need to ensure local industry is part of mainstream developments, stimulate institutional learning in order to use the new technologies, and assess the fit of country business practices with international norms and standards.

INTRODUCTION

The production and use of information technology (IT) is increasingly recognized by national leaders as a vital component of global competition. This technology, both in processing and communications, is now woven into the fabric of the economic and social life of developed countries and is a major focus of national investment in newly industrialized countries. Developing countries are playing catch-up by making significant increases in spending for IT in the hopes of not being left behind in the global struggle for competitive advantage.

National IT policy has become a center of debate. The debate rages between those who claim that national policy should serve only to help the robust private sector take the lead (Nelson, 1993; World Bank, 1993) to those who argue that concerted national government intervention can achieve rapid progress (Dedrick and Kraemer, 1995; Flamm, 1990; Kraemer, Gurbaxani and King, 1992; Kraemer and Dedrick, 1994a; Schware, 1992). Where active government intervention is recommended, policy choices are frequently portrayed as bimodal, favoring either production or use, rather than interrelated and mutually reinforcing. The arguments on all sides seem compelling, making the problem of policy making extraordinarily difficult. In most countries, national leaders are being asked by various constituents to take a strong stand on the IT policy issue, but there is very little reliable guidance about what stand to take.

This article discusses the dilemma of national policy formation in the context of the United States National Information Infrastructure initiative, which we will call by its acronym NII. The U.S. NII initiative is powerful for direct and symbolic reasons. The U.S. pioneered many of the important advancements in information technology during this century, and remains one of the world's leading suppliers of knowledge and products in this domain. The Bush administration reinforced U.S. resolve in this area by supporting the High Performance Computing and Communications program in 1991, aimed at maintaining the clear U.S. research lead in IT. On a more symbolic level, the Clinton administration has gone beyond the defense-oriented tradition of support for IT research to make IT a key part of a new industrial policy aimed at global competitiveness (Clinton and Gore, 1993; Gore, 1993; IITF, 1993; Council on Competitiveness, 1993).

The stakes are substantial. Over the next 20-50 years, the U.S. NII initiative is expected to mobilize $40-100 billion of national government investment and $1-2 trillion private industry of private investment (IITF, 1993). While there are no clear policy road-maps to follow, it is likely that government investments will occur mainly in the areas of R&D, demonstration projects, regulatory reform, NII promotion, the construction of intergovernmental networks, and in the expansion of IT-supported governmental services delivery. Industry investments will rewire the country with fiber optic cable, increase the capacity of existing coaxial and copper cable, upgrade switching equipment, install new equipment to provide new services, and build a large variety of privately-supplied information products and services including entertainment.

The NII has generated tremendous discussion among U.S. government, industry, and education communities, as well as among the general public. It has also generated great concern, and sometimes fear, abroad (TCOJ, 1994; *The Economist*, 1994). Much of the international reaction

to the U.S. NII initiative appears to be based on misconceptions about the origins and directions of the initiative. This article addresses the technological and policy bases of the NII, and assesses the likely role NII developments will play in global competition. It concludes with a set of calibrating observations that should assist national leaders in figuring out appropriate responses to the U.S. NII initiative.

FORCES OF TECHNOLOGY

The NII is first and foremost a *reaction* to the changing forces of technology. National policy arising from the NII initiatives might shape the future course of development, but to date the NII is a social movement arising from massive technological changes already underway. Two key domains of information technology—processing and communications—are converging to enable the NII.

Processing Technology

Information processing is practically synonymous with digital computers and their peripheral components. The technological progress in computers is legendary, particularly in price-performance. These shifts have been not only in degree, but in kind: it is now possible to do previously unimagined information processing with computers, at prices that make powerful computers affordable for individuals. The price of a given amount of processing power has been shown to drop by about half every two years, so that by the mid-1990's many desktop computers can run at several million instructions per second (MIPS). Large mainframes operate at hundreds of MIPS, and supercomputer and experimental parallel multiprocessor machines run at thousands of MIPS. Devices for information storage and human-computer interfaces have also improved, expanding the functionality of computers into the realm of multimedia and virtual reality. Equally important, but less often recognized in the context of the NII, computers are now embedded in a huge variety of products, from aircraft, automobiles and medical equipment, to toys and kitchen appliances.

The full implications of these changes for economic and social change were not evident until the 1980's, when the first microprocessor-based personal computers came into mass production. By the end of that decade, the focus of "computing" had shifted away from the previously exclusive zone of the "glass house" of corporate, government and scientific data processing, and toward a new era of distributed computers networked together by high-speed communications devices. Well over 100 million PCs are being used in businesses, schools, governments and households, and about 50% of these are connected to local networks. If this represented the culmination of processing progress, the concept of the NII might not have arisen. But every available forecast suggests that the next twenty years will show the equivalent improvement in capability and price-performance to that seen in the last twenty years. Capabilities will be orders of magnitude greater, costs will remain comparatively low, and the distribution of IT in business and society will accelerate.

Communication Technology

As exciting as the processing revolution has been, equally important progress has been made in all forms of communication technology. As noted above, many of the computers now deployed are connected to one another via communication networks, but this is only one indicator of a wholesale expansion and improvement in communication infrastructure. Fiber optic cable began to take the place of copper in high-volume communications lines in the early 1980's, and fiber is now the backbone of the U.S. terrestrial line network. At the same time, rapid progress has been made in satellite and radio communication, and in exploiting the bandwidth available on the huge installed base of copper in standard and coaxial lines. Communications is going multimodal just as processing is going multimedia. Cellular telephone, which uses both radio and terrestrial lines, has already penetrated 3% of the U.S. population, and a number of smaller countries have substantially higher penetration rates (Davidson, et al., 1993). The implications of these changes are illustrated by the prediction that communications services now delivered by wire will soon come by air, and the services now delivered by air will soon come by wire.[1] And, indeed, telephone service that was once provided almost exclusively by wire is now coming via cellular and satellites, while television which used to come almost exclusively by air now comes by wire in 80% of U.S. homes.

Urban areas of many countries are already heavily "wired," with new services being tried and established as the new capabilities become clear (Dutton, Blumler and Kraemer, 1987). Equally important, the communication infrastructure is shedding its terrestrial constraints. It is no exaggeration to state that technology now places within reach the prospect of equipping every human being on earth with a portable, personal communications device that he or she will carry throughout life, with a single address, accessible from anywhere on the planet. This device can support standard telephony as well as text, video and other communications. The deployment of such a ubiquitous infrastructure depends on the integration of many existing and emergent technological components, including copper wire and fibre optic land lines, cellular radio, microwave, geostationary satellites, and low-earth-orbit satellites. What is important for our discussion is the fact that the technological limits to deployment are significantly less daunting than the institutional and administrative limits. It is probably an exaggeration to claim, as some proponents do, that "bandwidth will be free" in the future. But it is safe to assume that communications capacity far beyond that imagined in the 1970's will be available to industrialized countries by the year 2000, and to most countries by 2020.

Convergence of Processing and Communication

Processing and communications technologies are converging in unprecedented ways, and this convergence gives rise to the NII. Processing and communications technology have never been completely separated from one another—each has depended on the other to some degree. But in the past, each realm of IT has been tied to different vectors of development, as shown in Figure 1. Electronic accounting machines (EAM) began the computerized processing era, with processing distributed across departments of organizations. The high costs and enormous processing capability of digital computers encouraged centralization of organizational information processing, but ushered in terminal communications networks to link processing to users. With the advent of minicomputers and microcomputers, processing again was distributed

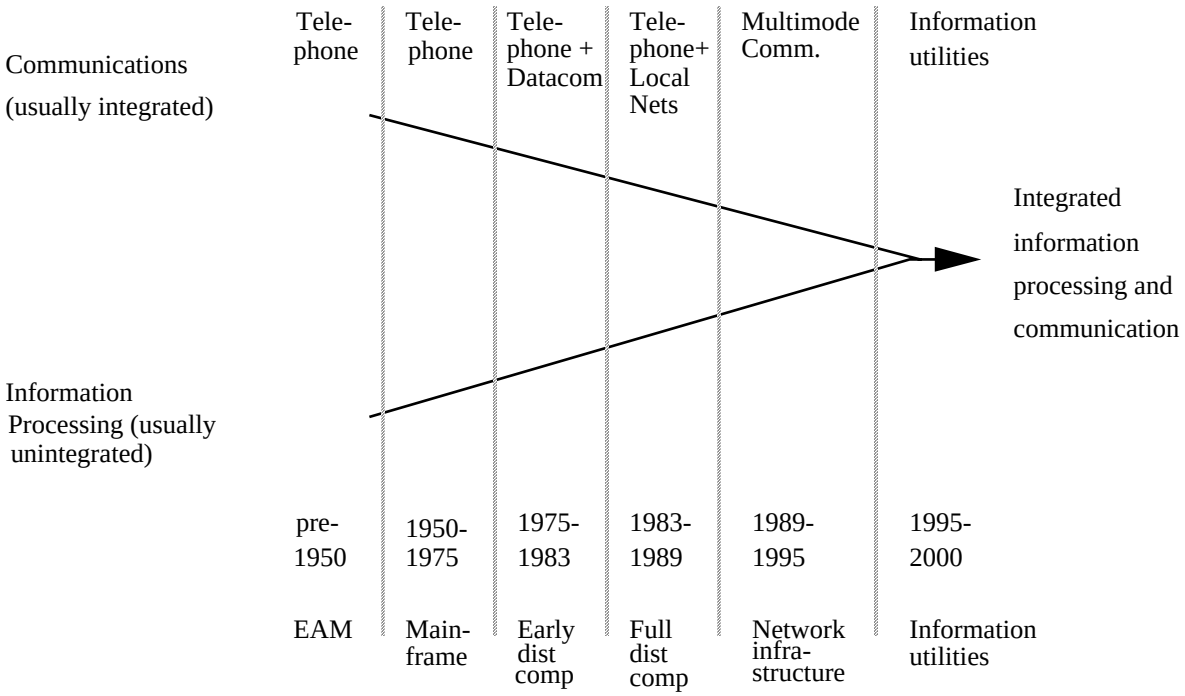
[1] This prediction has been attributed to Nicholas Negroponte of MIT's Media Lab.

back toward users. Nevertheless, issues of cost and control provided impetus for a growing role of data communications in the processing domain (King, 1983).

Communications technologies exist to link people in networks, but they have mainly integrated within each communication medium. Data, telephone, and cable services were deployed on separate physical networks. Information processing was used mainly to keep track of use for billing purposes, and eventually, to facilitate switching. High-capacity coaxial cable and fiber optic lines have enabled the multiplexing of all communication traffic onto shared lines, but the information processing requirements of such integrated services are substantial. Increasingly, the communications infrastructure is vitally dependent on information processing capability.

The great convergence between processing and communication has three consequences. First, computerized processing of information increasingly takes place at multiple sites in large, interconnected networks of computers in which communications technologies are vital conduits. Second, high-capacity communications services increasingly are dependent on sophisticated information processing to manage and keep track of traffic, bill for services used, and monitor for problems and network failures. Both worlds are becoming highly interdependent at all levels, from the small organization with a local area network of PC's, to global telephone and data communication networks. This convergence is enabling the creation of new kinds of information utilities serving individuals and organizations through networks. Some information utilities provide vertical services targeted to industries like law, health, education, finance or trade (e.g., Lexis/Nexis legal data, TRW credit data, or Reuters brokerage data). Others provide horizontal services like electronic mail, news groups and bulletin boards targeted to individuals (e.g., Prodigy, CompuServe and America On-Line). The convergence also has continued to destabilize the equilibrium of the perpetual centralization/decentralization debates over information service provision. It enables global centralization of corporate data processing through high-performance computers linked to operating sites around the world by ultra-high-performance communications, while facilitating the decentralization of information resources by making it possible to access data from almost anywhere and conduct local work on that data (as seen in the airline reservation systems, for example).

Figure 1. Convergence of Processing and Communications



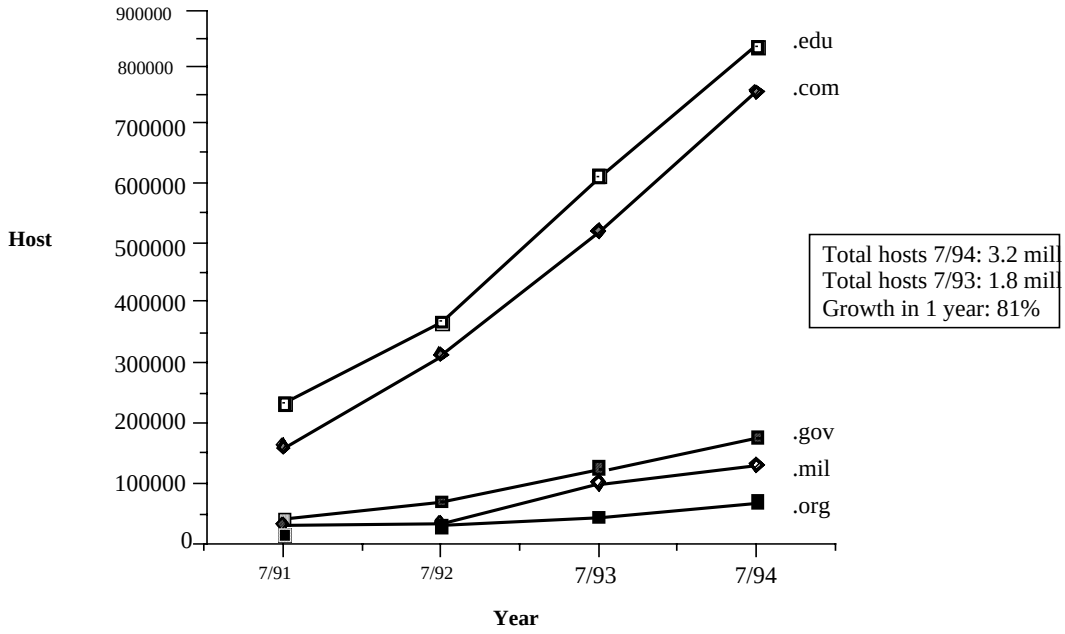
NETWORKS

The convergence of processing and communications has elicited its greatest contemporary interest in the emergence of the Internet, which for some is emblematic of the NII itself. The Internet is a "network of networks" that has its roots in a defense-sponsored research project called the ARPANET, which was designed to test the feasibility of building a packet-switched communication network that could survive nuclear attack and remain functional. It was also hoped that this communication network would help defense-sponsored scientists to share expensive computer resources. The ARPANET took shape in university research laboratories in the western United States in the late 1960's, and eventually grew into a hugely successful communications utility. From two dozen sites in 1971, the ARPANET grew to more than 200 sites by 1981. The initial military purpose was served, and the capacity for sharing computer resources was proven. But more important, the ARPANET had created a new form of communication infrastructure not previously foreseen, and by the 1980's only hinted at (Hiltz and Turoff, 1978). Geographically separated university researchers were united by technology through applications such as electronic mail, file transfers, news groups, and bulletin boards (Sproull and Kiesler, 1991). Sites in other countries were connected, initially via military installations, but the international dimension of the ARPANET grew rapidly and by 1993, 160 countries were being served (Abbate, 1994; *Newsweek*, August 8, 1994).

The ARPANET was not the only important networking venture. Several large companies also built their own private networks. For example, IBM built VNET which, for part of the 1980's, had more nodes than the ARPANET. There was also growing pressure during the 1980's to expand access to computer networks beyond the narrow academic domain of DARPA-sponsored computer scientists, and into non-DARPA computer science and engineering programs. The National Science Foundation's CSNET program was instituted to provide such services, and

signaled NSF's entry into the academic networking business. Another network called BITNET was formed to provide access to networks in the sciences, social sciences, and professional schools (Gurbaxani, 1990). The research and development departments of many commercial companies also linked themselves to the emerging network world.

Figure 2. Growth of the Internet in the U.S., 1991-1994



This growth of heterogeneous networks began causing problems when users on one network wished to communicate with users on another network. To make such communication possible, "gateways" were established to link the networks together. The gateways made obvious the problems that arose from lack of standardization around such fundamental policies as address form. In an effort to straighten out the mess, a set of conventions was drafted and promulgated throughout the networking community to standardize key aspects of network operation. This was the genesis of the Internet, which is not a network itself, but an overarching network of networks. Also, as the Internet evolved, the role of defense declined and the governmental support apparatus shifted to the National Science Foundation. The NSFNet built to link NSF's national supercomputer centers became the backbone of the Internet, and the primary laboratory for the testing of new technologies such as the one-billion bit per second "Gigabit" testbed.

During the early 1990's the use of networks under the Internet umbrella has grown phenomenally. As shown in Figure 2, the number of Internet Protocol (IP) Hosts grew by 81% worldwide in just one year, between 1993 and 1994, and the total number of hosts was estimated at 3.2 million. Given that each host might support between one and several hundred Internet users, the actual number of users has been very difficult to determine. Current estimates range from 15 to 30 million, with estimates as high as 40,000 new users each month. However, no one agrees on the actual number, and it is doubtful that any simple and reliable measure is possible at this time

given the Internet's historical lack of incentive (e.g., billing for use) to require such information. From 1991-1994, there has been growth in all the main domain categories (organizations, military, government, commerce and education), but education and commerce have grown dramatically.

Further growth in the education domain is expected as access is extended to K-12 levels. Commercial domain growth is also expected to accelerate. Companies such Sun Microsystems have established Internet access for all their employees—Sun claims to have 12,500 users on its network generating over 1 million transmissions per day (McNealy, 1994). An Internet address has become a new corporate status symbol, indicating one to be a member of the cyberspace elite. Even President Clinton and Vice President Gore are on the Internet (president@whitehouse.gov and vice-president@whitehouse.gov), although everyone knows not to expect any answers to email messages sent to those addresses.[2] The Internet has galvanized much of the visionary rhetoric about the future of computer-mediated communication (Sproull and Kiesler, 1991; Pickering and King, 1992). The development of the Internet coupled with expectations of its extensions to new domains of service has given rise to the forecast seen in Figure 3, wherein network service for the general public will be routine early in the next century.

NATIONAL INFORMATION INFRASTRUCTURE

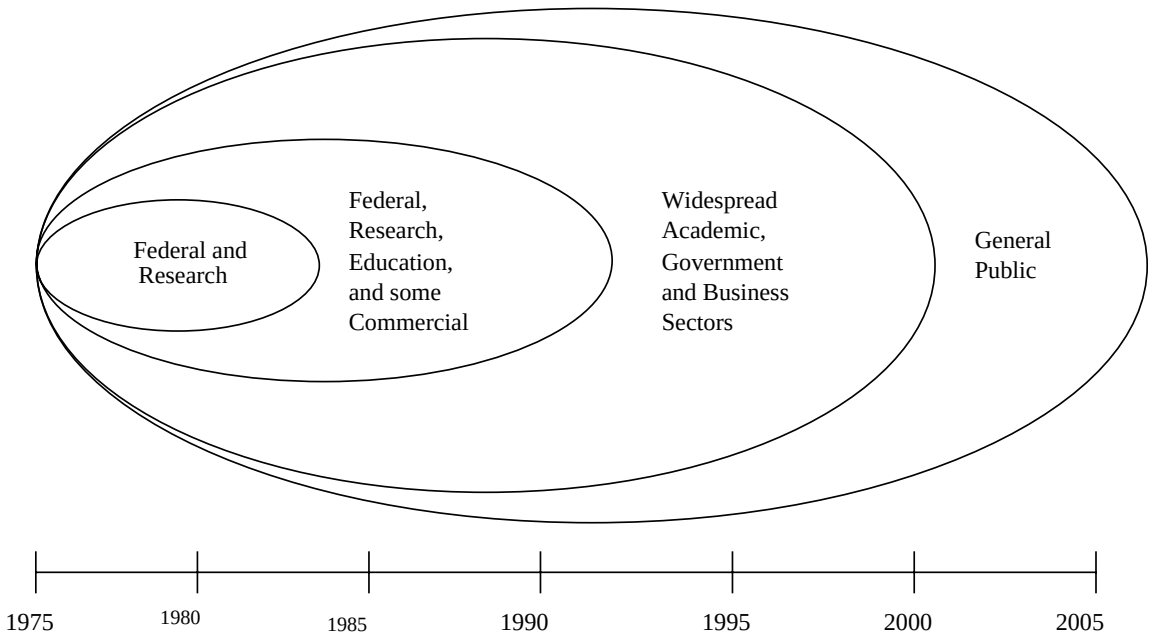
Definition of NII

The Internet is the forerunner of the NII and is evolving to be a major part of it. However, the NII is conceived to be much broader than the Internet. The Information Infrastructure Task Force has called the NII "a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips" (Information Infrastructure Task Force, 1993). This web is expected to provide new ways of learning, working and interacting with others—it will *create whole new ways of doing things*. These somewhat nebulous claims do not arouse much concern outside the U.S., but the Presidents' Council on Competitiveness in 1993 made a much bolder assertion:

> The information infrastructure of the 21st century will enable all Americans to access information and communicate with each other easily, reliably, securely and cost effectively in any medium—voice, data, video—anytime, anywhere. This capability will enhance the productivity of work and lead to dramatic improvements in social services, education and entertainment (Council on Competitiveness, 1993).

[2] In fact, all messages sent to the President and Vice-President are loaded onto tape and stored. At this time there is not even provision for an automatic answer to acknowledge receipt of a message by the host machine containing those addresses.

Figure 3. The Expansion of Networking



This is a bold statement. How likely is it that the NII will materialize along anticipated lines, and beyond this, what economic effects can be expected if it does so? To examine these questions, we look first at the trajectory of expected development in services, from current to projected services, to see what is really new. We then look at the players in the NII crusade, and the roles they are playing. This enables us to anticipate the interests to be served by the development of NII under various scenarios. We then examine the role of the Clinton Administration and government generally in the NII's evolution, as well as the role of the expected community of users.

NII Services: Present and Future

Technological advances in processing and communications, together with specific institutional objectives such as DARPA's desire to create a robust packet-switched network technology, have given rise to the first elements of the NII such as the Internet. The key driver of the NII's expansion and growth will be the services available to business, government, education, and household users. The Internet is new, but many of the services that form a core of the NII are have been in place for decades, and have achieved great penetration as illustrated in Figure 4.

The current penetration of services must also be seen in terms of time to diffusion for the underlying technology. For example, voice communication via the telephone was invented in the last century and only deployed to most households between 1910-1930. That is, it took about 70 years from its first invention for plain old telephone service (POTS) to be diffused to 50% of the

households in the U.S. (Figure 5). Today, telephone service is available with enhanced features such as voice mail and conferencing, but not yet widely diffused.

Table 1. Penetration of Current NII-Related Services in the U.S.*

Local and long distance voice via 2-way and multiparty communication
94% of U.S. households have telephones.
20 million Americans, mostly business people, use cellular phones.
11 million Americans use 900 numbers each month, 50% of which are for erotica.
2% of the U.S. workforce telecommutes, working at home several days a week.
Entertainment via television and cable
98% of U.S. households have TV.
85% have a videocassette recorder.
65% are connected to cable TV.
Text data access via computer networks
30 million households (20%) have a personal computer.
6.3 million households are connected to online computer services (e.g., CompuServe, Prodigy, America On-Line, growing at 40% annually.
20 million Americans use the Internet, growing at estimated 40,000 monthly.
6000 bulletin boards exist on the Internet where people can exchange information.

* U.S. population = 240 million people in 160 million households.

Entertainment is available via radio, broadcast and cable television, and recorded programming such as videos and music. The underlying technology of TV took 34 years to diffuse to nearly all households but the VCR took only 13 years to diffuse to 65% of households. Entertainment is a primary vehicle for promoting greater information services into the home, and there is a very large industry built up around providing content in the form of movies, TV programming, news, home shopping and education. But, some of the new technologies (multimedia, CD-ROM) for the newer entertainment services have yet to be diffused to a large number of households. Text

data access via computer networks is presently being extended to the home, and is growing rapidly as shown by the Internet figures earlier. Yet, diffusion of the PC to 30% of U.S. households has taken 20 years. The NII vision did not create such services or technologies. Instead, it recognizes and captures them under its banner, proclaiming their expansion, enhancement and integration. The NII is expected to bring us what we already have, but in ways that are better, faster and cheaper. Many services and technologies claimed as new can be expected initially to be little more than improvements on what already exists.

Table 2. Time for Diffusion of Technologies

	Years
Telephone diffused to 50% of households	70
TV diffused to nearly all households	34
VCRs diffused to 65% of households	13
PCs diffused to 30% of households	20
On-line services diffused to 50% of households	?

New services can be expected, and are already in experimental form. Many of these are predicted for home use. Publication traditionally seen in print such as magazines and newspapers can be expected to move to video/computer forms with high-resolution "print on demand" capability. New entertainment will take advantage of networked interactive video and virtual reality. Telemedicine applications will allow individuals to assist remotely located physicians perform in-home physical exams and therapeutic procedures. Utility companies will read meters remotely over the communication network, and regulate power use by appliances like home freezers and air conditioners at times of peak electrical demand. Advertisers will use intelligent agents over the network to learn the interests of consumers to facilitate marketing.

In spite of the excitement over home-based NII services, the largest initial markets for NII service appear to be in business. For example, most Internet growth has occurred in the domains of educational and commercial organizations, not through individual access over services such as Prodigy or America On-Line. Organizations with large, dispersed workgroups already have a demonstrated need for "cooperative work" support services (McNealy, 1994), and the needs of "occupational communities" have been predicted as a major cause for the expansion of Internet use (Pickering and King, 1992). The promotional rhetoric for the NII focusing on services to the home is reminiscent of earlier promotion about home computers, which focused on the household market. While computers did appear in homes, it did so mainly as an extension of

work at the office, and secondarily as an extension of work at school (Venkatesh and Vitalari, 1993). Home-based computing for non-work/school purposes has been much slower to develop, but to the extent it is growing, it is doing so by leveraging the investment made for external work/school purposes.

At issue in the service mix of the NII is not merely the kinds of services that might be offered, but the timing and patterns of service penetration to be expected. Expanded access to traditional services such as video programming has already occurred in both urban and rural settings, across a wide socio-economic spectrum through both cable and satellite, but this is mainly in the form of one-way broadcast television. The NII will make only marginal improvements on this service mix, perhaps by expanding the number of one-way television channels available. More complex, interactive services based on computers as well as video are likely to follow the pattern of home computing in the 1980's, with initial penetration an extension of work and school activities. Although much has been made of the possibility for the creation of remote "telework" havens where professionals will congregate, it seems much more probable that the early markets for these new NII services will be concentrated in large, urban areas where most of the professional work force already lives and is already networked socially (Saxenian, 1994). This forecast of a "business as usual" pattern to NII service evolution is reinforced by an examination of the players in the NII as of this time.

Players in the NII

The NII players can be characterized in terms of their roles as *providers*, *users*, and *regulators,* as shown in Figure 5. This list is in approximate order of importance, which comes as a surprise to many observers of the NII discussion. Contrary to what one might gather from reading the popular press accounts, the NII in the U.S. is not being built or led primarily by government. The NII is largely a private initiative, led and built by the providers. Government is a relatively small player, but as seen below, an important one in its promotional and regulatory roles.

The various providers of the NII are currently engaged in fierce competitive struggles for control over the NII's audience—individuals in organizations and households. The providers include the (1) *owners of the conduit* (telephone, cable, cellular, satellite, broadcast TV), (2) *makers of information appliances* (TVs, telephones, computers and new integrated products), and (3) *providers of content* (movie studios, television programmers, information services, publishers, education).[3] The NII is in a state of transition from the mix of current providers to future ones, and none of the current players know with any certainty what will be successful in the emerging market of the NII's information highway. Consequently, each provider is trying to shape future visions in its own interests, while ensuring it will have a role in the transition in order to learn how the NII is evolving. Through this strategy, each provider hopes to position itself as a player in the future.[4] Some of the emerging visions are quite predictable: conduit provider AT&T, for

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[3] Commentators on NII often talk of information delivery through *conduit*, a notion that was explored in detail in precursors to the NII vision such as the "wired city" (King, 1987).

[4] This is also happening among providers of information services. For example, considerable partnering has evolved following the success of Electronic Data Interchange (EDI) systems such as Singapore's TradeNet (King and Konsynski, 1991; Neo, King and Applegate, 1993). DHL, the integrated forwarder, has joined with IBM for the development of Tradelink in Hong Kong to learn what EDI means for its current business, to position itself for a role in EDI, and to find new business opportunities that exist because of EDI (Kraemer, Dedrick and Jarman, 1994).

example, would like to see the information infrastructure provided much like a utility with a single high-bandwidth cable coming to a central box outside each office or home as telephone and utility services currently do. In contrast, a software provider like Microsoft does not care about how many lines come into the workplace or home, but wants to control the distribution of the signals to TV, stereo, telephone, fax, or other end-user devices (*International Hearld Tribune*, August 1994; *USA Today*, August 1994; *Fortune*, August 22, 1994; Piller, 1994).

Conduit providers are trying to position themselves for end-to-end communication. The long distance telephone companies—AT&T, MCI and Sprint—are trying to get into cable operations so they have a pipeline to homes and businesses—something they currently are prevented from doing on their own by government regulation. The local telephone companies—the Regional Bell Operating Companies and the independents—are trying to get into the cellular business so they can provide long distance services. They are also forming alliances with entertainment companies so they have content to deliver over the networks. At the same time, they are working on compression technologies which will allow them to transmit high speed data and video over existing twisted pair copper wires to the home, enabling new services, such as video on demand, to be available through the existing local telephone network. The cable companies are working with computer hardware and software companies to develop set-top boxes for TVs that will allow multimedia services to be delivered to the home. They also are working on voice over coaxial cable technology that will allow them to offer telephone service to their subscribers. Thus, the various providers are attempting mergers, buyouts, alliances and technological solutions on an unprecedented scale *that preserve their options* and *position them for markets that might take-off*. It is expected to result in reorganization of the entire industry and it is unclear who will be winners and losers (*International Hearld Tribune*, August 1994; *USA Today*, August 1994; *Fortune*, August 22, 1994; Piller, 1994).

Table 3. Players in the NII

Providers

Conduit
- Long distance telephone companies (AT&T, MCI, Sprint)
- Local telephone companies (RBOCs, GTE)
- Cable companies (TCI, Cablevision, Cox Cable, Comcast Corp., Continental Cablevision Inc.)
- Cellular phone companies (McGaw, Bell Atlantic)
- Satellite communications companies (COMSAT, Hughes)

Information devices
- Computer hardware companies (IBM and clonemakers, DEC, HP, Fujitsu, Apple, Compaq, Silicon Graphics)
- Systems Software companies (Microsoft, IBM, Apple, AT&T)
- TV and electronics companies (RCA, Sony, Panasonic, Samsung)

Content
- Broadcast television and radio (NBC, CBS, ABC, Fox)

Cable companies (CNN, TCI)
Movie studios (Disney, Universal, Sony)
Publishers—newspapers, books, magazines
Online data services—credit (TRW), legal (Mead Data), brokerage (Quotron), commodities (Reuters), general (Prodigy, CompuServe, America On-Line)

Users
Corporations
Federal, state and local governments
Education institutions
Households and individuals

Regulators
Federal Communications Commission
Department of Commerce
National Telecommunications and Information Administration (NTIA)
National Institute of Standards and Technology (NIST)
State Public Utilities Commissions

Content providers of the NII are also jockeying for position, but not to the same extent or in the same way as the owners of the conduit. They want to see the NII built and used. Their main concern is open access to the end consumer, free or low prices, and protection of their intellectual property as it travels through the conduits. Ideally, of course, the content providers would like to gain the kind of monopoly rents that the conduit providers such as the AT&T Bell System once enjoyed in the telephone world. The conduit providers would like to reestablish their monopoly status if possible. Given that such a position is no longer possible, *the primary shakeout in the near term is less about creating new markets than it is about appropriating revenue from existing ones*. In many cases, the providers of NII hope to raid other industries' markets. Existing providers are hoping to hold onto their stake in traditional, fragmented delivery arrangements. New entrants are betting that users will chose integrated delivery channels over existing, noninteractive and fragmented ones. The revenue transfers at stake could be large as shown in Figure 6. For example, the U.S. cable TV market is $20 billion annually; the video-rental market is $12 billion; catalogue shopping is $55 billion annually; video gaming is $15 billion. These services alone amount to about $103 billion—more than the $82 billion in revenues of all the regional telephone companies in the U.S. (*Fortune*, August 22, 1994). Other services add to the stakes; for example, online information services constitute another $9 billion.

Table 4. Stakes in the NII - Transfer of Markets

Home Markets	**Billions of Dollars**
Catalog shopping	$55
Cable TV	20
Video games	15
Video rental	12

Consumer on-line services	1
Selected Other Markets	
Local telephone	82
Business on-line services	9

The incentives to move rapidly and aggressively in the era of the NII are primarily in the private sector, and most of the initiative for actual investment is coming from the private sector. Total investment in the Internet, as a point of comparison to the numbers above, has been estimated at less than $2 billion over 20 years. The private sector can therefore be said to dominate the NII action agenda as it creates what it believes will be in demand by the willing and able customers known in the computing trade as users.

Users of the NII

Some communities of users can expect to get immediate and solicitous treatment by the providers. For example, business and government users are likely to be served readily because they traditionally represent substantial, concentrated buying power and the prospect of continuing sales with respect to information technology. Similarly, educational institutions have already proven a ready market for some NII services, as with Internet at the higher education level. As enthusiasm for computer-assisted instruction grows and prices for the requisite infrastructure drop, huge investments in NII-like services can be expected. Education expenses already constitute the largest portion of most state budgets in the U.S., and the content providers such as publishers will move rapidly to serve the demands of the educational sector once those demands become sufficiently focused.

The interests of household users are least likely to be given consistent attention by the providers of NII. Households are highly heterogeneous in their needs and capabilities. They offer disaggregated purchasing power and expectations of intense price competition. Most important, perhaps, they expect technology that is easy to learn and use, but at the same time serves their needs. A recent *MacWorld* survey (Piller, 1994) indicates that household users are primarily interested in voting, public opinion polls, town-hall meetings, and the capability to do electronic mail with political leaders and other citizens. They want access to reference materials, databases, how-to programs, education courses, and information about government programs and services. In contrast, services that usually lead lists of NII offerings such as video on demand and electronic games are relatively low on the list. This is a troublesome indicator for telephone, cable and other providers that wish to deliver interactive broadband communications that support services like video on demand, video gaming, electronic gambling, electronic shopping, and electronic advertising.

Creating services that households really desire could require huge investments and substantial markets to recoup the costs. Providers hope to raid other industries to speed up market development, but it is quite possible that such raiding will not result in massive shifts because households are already well-invested in and satisfied with traditional services. Shifts to new technology involve not only up-front costs for equipment, but also costs for operations, support

and learning. The experience with educational television and computer-aided instruction in the schools illustrates how badly predictions of demand can fail. In both cases, lack of essential resources to develop the content and provide the user-level technology and learning resulted in massive failure of expectations. Private sector firms can be counted on to provide what preserves their position and allows them to make money. Other institutional intervention is likely to be required if specific public goods are desired.

The NII Agenda in the United States[5]

The stakes for the providers of the NII are high, and the needs of a diverse population of users are not certain to be met in entirety by the way providers leverage their stakes in the game. For these reasons, many believe government must play the roles of setting the rules of the NII game and mitigating against socially damaging consequences from the resulting NII service package. This is in addition to the traditional role of government in research, standard-setting, promotion, demonstration projects, and providing specific public goods.

The fundamental principle of the Clinton Administration's NII agenda is that the private sector, not the government, will lead the deployment of the NII. The government's role is circumscribed to seven key areas (IITF, 1993):

1. *Promote private sector investment.* The government, through the FCC (Federal Communications Commission), is liberalizing the telecommunications industry as a spur to competition and investment among telephone, cable, cellular, satellite and other providers.

2. *Extend the "universal service" concept to ensure information resources are available to all at affordable prices.* The government, through the NITA (National Information and Telecommunications Administration), is defining the concept of universal service in the context of the new communication modes and information services.

3. *Act as a catalyst to promote technological innovation and new applications.* The government, through the NIST (National Institute of Standards and Technology), is sponsoring research into technological issues such as standards for interoperability and security. It is also supporting demonstrations of new applications such as digital libraries, electronic commerce, medical diagnosis, medical record sharing and distance education.

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[5] The NII as articulated in Clinton Administration policy is mainly the interest of Vice President Albert Gore, Jr., but President Clinton endorses it fully. Gore's interest is long standing. He reportedly coined the term 'information superhighway' ten years ago while a Senator from Tennessee. His interest stems from the earlier work of his father, Senator Albert Gore, who authored the legislation for the U.S. interstate highway system--another major infrastructure. Vice President Gore saw the potential of information technology to play the same kind of role in uniting the nation, stimulating economic growth at home and increasing competitiveness globally. Since becoming Vice President, he has worked unceasingly to promote the NII to all segments of government, business and society. It is not clear what new Republican majority in the U.S. Congress means for the Clinton Administration's agenda. The new Speaker of the House of Representatives, Newt Gingrich, is known to be supportive of "cyberspace" visions for the U.S. economy, but there also appears to be a bias in the new Republican agenda to let the private sector take its course with only minor governmental regulatory intervention.

4. *Establish standards to remote seamless, interactive, user-driven operation of the NII.* Because the NII will be a network of networks, information must be easily transferable over disparate networks. The government is insisting that all network providers adhere to standards that provide for interoperability, interactive uses and ease of connection between networks. It is also reforming regulations and policies that inadvertently deter development of applications.

5. *Protect intellectual property rights and privacy.* Development of the NII provides new market opportunities for software products and information services. However, those opportunities will be realized only if government provides intellectual property protection of the creators of new software, information products and services. Also, getting broad use of the NII requires protection of individual and organizational privacy. People simply will not use the NII if their communications and data are not protected from unwarranted intrusion by government, industry, or individuals. While governments in particular have a need to know that sometimes must override the right of privacy, widespread use of the NII will not occur unless the balance is tipped in favor of individuals and organizations.

6. *Provide electronic access to government information and services.* The government is developing its own applications for the NII including the provision of broad access to executive and legislative documents, the provision of information about government programs, the receipt and processing of applications for services or funding under various programs, the electronic transfer of funds and payments, and the processing of income tax and other payments.

7. *Improve management of the radio frequency spectrum.* The ability to access the resources of the NII will be constrained if there is inadequate spectrum available. Therefore, the government will distribute spectrum by relying upon market principles, will promote public and private sharing of spectrum, and will increase choices for use of the spectrum by licensees.

The Clinton Administration's role in the NII is limited to that of regulator and promoter, including promotion through its own demonstrations and use of the technology. Despite this limited role, the Administration plans to spend $1-2 billion annually in promotion and use (IITF, 1993).

THE NII AND GLOBAL COMPETITIVENESS

A Global Perspective

The NII in the U.S. is an example of a global phenomenon, already recognized as the global information infrastructure (Gore, 1993). Telephone service is global. The Internet is now operating in 160 countries. Television programming reaches even into countries that try to keep it out. American movies are seen all over the world, Japanese games are played all over the world, and CNN is the world's news network. The stakes in the emergence of this global infrastructure are clearly economic, but they are also cultural as intense disputes over European tariffs on U.S. films during GATT negotiations testified.

The U.S. NII initiative has sparked much discussion, but national planning for information infrastructure is widespread around the world. Some countries such as France and Singapore adopted aggressive NII planning in the 1980's (Gurbaxani, et al., 1990). Plans to follow suit have been announced by many other countries, including Finland, Denmark, Japan, Korea, Malaysia, and Taiwan (Committee on the Information Society by the Year 2000, 1994; Dedrick, Kraemer and Choi, 1994; Kraemer and Dedrick, 1994b; Kraemer and Dedrick, 1994c; Kraemer, Dedrick and Jarman, 1994; King, et al., 1992; Raman and Yap, 1994; Valtiovarainministerio, 1995). Singapore, already a leader in its own NII development, has begun selling NII planning and building services to other countries. To a considerable degree, all the countries involved in NII planning are working in the shadow of those countries that "own" the information processing and communication technology industries: France, Germany, Japan, Sweden and the U.S. The influence of these countries is not through national governments, but through their powerful multinational corporations that lead in these industries.

This raises what might be the most crucial fact regarding government's limited role in the NII: *multinational corporations are moving ahead on NII whether governments do so or not*. In part this is true because of the power and desire of the processing and communication providers, which seek to market their products and services in every market on the globe. But it is also true in part because large multinational corporations are major users of NII-type services, and they will continue to expand their use of such services no matter where their offices and factories are located. Global sourcing and production, not to mention marketing, require information processing and communication services, and multinational firms will build the required capabilities using whatever means necessary. If host countries provide the requisite services, fine; if not these multinational firms will find the services elsewhere. In any case, multinational firms will be major agents in the transfer of NII technology and services, as they have been in other key realms of technology transfer in the past three decades (Chesnais, 1988; Cantwell, 1989; Encarnation, 1989; Rosenberg, 1992; Pavitt, 1992). Governments can either lead, cooperate with, or react and follow; they cannot ignore the trend. And, whatever governments' role, the information superhighway will not be simply a national infrastructure, but a global one. Also, it is not something in the future, but something that is already here and growing rapidly. Individual countries must expect their NII to be part of the global information infrastructure. Indeed, as with many communications technologies, the greatest benefits will accrue when use is ubiquitous.

From the beginning, the NII in the United States has been characterized as promoting the competitiveness of U.S. business and industry (Council on Competitiveness, 1993; USITC, 1993). Indeed, this is a stated reason by many nations as to why they are developing their information infrastructure (BPT, 1990; MPT, 1989; NCB, 1987). But expectations of competitive effect do not contain much guidance on how such effects will materialize. The importance of the U.S. effort in NII for global competition lies in recognition and focus upon the crucial role that information processing and communication *already* play in national economic welfare. It was once the case that the industries of nations gained success in international competition based mainly on the quality of transportation infrastructure available. Nations with deep water ports and well developed terrestrial distribution to and from those ports could exploit the technology of ocean transportation. After World War II, nations with a good mix of road, rail, and air transport infrastructure could bring goods and services to market cheaper and faster

than those without them. Reliable, safe international air transport enabled the growth of tourism and global sourcing during the eighties and nineties, and countries with well-developed air transport benefited. Transport will remain important, but increasingly commerce in all forms, including transportation, will depend on information highways. Nations with low cost, reliable communications infrastructure will attract business and compete successfully against those that do not. Many factors have helped Hong Kong and Singapore become globally significant manufacturing locations and regional headquarters for many multinational corporations, but there is no doubt that their telecommunications infrastructures were vital in this regard (Gurbaxani, et al., 1990; Kraemer, Dedrick and Jarman, 1994).

The NII can potentially affect economic development and competitiveness in four ways:

1. *Support the activities of existing industries and enhance their competitiveness.* Better computer and communications technologies will enable all organizations to operate faster, more flexibly, more coordinated and less expensively, thereby enabling them to compete more successfully. It will enable a nations businesses to be at the forefront in exploiting new opportunities created by the technology whether these enable shifts in market share, focus on niche markets, or entirely new products, services and markets.

2. *Attract new multinationals to locate in a country, and encourage existing multinationals to expand.* Advanced communications and computer technologies such as those proposed for the NII, allow businesses to locate manufacturing, engineering and sales closer to markets and still coordinate these distributed and far flung activities with headquarters and regional locations around the world.

3. *Increase communications traffic over the nation's network thereby enabling cost reductions and/or reinvestment in advanced facilities and services.* An advanced infrastructure can attract in-transit communications activity and stimulate greater use of telecommunications through advanced services such as electronic mail, teleconferencing, EDI, packet switching and data communications.

4. *Develop information industries that can create information products and services for export.* It is likely that firms within nations that lead in deployment of NII will be first to create the new information products and services used domestically that can be exported to the rest of the world. The providers of information services and the makers of information appliances will have growing opportunity for export. France has become a substantial exporter of information services through its Minitel System. Minitel services are now available in multiple languages in at least 14 other nations, and international access time to the Minitel System now runs several hundred thousand hours per year (Davidson, et al., 1993).

The competitiveness issue is not primarily a matter of whether a country is left out of the communications infrastructure altogether; all nations will be connected sooner or later even if national governments take no action. Nor is the issue one of being "first" with a plan for building NII. *Rather, competitiveness will depend on whether a nation moves fast enough to be part of the critical mass of other movers when the key shifts to new modes of commerce using the NII take place.* All communications technologies require diffusion to a critical mass in order to gain

the benefits of use (Rogers, 1983). The goal is to be part of the mainstream rather than so far ahead that resources are wasted or so far behind that the crucial opportunity to establish oneself in the game is lost. Government has a key role in mobilizing action among the critical mass of users as the NII is implemented.

A related competitiveness issue is that all nations must undergo institutional and social learning in order to use the new technologies. Although one could outsource the technical provision of a nation's information infrastructure (as is now being done with telecommunications in China), the NII is not something a nation can simply plug into—even though such images often appear in the popular press. A nation must learn how to build and maintain the NII, and develop applications on it. A nation must develop the institutional structures required to coordinate its deployment, governance, regulation, and use. And it must develop the awareness and skills of its population for effective use. Such learning cannot occur overnight. Singapore, which is faster in its development than any other nation will probably do it over a period of twenty years partly because it is small, has a unified government, and is highly focused on the NII as part of its self-image as a nation. For example, it is the stated plan of the Singapore government that every household in the city-state with a computer will be connected to the Internet by the year 2000. The speed and ease with which such learning occurs affects the competitiveness of a nation's businesses and people.

A final competitiveness issue relates to effects on the freedom of nations to operate inefficiently and outside international business norms and standards. As commerce is increasingly conducted electronically, it will not be possible for nations to hold to their own unique institutions, norms and standards without paying a price. For example, if a nation's coordination mechanisms for the NII are bureaucratic, cumbersome and slow, it might loose out to a nation with focused institutions that can move fast in response to market opportunities. Similarly, if a nation chooses to flaunt intellectual property protection laws in the name of furthering its own businesses, it will have to deal with the business culture it has created when it wishes to enforce such laws to aid its own software, entertainment or publishing industries. Also, protection of domestic producers through import duties will be less feasible because of GATT agreements and gray markets. Protection of the local market through unique domestic standards will be self-defeating because of the requirement to follow international protocols in order to participate in global communications. Similarly, protection through quotas on imports of information services will be infeasible. All such measures simply increase costs to the economy as a whole.

POLICY PARAMETERS

In summary, there are seven major points that derive from the NII experience in the U.S.:

1. *The NII is already here.*

   It is not some futuristic electronic highway that is yet to come. It is here in the telephone, cable and computer networks that already exist. Its potential is illustrated by the Internet.

2. *The extension and integration of existing facilities and services "out and down" is at the heart of the NII.*

Although there will be new facilities and services downstream, the near term development of the NII will focus on extension of existing voice, video and data facilities and services through existing networks. The services will be more varied and the networks will be more integrated, but services will be provided mainly through upgraded and expanded telephone, cable, broadcast, cellular and satellite facilities for communication. The key is extension of these services "out" among the markets and communities that are now using them, and "down" into new markets communities that do not yet have them.

3. *The NII services that will have the greatest initial demand are those that are already here in one form or another.*

These include telephone, voice mail, electronic mail, file transfers, teleconferencing, electronic document interchange, online data services, and data communications. Services such as video on demand, video gaming, electronic gambling, remote shopping and electronic banking will be slower to develop and will require a long time for payback. Many will payback only after failed ventures are taken over by new owners at a fraction of their costs to build.

4. *The market for new NII services will be greatest in business and government, and secondarily in education and the home.*

When home computers were first produced in the early eighties it was felt that the household market would take off, but it taken much longer than expected. Empirical studies of computing in the home show that computer use is primarily an extension of work at the office, and very secondarily an extension of work at school. The notion that home computing would develop its own place in the market has not yet materialized although it may soon. Instead, computing continues to come into the home incrementally. In the past, entry was primarily through work and school and individual smart appliances. Recently, entry has been stimulated by the Internet, on-line services and multimedia. The vision of a single nerve center providing all services and controlling all appliances, systems and communications in the home has failed to materialize; ubiquitous computing seems to be a more realistic vision for the future. Government can stimulate greater application by using the NII as a teaching tool in the classroom, building familiarity with it, and providing government services and information.

5. *The building of the NII is basically a private sector affair.*

Investment in the NII will be mainly a private affair as will the expansion of existing infrastructure, the provision of new communication modes and the provision of products and services. Private investment over the next 20-30 years will be ten times that of government.

6. *Government plays several key roles in the NII and will continue to do so, but leadership in the NII is more than simply a governmental concern.*

Coordination among the various players in the NII is the key leadership issue. In contrast to other nations with a single central coordinator, in the U.S. coordination will be shared between government and private institutions such as industry associations, business leaders, professional associations, and user groups. As a consequence, deployment might be slower but innovation might be higher. A particularly important and changing leadership domain is in standard-setting, where traditional standard-developer organizations are clearly losing their ability to guide standard setting processes, while new and flexible "consortia" are emerging to fulfill this role. The consortium model requires public and private partnerships of a kind not common in the U.S. in the past.

7. *A key goal of government involvement in the NII must be to increase the competitiveness of business and industry in the global marketplace.*

It is expected that competitiveness will result from creating a critical mass for use of the NII that enhances industry leadership, supporting institutional and social learning that facilitates use of existing and future services, creating new opportunities for existing and emerging information industries, increasing the efficiency and effectiveness of government, business and the whole economy, and setting the standards and norms for the global NII in concert with other nations, recognizing their likely impacts for competitive advantage.

CONCLUSION

During the past two years there has been a huge growth in public commentary about the NII, the "information superhighway,' 'cyberspace,' the information economy, and similar signifiers discussed above. Some of the expectations embodied in these signifiers are likely to be fulfilled; many will surely be proven incorrect. It is important to focus on what might change, but if the information revolution is truly upon the policy community, it is equally important to focus on what will *not* change as a result of the revolutionary forces at work. Fundamental social forces and long-established conventions and institutional apparatus will surely govern much of what emerges. Technological change, even if radical, emerges from and proceeds in a highly "path-dependent" pattern that carriers forward much of the old into the new (David, 1975, 1985). The characteristics of the path dependencies are vital for the formation of sound policy in reaction to, and proactively for, the emerging NII.

A recent editorial in *The Economist* (1994) provides an example of how elusive the appropriate policy response to the NII can be. The editorial notes that a popular cliché of the information age is that telecommunications and networks decrease the importance of time and space. In this vision, companies can be decentralized and their operations located anywhere; their employees will no longer need permanent offices as they work at home, in their client's offices, in cars and airplanes, and so on. There is something to this vision: Texas Instruments programmers in Bangalore, India start work over computerized communications systems when their colleagues in Austin, Texas go home. Foreign exchange markets run 24 hours a day. At least one California company has no offices; all employees have a portable computer and CompuServe account and meet when needed anywhere that is convenient. Policy encouraging, or at least facilitating, such decentralization might seem warranted or even necessary. However, as compelling as these

examples might be, history provides important constraints on our expectations. Experience that shows location to be vital regardless of other factors, and efforts to relocate populations and economic functions away from urban centers provide a good example of this point. Tokyo has been trying to decentralize for 25 years, but its decentralization plans have not worked despite great national and city government efforts and a 20-30 fold increase in the region's information infrastructure. The French government has also been laboring to decentralize government and economic activity away from Paris to the provinces, with limited success, even though France has pursued an aggressive policy of building information infrastructure.

Path dependency reveals that people *can* be distributed by use of information infrastructure, but they are unlikely to comply with distribution schemes as long as economic and social conditions reward concentration. New computer and communications technologies enable decentralization, but by themselves they will not bring decentralization about on a broad scale unless equally revolutionary changes emerge in factors as broad as industrial organization, transport, and even family formation. As the insightful work of Saxenian (1994) shows, even the most advanced use of the Internet has not been to found a global village, but to strengthen business and social ties of firms and people in and around Silicon Valley, California. New technology, especially communications technology, often supplements and reinforces existing arrangements rather than supplants them. Communication begets communication, and as communication becomes more intense, so does the need for and the desire for face-to-face communication that helps to produce concentration. Predicting what will be reinforced and what will be supplanted is very difficult. There is an old Chinese saying which some say is meant as a curse: "May you live in interesting times." That is why the future being created by national and global information infrastructure is going to be very interesting—for the providers, regulators and users.

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