The National Information Infrastructure:
An Industry Analysis

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ABSTRACT

The U.S. National Information Infrastructure (NII) also known as the Information Superhighway is supported by the information and telecommunications technology industries (ITT). This article analyzes the role of these industries in the U.S. economy, and their technological and structural strengths and weaknesses. An exploratory study of executives in ITT companies is described. Based on results from this study, the evolving structure of these industries is proposed in two phases: "telecomputing" and "telinfocom." The article concludes that although the technologies necessary for the NII are well developed, the major hurdles to the NII will be the regulatory climate and the structural problems in the industries themselves, upon their convergence to form the U.S. National Information Infrastructure.

INTRODUCTION

The U.S. National Information Infrastructure (NII) is the official name of the popular concept of "Information Superhighway" [1]. It contains a hybrid assembly of technical, organizational, political and managerial agendas in both information and telecommunications technology (ITT) [2].

Since 1993, the Clinton administration has taken the initiative to foster the NII in the on-going effort to improve the U.S.'s competitiveness in the world's markets. Among the legislative accomplishments are the Antitrust Reform Act of 1993, the National Competitiveness Act of 1993, and the Communications Act of 1994. [3]

Although much of the language in the legislation and in the popular discourse on the NII specifically centers on telecommunications [4], nevertheless the NII is a forum for convergence of information and telecommunication technologies (ITT).

There are as many analyses of the future and prospects of the NII as there are disciplines involved in its creation. However, most of the forecasts are technical or managerial and seem contained within the contours of the industry. [5]

This article brings together analyses of the Information Technology (IT) sector and the Telecommunication Technology (T/C) sector, so that a more comprehensive perspective on the NII may be advanced. Together with findings from an exploratory study of ITT companies, the resulting analysis of the industries that will support the NII emphasizes the structural strengths and weaknesses of the IT and T/C sectors.

CONSTRUCTING THE NATIONAL INFORMATION INFRASTRUCTURE (NII)

The NII is essentially the convergence of Information and Telecommunication Technologies (ITT) to provide the means for the exchange of information. George Heilmeier summarized this concept in predicting that "people and their machines should be able to access information and communicate with each other easily and severely, in any medium or combination of media voice, data, image, video, or multimedia any time, anywhere, in a timely, cost effective way" [6].

There are three key components that underlie the NII: the computing industry, telecommunication industry, and the information industry. The first two provide the framework, and the latter generates the content which fills the lanes of the "superhighway." Two major phenomena have had a crucial mark on the evolution of these components ubiquitous computing, allowing for high mobility of the computing environment, and technological evolution of wireless communications, networking, and intelligent systems [7]. These phenomena are contributing to the rapidly diminishing differences between the IT and Telecommunications Industries.
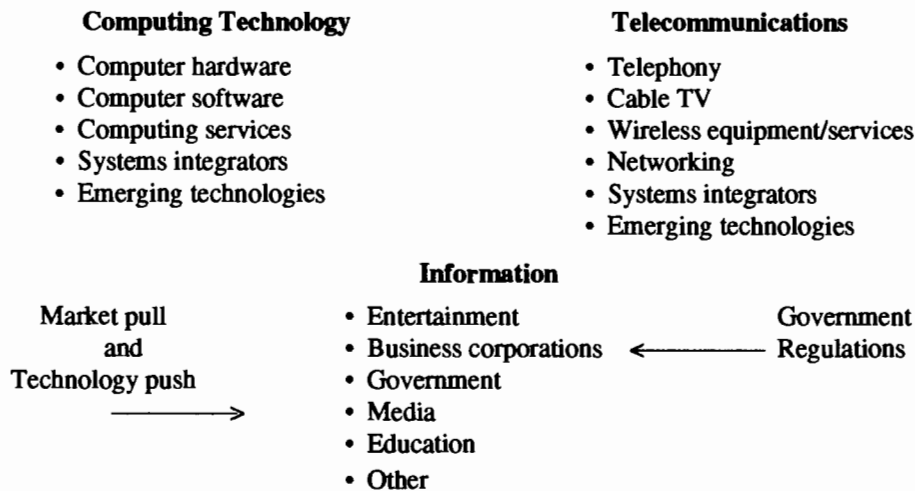
Current Industry Structure

Figure 1 shows the current structure of the industries that compose the foundation of the NII.

Presently, the three industries are still largely separated. Yet they are undergoing an evolving trend of structural

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Figure 1

Current Structure of Industries in the National Information Infrastructure

Computing Technology

- Computer hardware
- Computer software
- Computing services
- Systems integrators
- Emerging technologies

Telecommunications

- Telephony
- Cable TV
- Wireless equipment/services
- Networking
- Systems integrators
- Emerging technologies

Information

Market pull
and
Technology push
———————>

- Entertainment
- Business corporations ←——————
- Government
- Media
- Education
- Other

Government
Regulations

solidification and convergence [8]. The areas of interface are constantly growing. This phenomenon describes a sector that is changing with a shift from narrow disciplinary confines to interdisciplinary reach and to global advancement. Furthermore, the sector is rapidly changing through waves of mergers, acquisitions, and strategic alliances. Interindustry linkages are becoming commonplace and are newsworthy when the industry giants begin to integrate their activities, skills, and markets. For example, Sprint Corporation enters into partnership with Deutsche Telekom and France Telecom (within the telecommunication industry). Similarly, British Telecom invested in a 20 percent stake in MCI. Interindustry alliances include: IBM and Siemens AG; Nextel Communications allies with Motorola; Bell Atlantic forming strategic alliance with the Oracle Software Company; Bell Atlantic and TCI involved in a stormy courtship; AT&T and McCaw Cellular Communications and EDS and Sprint have entered into specific technology mergers. Other sector dynamics include such consortia as: Bell Atlantic and BellSouth to bid on licenses for personal communication services; MCI and 150 telephone, cable, publishing and paging companies jointed to gain license for nationwide cellular service. The "megadeals" continue to be discussed and contemplated as the structure of the industry is constantly shifting and additional players are forming workable consortia.

Spurred by the Clinton-Gore initiatives, 28 IT/TC companies formed a Cross-Industry Working Team (XIWT), with the goal of "promoting and accelerating the deployment of a world-class NII by fostering the development and application of technologies which cross traditional industry boundaries" [9]. These and other such initiatives are emerging across the sector [10] in various industries. They indicate the state of fluctuation and change with which these industries are confronted.

Basic Industry Profile

The IT and T/C industries are an important, perhaps vital, component of the U.S. and world economies. Table 1 shows the overall market profile of these industries in the U.S.

Although the bulk of activities in the sector is in the domestic American market, the impacts of these two industries is felt worldwide, increasingly through the international alliances of U.S. companies.

In the U.S. the telecommunication services industry impacts about 100 million households and 28 million businesses. Its revenues in 1994 should reach almost $180 billion. This industry includes: 1) local exchange; 2) long distance communications; 3) international communications; cellular and other mobile communications; 5) satellite communications; and 6) data, video and network communications. About 75 percent of its employees are production workers.

The U.S. telecommunications equipment industry includes makers of telephone and other transmission equipment and components. Canada and Mexico are the largest export markets for U.S. firms (15% and 12%). Exports to the European Union are in the range of 20% of total exports. Imports are primarily from East Asia. There are currently 700 million telephone and data terminals worldwide, and

Table 1

Overall Market Profile of IT and T/C in U.S.

Sector	Shipments or Revenues (1994)	Employment (1994)	Growth 1993–94	R&D Spending in 1994	Exports (in billions)
Information Technologies					
Computer Equipment	$65 billion	190,000	3%	$15 billion	$28.0
Software and Networking	$40 billion	500,000	12%	$6 billion (estimate)	$12.0
Telcom Technologies					
Telecommunication Services	$180 billion	900,000	12%	$11 billion (estimate)	$13.2
Telecommunication Equipment	$75 billion	200,000	3%	$4 billion (estimate)	$9.1

Sources: [14] and other statistical data sources

45% of these are in the U.S.

The information technology industry in the U.S. is multifaceted with ramifications into every aspect of the economy. Some indicators are revealing. By 1995 about 200 million personal computers and workstations will have been sold, offering color, audio, and video. Portable computers are gaining a growing share of the market, from about $5 billion in 1992 to over $10 billion in 1994 [11]. A related phenomenon is the growth in activities by software companies. Microsoft, IBM, Apple and their subsidiaries are actively pursuing linkages to telecommunication companies. This is also true for a host of smaller software companies. In 1994 this industry had revenues of $40 billion and an annual rate of growth of over 10 percent.

EXPLORATORY STUDY OF ITT COMPANIES

During the early part of 1994 we conducted an exploratory study of ITT companies. Executives in 9 Fortune-500 companies were interviewed. These executives were at the second to third levels from the President. Three of the interviewees hold staff positions of Vice President for corporate planning (or its equivalent) and six held operational positions within divisions of the corporations.

The objective of the study was to explore the future development of ITT industries, the key issues confronting the industries and their strengths and weaknesses. With the dazzling array of technical innovations in these industries, coupled with constant structural tremors via consortia and mergers and acquisitions, it was felt that perhaps ITT executives could shed some light on what lies ahead for their industries.

Two main outcomes emerge from the interviews: key issues resulting from the emerging information infrastructure (NII), and the strengths and weaknesses of the industries. Also, based on the interview, a future industry structure is proposed below.

Key Issues Resulting from the NII

The exploratory study generated ten issues of concern to executives of the ITT industries. The issues are shown in Table 2. The top five issues of concern resulting from the exploratory study include managerial, technical and environmental issues. The first issue is the conflict between management and competition in the emerging information infrastructure. This is an issue of ownership and has recently received public attention with the auctioning of portions of the telecommunication spectrum. Executives interviewed emphasized the inherent conflict between the wish of many in the industries to open the market to competition, versus the need to maintain some public control and management of the key elements of the infrastructure.

A second issue is the perception that there are myopic distortions in the way senior maangers in the ITT industries view the longer term objectives and future direction of the infrastructure. The feeling is that due to the complexity of the phenomenon, some key managers who rose from the ranks of vendors and makers of equipment lack the insight and appreciation of what the NII entails. As one executive interviewed explained: "It's like having makers of stage-coaches in charge of the nation's airport system."

Another issue related to the previous issue is the lack of

Table 2

Key Issues of Concern to Executives of ITT Industries Resulting from the NII*

LIST OF ISSUES *

1. Management versus competition: who will own what part of the information infrastructure.

2. Misconceptions and myopic distortions by industry senior managers of objectives and future direction of the information infrastructure.

3. Lack of a systematic mode of behavior of participants from various disciplines and industries who "muddle through."

4. Safety and security of operational networks such as the internet and private networks.

5. Regulations and regulatory climate that respond belatedly to needs and crises well after they occur.

6. Consortia, cooperation and inter-company agreements that are based primarily on short term reasoning, not on technology.

7. Lack of agreement on and understanding of what will be the content of the information superhighway.

8. Lack of understanding and thus incorporation into strategic decision-making of who are the customers of the NII and their needs.

9. We'll end up soon with technology and managerial structure chasing business, in a sense a variant of over-production.

10. How to live through the coming period of learning and adaptation.

* Source: Interview data with nine executives of ITT companies.

** By descending order of degree of concern to the executives interviewed.

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cohesion and systematization in the behavior of companies from different disciplines. They seem to "muddle through" rather than work aggressively and in concert towards the common goals of setting up an infrastructure.

Other issues suggest a future period of learning and adaptation, yet marred by lack of understanding of some basic premises of the NII. Moreover, there is a feeling among interviewees that these issues will create a situation of "overproduction" in which a period of recession will follow the current and near-future periods of dynamic expansion and unmitigated (yet poorly planned) growth. [25]

The implications for business and public policies from these issues are twofold. For the business decision-maker, the list of issues brings about the need for a better understanding of the NII within the framework of other industries and the economy at large. Furthermore, the complexity of the phenomenon requires more cohesion among companies and a strife for added standardization not only in technical matters but also in managerial approaches to the design and engineering of the infrastructure.

For the public policymaker the main issue is a balance between control and market forces, and with respect to regulations and the regulatory climate. The NII is generating questions, problems and issues never before encountered in

such a mix and with such wide public influence. Therefore public policymakers will be forced to approach these issues with innovative perspectives and perhaps new solutions.

STRENGTHS AND WEAKNESSES

The information technology (IS) and telecommunications (T/C) industries are essentially the blood vessels that move information and the heart that manipulates it throughout the body economic of the U.S. and the world. In the U.S. these industries account for about 14% of the Gross National Product and employ about 8% of the American job market. However, one in five people employed in the U.S. is working in an area of information manipulation (processing, storing, retrieving, analyzing, and transmitting).

Strengths and Weakness of the U.S. Information Technology Industry

In the hardware category, U.S. firms have competitive strengths in three areas, whereas in the software category, U.S. firms have strengths in five areas. There are all summarized in Table 3.

Although U.S. companies are besieged by competition from Asian manufacturers, some standard and specialty

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Table 3

Strengths of the U.S. Information Technology Industry

A. **Hardware**
 • Engineering of standard computer boards
 • Specialty computer boards
 • Parallel processing/computing

B. **Software**
 • Relational data bases
 • Machine intelligence
 • Virtual realtiy
 • CASE tool development
 • Security

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computer boards are boosting the U.S. competitive presence. In supercomputers, Cray Research has about 80% of the U.S. market. Convex has 60% of the minisupercomputers. Apollo's advantages in workstations and IBM's in storage technology in mainframe disk arrays join such companies as Terradata, Sun, and Del in parallel computing and Intel and Motorola in microprocessing [12].

In software, the strengths are in the advances U.S. firms have made in such technologies as relational data bases, machine intelligence, and virtual reality. The U.S. is also very strong in CASE (Computer-Aided-Software-Engineering), used to develop new software applications with improved time and effort efficiencies.

Areas of weaknesses in information technology are summarized in Table 4. They include lack of standardization and lack of direction. These weaknesses, as many other below, are structural deficiencies in the industry. Because of intense competition and proprietorship concerns in the hardware area, U.S. industry resembles a hodgepodge of niches. Differentiation of products has led many companies into the trap of going beyond their core competencies.

Table 4

Weaknesses of the U.S. Information Technology Industry

A. **Hardware**
 • Lack of standardization
 • Lack of direction and convergence

B. **Software**
 • Poor connectivity
 • Offensive warfare
 • Vertical disintegration

In the software areas, there is still a strong trend of proprietary specialization, leading to poor connectivity among systems. The continuous offensive warfare of U.S. companies leads to "vertical disintegration" in that entire companies are working as specialists. There are very few, if any, "generalists" such as IBM used to be [13]. The complexity of the sector and the current marketplace are perhaps prohibitive to the generalists and strongly encourage specialization behavior.

Strengths and Weaknesses of the U.S. Telecommunication Industry

As in the case of the information technology industry, the T/C industry's strengths are in its development and use of both current and emerging technologies. These are summarized in Table 5 below.

Table 5

Strengths of the U.S. Telecommunication Industry

 • Chip design for mixed signal applications
 • Convergence of technologies for multimedia communications
 • Mobile and wireless communication technologies

The T/C industry in the U.S. is not only powerful due to its size, but also because it is able to allow emergent technologies to rapidly move from the experimental stage to the stage of readiness for potential commercial applications [14]. This is the case of chip design, multimedia communications, and mobile and wireless technologies. This technology push is creating a situation whereby there is an accumulation of cutting-edge technologies which leads to a slow down in the time-to-market for the applications.

The weaknesses in the T/C industry in the U.S. are inherent in the structure of this industry and in the external environment in which it operates. Table 6 summarizes these weaknesses.

A major weakness of the T/C industry is the lack of direction and lack of cohesion of the technologically driven companies that compose the industry. There is so much fervor and activity in the industry, with a strong annual growth and constant demands from the marketplace that corporate players are unsure where they are going. This is a real "race" to a finish line that is not clear, has not been defined, and that seems to be pushed farther with each passing year and with each technological or product achievement.

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for example, just a "least cost producer," as the product or service may disappear in the next shake out of the industry. To join the NII would mean added risk-taking and a more robust comprehension of the playing field.

CONCLUSIONS

We are bound to be witnesses in the not so distant future to a wave of revolutionary developments in the information and telecommunication technologies in the United States with global repercussions. Due to the size of the American IT and T/C sector, and its technological advancement, the understanding of the dynamics of the sector requires an analysis of U.S. industry. The success of the National Information Infrastructure will depend on the U.S. ability to resolve some or most of the structural weaknesses of its IT and T/C industries, and to bring some order and consistency to its regulatory climate. The successful development of the information superhighway requires governmental support up to the point where corporate America allows market forces to influence its evolution. Unlike asphalt and air superhighways, the NII is a complex array of interrelated industries, interests, and technologies. The "golden rule" of balancing all the participants should apply, by avoiding extremes and by letting the NII evolve in a natural, technology and market driven pace [24,25].

ACKNOWLEDGMENT

NOTES AND REFERENCES

[1] Information Infrastructure Task Force, "The National Information Infrastructure: Agenda for Action," Washington, D.C., Department of Commerce, 1993.

[2] A review of the outlook for ITT is given in: Geisler, E., "Information and Telecommunication Technologies in the 1990s: Trends and Managerial Challenges,", In *International Journal of Technology Management*, 1992, 7, (6/7/8), pages 381-390. Also in the entire volume of: Geisler, E., (Editor), "Strategic Management of Information and Telecommunication Technology," *International Journal of Technology Management*, (Special Issue, 1992, 7 (6/7/8)).

[3] Clinton, William, and Albert Gore, "Technology for America's Economic Growth: A New Direction to Build Economic Strength," Washington, D.C., Executive Office of the President, 1993.

[4] Fowler, T., and Wright, K., "Telecommunications for the 21st Century," *OR/MS Today*, June 1994, pages 20-

27. See, for example, Flanagan, P., "Future Industry Directions: The 10 Hottest Technologies in Telecom," *Telecommunications*, May 1994, 28(5), pages 31-48.

[6] Heilmeier, G., "'Global ' Begins at Home," *IEEE Communications Magazine*, October 1992, pages 50-56.

[7] Katz, R., "Adaptation and Mobility in Wireless Information Systems," *IEEE Personal Communications*, First Quarter 1994, pages 6-17.

[9] See Geisler, 1992, op. cit., reference 2, pages 382-384.

[10] Dziatkiewicz, M., "XIWT: Can It Make Convergence As Simple As ABC?" *America's Network*, February 15, 1994, page 35.

[11] The term sector refers to the existence of several industries with some relations or connections. In this paper the IT/TC sector is the combined market presence of the Information Technology (IT) and the Telecommunication (TC) industries. "Telecommunications Survey," *The Economist*, October 23, 1993, pages 5-20.

[12] The analysis has benefitted from several sources. For example: Keen, P. G., Shaping the Future: Business Design Through Information Technology, (Cambridge, Harvard Business School Press, 1991); Ehrlich, E. M., "Information Technology, Global Linkage, and U.S. Competitiveness," *Vital Speeches*, 1 October 1989, pp. 755-759.

[13] Recently Microsoft has announced plans to become a generalist software provider, along the lines of the "Office of the Future" concept.

[14] U.S. Department of Commerce, *U.S. Industrial Outlook 1994*, (January 1994, Superintendent of Documents, Washington, D.C.).

[15] Gomes-Casseres, B., "International Trade, Competition and Alliances in the Computer Industry," (Working Paper 92-044, Harvard Business School, December 1991).

[16] Loh, L., and N. Venkatraman, "Diffusion of Information Technology Outsourcing: Influence Sources and the Kodak Effort," *Information Systems Research*, 1992, 3(4), pages 334-358.

[17] Spectrum is the totality of frequencies in which transmission is carried out. The spectrum is currently limited by the physical number of the total available frequencies, and by the Federal Communications Commission (FCC) which regulates the spectrum and its distribution.

[18] Heilmeier, who is President and direct Executive Officer of Bellcore (reference No. 6 above), has suggested that: "The United States' movement toward information networking is chaotic. A national sense of purpose would enhance both local development and global integration" (p. 50).

[19] Kay, K. R., "The NII: More Than Just a Data Superhighway," *Telecommunications*, 1994, 28(1), pages 47-50.

[20] Stapleton, R., "Some Thoughts on NII Development:

Infrastructure in a Larger Context," *Telecommunications,* 1994, 28(1), pages 85-86.

[21] Ohmae, K., *The Borderless World,* New York, Harper-Collins, 1990.

[22] Benhamou, E., "NII Development: Where Do We Go From Here?", *Telecommunications,* January 1944, 28(1), pages 23-26.

[23] Mannermaa, Milea, "In Search of an Evolutionary Paradigm for Futures Research," *Futures,* 23(4), May 1991, pages 349-372.

[24] Some authors have suggested that the NII may hold promise "for leveling social inequities"- (reference No. 20, page 85). This *a priori* use of the NII as a social policy tool may inherently divert resources from support of the infrastructure and subvert the purpose of government support of the NII. In the U.S. there currently are, and will continue to be, active discussions of socio-political issues of information access, security and ownership. The successful development of the NII depends on such a public discussion leading to relative freedom of the industrial infrastructure to achieve its potential in growth and global reach.

[25] Plennert, G., "From Megatrend to Megadisaster," *OR/MS Today,* 21(6), December 1994, pages 24-26.

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