From Public Access to Private Connections: Network Policy and National Advantage

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To businesses, telecommunications networks once were like electricity or water distribution facilities -- an important resource, but one over which they had little control. They had little choice of equipment and even less of services. Telecommunications managers had seldom more to do than provide employees with telephones, and the company with as low communications costs as possible.

Restricted corporate choice and action were the internal mirror image of the external organization of the telephone system. By and large, MA BELL provided a relatively undifferentiated class of services over a basically uniform network that terminated in essentially the same equipment on each customer's premises. As "pharoah" of the technological pyramid that delivered restricted choice, ATT had only to fear the gods of monopoly regulation.[1] But as with more than a few pharoahs, the gods were normally compliant -- more concerned about the integrity of the empire than the exercise of free will by the people.

In the United States, after two decades of user-driven revolution in technology, products, and services, 'the people' have been liberated. Or more accurately, relatively unrestricted choice has been achieved by a specific subset of the people -- those organized and wealthy enough to take advantage of the opportunities available to them in the market.

Corporations operating from an American base now regard their communications network not as a basic utility, but as a "competitive weapon". They are turning their telecommunications managers into "Chief Information Officers" entrusted with implementing business strategies articulated around the new possibilities now open to them. A staggering array of corporate telecommunications networks that control the delivery of voice, packetized data, video and documents, now link internal operations and tie them to those of suppliers and customers.

A powerful set of market opportunities now surround the intelligent products and services digital technologies make possible. In ways never before possible, companies are able consciously to design and build telecommunications networks that decisively enhance their competitive position, whether that position lies in financial services or traditional manufacturing.

To implement the new business strategies, companies no longer rely exclusively, or even primarily, upon the public network. In the market that now substitutes for regulated monopoly, corporations pick and choose from a variety of options and use them to create their own networks. They combine lines leased from common carriers with privately-owned transmission and switching facilities, and with still other networks they jointly own with other organizations in their industry. They bypass the public network entirely or in part. Over these networks, they use a variety of advanced services such as voice messaging, videotex, electronic mail, high-speed data trasmission, or video-conferencing. They develop these services themselves, or buy them from any number of independent suppliers.

Again, there is a mirrored external image -- that of competitive US deregulation and the break-up of the pharoah's empire. Technically, the new structure is perhaps a geodesic network, in which exceedingly powerful switch nodes proliferate and are interconnected along transmission paths of minimum length.[2] The animating external image may indeed be a technical geodesic, but its delivered form is nevertheless that of a market, and its control is therefore through the exercise of market power.

Consider that the private networks built by US companies to serve their own telecommunications needs now constitute a non negligible part of the national telecommunications network infrastructure. Indeed, in their technology and conception, those networks are anything but marginal. They are the

1 The metaphor is drawn from Peter Huber, *The Geodesic Network: 1987 Report On Competition in the Telephone Industry*, US Dept. of Justice, January 1987, at p.1.3,n.5

2 *Ibid.*, at Chapter 1.

cutting edge of demand. Private buyers now account for 40% of the switch market, 20% of microwave and fiber-optic transmission equipment and electronics, and 80% of the market for satellite transmission services.[3] And since their power of demand is exercised through the form of the market, the facilities and services they require will ultimately shape the evolution of less technically advanced networks -- especially those networks that can still be considered to reside at least partly in the public domain.

Therefore, as a growing number of firms turn to private network solutions, an increasing share of the US telecommunications network falls under direct private control -- or to be more precise, increasingly escapes from public control. Indeed, corporate private networks are specifically built to serve private corporate goals, though they may also serve public goals in passing. The organization that controls them sets the terms of their access, connectivity, operation and functionality.

The policy implications are substantial. Not only do they obviate the continued regulatory preoccupation with the question of whether competition effectively constrains the exercise of the rapidly evaporating monopoly power of exchange carriers, they pose a whole host of new questions. The private choices that influence public network development can add up to substantial control over network evolution: Who controls the disparate pieces that comprise the nation-wide infrastructure matters.

Digital information networks are the essential infrastructure needed to capture the vast new economic opportunities available from the exploitation, control and processing of information. One need not make the case that we and numerous others have argued elsewhere -- for an economic transition from an industrial economy based on the processing of raw materials to one based on the processing of information[4] -- to recognize the economic significance of the exploitation of information technologies even for the production of traditional goods from agriculture to steel.

How, and how successfully, nations manage the transition to a mode of production heavily dependent on the manipulation of information, will shape their respective opportunities for national economic development. Thus, the implications of the emerging national network infrastructure, of who controls its parts and to what ends, have centrally to do with America's economic future.

The U.S. choices to deregulate and foster private network development, rest upon the belief that market competition between the owners and builders of rival telecommunications networks will stimulate innovation and promote the construction of the networks that are best able to serve the interests of the US economy. There is also a hidden assumption which may rest on a fallacy of composition: That private efforts operating through the market will, as if by an invisible hand, add up to an efficient national network that captures the gains to be had.

These beliefs differ from those held in most other countries, where governments estimate, to varying degrees, that they need control over the networks' evolution if their potential for economic growth is to be fully exploited.[5] We have characterized the various national approaches as *liberalized* re-regulation throughout most of Europe, and as *developmental* re-regulation in Japan.

In each case, to a greater or lesser extent, continued public control is exercised over the provision of digital network infrastructure, over the underlying technology development and application, and most critically, over access and functionality -- that is, ensuring that all segments of the polity have access to advanced services and facilities. In our view, Japan is the most self-consious in its belief that digital networks play a critical role in the transformation of production, and in recognizing the need for simultaneous development of both public and private network facilities and services (including public subsidy to the underlying technological R&D) in order to capture the greatest possible national economic gains from the new opportunities.

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3 *Ibid.*, at p.I.11.

4 Our statement is contained in the collected writings of the Berkeley Roundtable on the International Economy. For other statements, see, e.g., the works of Robert Boyer, Benjamin Coriat and Jacques Mistral in France, of Christopher Freeman in England and Giovanni Dosi in Italy, and in the U.S., among many others, of Jay Jaikamar and Shoshanna Zuboff at Harvard, Michael Piore and Charles Sable at MIT, Paul David, Paul Adler and Nathan Rosenberg at Stanford, and Peter Drucker and Daniel Bell.

5 For a detailed analysis of these differences, see Borrus, Bar et al., "Telecommunications Developement in Comparative Prospective: The New Telecommunications in Europe, Japan, and the US", *BRIE Working Papers*, 1985.

Do such national differences of approach to the development and control of the network infrastructure really matter to relative economic performance and position? There are several ways in which the distinct national approaches can matter to long-term relative performance. We have not as yet worked out a thorough theoretical approach to this issue, but a few ideas will suffice to give a flavor for our intended direction.

There are strong learning effects associated with progress in both the development and use of the information and microelectronics technologies that underlie network creation.[6] Degrees of learning are intimately bound with producing the network itself -- i.e., in development of the products and processes embodied in the network -- and with producing and executing the applications (i.e., services) used over it. In that sense, the choices surrounding creation of the national network infrastructure -- including who actually develops, deploys, uses and controls access to it -- will simultaneously open and foreclose future learning opportunities and the prospects for future growth those opportunities imply. It is therefore possible simultaneously to envision 'virtuous' paths of accumulated learning and dynamic advance, or 'vicious' paths of scattered learning and much slower growth -- in essense, path-dependent processes of industrial development.[7]

Directly related to, and in part reliant upon the processes described above, is the probability that accumulated learning leads to accumulated earning. It is likely that different approaches to network creation and control entail different possibilities for capturing the international opportunities for economic gains associated with the network. More specifically, the information industries underlying the network, and the network infrastructure itself, generate the possibility for earning persistent, comparatively high returns for the nation because they generate expansion and efficiencies in the economic activities that use them. In other word, they generate what economists call external economies (or externalities).[8] The degree to which such external economic gains are generated and captured depends upon how the network is developed, deployed and used.

Because they are cumulatively unpredictable and also generate externalities which can not be captured by individual firms or industries, the choices over network creation influence future opportunities for learning and earning in ways that are not, and probably can be *neither signalled accurately nor traded* through the market.[9] In such conditions, there is no reason to suppose that market relations alone will generate optimum accumulated learning and growth for the national economy as a whole. Whether the U.S. market-bound approach is likely to foreclose optimum development paths or open possibilities that other approaches foreclose, is very much a question for empirical research.

Does, however, our examination of the micro-level behavior of private networking efforts give any real insight into the overall national infrastructure, and into the theoretical possibilities touched-on above?. Again, this is not the place for a fully elaborated theoretical justification for our approach, but a few ideas will again be indicative.

As Alfred Chandler suggested in his work, new economic structures get built up at least in part in response to strategic dilemma's facing firms as they adjust to competition in their industries.[10]

6 This is directly implied in the work of Norman Rosenberg, *Inside the Black Box*, (Stanford University Press, 1983) and Richard Nelson, *High Technology Policies*, (American Enterprise Institute for Public Policy Research, Washington D.C., 1984).

7 The idea of path-dependent process has been developed in W. Brian Arthur, "Competing Technologies and Lock-in by Historical Small Events: The Dynamics of Allocation Under Increasing Returns," *Technological Innovation Project Working Paper*, Center for Economic Policy Research Publication No.43, Stanford University, 1985.; and explored by Paul A. David in, among other publications, "Clio and the Economics of QWERTY," *American Economic Review* 75, 2 (May, 1985); similar ideas can be found in the works of Nicholas Kaldor, Nelson, Rosenberg, and implicitly in Shumpeter.

8 These externalities take the form of technological or efficiency-generating inter-industry spillovers to other economic activities. See the discussion in Paul Krugman, "Strategic Sectors and International Competition," (paper prepared for the conference on *U.S. Trade Policies in a Changing World Economy*, Institute of Public Policy Studies, University of Michigan,) revised, June, 1985.

9 This point is drawn from Giovanni Dosi, "Some Notes on Patterns of Production, Industrial Organization and International Competitiveness," unpublished paper, July 1987 (Prepared for the Meeting on *Production Reorganization and Skills*, BRIE, U.C. Berkeley, September 10-12, 1987)

10 See Alfred Chandler, *Strategy and structure: chapters in the history of the industrial enterprise*, Cambridge, M.I.T. Press [1970, c1962], and *The*

Since, as we argue below, network creation is a fundamental structural adjustment to changed strategic circumstances in each industry, the character of the new (infra)structure can only be gleaned by examining the character of the circumstances and corporate choices that are creating it.

In a sense, we are looking at the emerging network infrastructure as a highly functionally articulated industrial organization -- which of course, as Huber points out, it very much more clearly used to be -- made up of the constituent private and public components. Taken in that way, the emerging network exhibits features usually associated with both markets and hierarchies,[11] and which structure predominates in which functional arenas may matter mightily to its impacts on the nation. Viewed that way, the constituent parts may not sum to a geodesic whole, but the effort at articulating the functional structure, who controls it and to what ends, ought to provide sufficient insight to give pause to the more wholistic engineering- and market-based approaches currently in fashion.

Our purpose here, however, is far more modest. It is to take a few tentative and indicative steps toward investigating the dynamics governing the construction of private telecommunications networks in the United States, and toward examining their more general effects on the national network. For those purposes, this paper is divided into four parts.

The first part looks at the telecommunications-based strategies of some US companies, enumerating a few of the circumstances and motivations that prompt what they are doing. The second part examines the consequences of these strategies for the networks companies build. Part three raises the first set of policy questions for the U.S., by examining some of the issues the private network strategies raise for the future of the US network infrastructure. Part four places our concerns and the policy issues in comparative context by using the counterpoint of certain contrasting approaches in France and Japan to some of our larger issues of concern.

In each of these parts, as hinted before, we have made no effort to be exhaustive in our review of strategies, networks or policy concerns, since our ability to do so will ultimately rest on a sufficiently worked-out set of theories to bound the effort. Instead, here we aim to provide a bit of flavour and context.[12]

1. Using Telecommunications to Create Competitive Advantage

Companies are discovering they can use the new telecommunications technologies to improve their operations and modify their competitive environment to their advantage.[13] The shape, characteristics, and functions of the networks they build, can be traced directly to the competitive strategies that fostered them. Before we try to evaluate the implications of private networks for the entire US network, it is therefore important to understand the strategies they were built to support. Companies are using telecommunications to achieve a variety of competitive effects: to improve various

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visible hand : the managerial revolution in American business, Cambridge, Mass. : Belknap Press, 1977.

11 These are the functional alternatives for industrial organization developed by Chandler and formalized ad infinitum by Oliver Williamson's transaction cost economics (or in an earlier variant by Ronald Coase).

12 The data presented here is based largely on original field research conducted at the Berkeley Roundtable on the International Economy (BRIE), under the *OECD-BRIE Telecommunications User Group Project*. It was gathered and discussed during regular meetings of BRIE's US telecommunications user group, which is comprised of representatives from the Bechtel Group, Levi Strauss, British Telecom Int'l, VISA, Pacific Telesis, Bank of America, MCI Telecommunications, the Transamerica Corp., Syntex, UC Berkeley, McKesson, and Hewlett Packard.

13 A recent, but rapidly growing business literature draws from examples of the network applications installed by some pioneering companies, to guide the efforts of other businesses. We draw substantially on that literature to complement our own research. See for example: Peter Keen, *Competing in Time: Using Telecommunications for Competitive Advantage*, Ballinger Publishing, Cambridge, MA, 1986. Charles Wiseman, *Strategy and Computers: Information Systems as Competitive Weapons*, Dow Jones-Irwin, Homewood IL, 1985. Byron Belitsos & Jay Misra, *Business Telematics*, 1987. And a series of articles in the *Harvard Business Review*: Erik Clemons & Warren McFarlan, "Telecom: Hook up or Lose out", July-August 1986 ; Michael Porter & Victor Millar, "How Information gives you Competitive Advantage", July-August 1985 ; Warren McFarlan, "Information Technology Changes the Way you Compete", May-June 1984.

aspects of their internal operations, to link up with their clients, and to link up with their suppliers.

Improve Internal Operations

Telecommunications has the potential to improve a company's internal operations in a variety of ways. The following examples are by no means exhaustive.

To coordinate resources. Telecommunications can improve coordination among a company's resources in many ways, ranging from voice-mail and electronic mail systems to more formal systems that track corporate resources to optimize their utilization. For example, some trucking companies use advanced networks to track cargoes and optimize delivery routes. The Transamerica Corporation, an insurance holding group, has linked all its small subsidiaries to central computer resources through a shared data network, avoiding the purchase of redundant computers.

To allow people in far-away locations to work together. When Hewlett Packard engineers in Grenoble, France, could not solve a problem with the design of a computer interface, they called upon engineers in Palo Alto for help. Circuit designs and operating codes were sent across the Atlantic so that as the work day ended in Grenoble, Palo Alto engineers could take over and send their results back for the Grenoble team to find the next morning. To work out the design of an X.25 PAD, HP established a 2-way videoconference among engineers in Fort Collins, Boise, and Cuppertino. The teams involved estimated that it would have taken at least six months to solve the problem, had they had to travel back and forth; they did it in two weeks of intensive video-conferencing.

To regulate materials flows within the company. By tying together their various divisions, manufacturing companies can manage inventories and shipments to distribution centers, adjust production to market demand, and better estimate their needs for raw materials. As they monitor and regulate these flows throughout the company, they minimize costly inventory build-up and reduce the risk of shortages. Levi Strauss, the blue-jean manufacturer, has linked its sales representatives with its factories and warehouses, so that as they enter customers' orders, they can check stocks at hand and re-order as necessary.

To provide support to remote teams. With the appropriate network support, field personnel can take advantage of information-processing resources in the home office. For example, Bechtel, an engineering consulting group, uses satellites and leased lines to link engineers on a project site to its central computers.

To inform and train employees. Hewlett Packard uses its TV and video conferencing network to hold interactive product announcement sessions for its sales force, offer training courses, or broadcast executive speeches. The broadcast network is used to offer classes on new products for service and support staff, as well as to provide HP's personnel with access to classes at several US universities, through which they can obtain advanced degrees.

To cut costs. All the applications described above are also ways in which telecommunications help companies reduce costs: by reducing their inventories, making more efficient use of their resources, or reducing the need to travel. Importantly, however, although cost savings matter, they are not always the primary reason for installing a telecommunications system. For example, in the case of HP's video-conference between Geneva and Palo Alto, the travel expenses saved are almost irrelevant: in the fast-paced computer business, a six-month delay in introducing a product would have made the difference between market success and failure.

Link-up with customers

Many companies are extending their internal networks to their customers, allowing them to enter orders directly, check a product's availability, or track shipment. The network application McKesson offers its clients illustrates this strategy.

The McKesson Corporation is America's leading distributor of non-durable consumer products (such as drugs and health products, paper goods, and wines). Every day, from its 200 distribution centers, it fills and delivers 41,000 orders, serving a total of 120,000 retailers throughout the United States.

McKesson's customers (the retailers) can transmit their orders directly to the company over public telephone lines. As they walk through their store, they use a small optical bar-code reader to record the tags of products they need, then plug the device into a phone jack to transmit their orders directly to McKesson's central computer.

Once received, the order is automatically processed and dispatched to the appropriate warehouse, where it generates a series of "bills of lading". These help employees optimize their routes through the warehouse as they box the merchandise. They also optimize the loading of delivery trucks so that the first box to be delivered finds itself on top, and then optimize the delivery route. Thanks to its information network, McKesson can guarantee its customers that, if they dial in an order before 4:00 pm, the products will be delivered the next business day before 10:00 am.

This system, combining reliability and speedy delivery with easy-to-use hand-held terminals, accounts for much of McKesson's competitive dominance of its market. Indeed, it offers multiple advantages.

The system shifts work and responsibility to customers. They become responsible for entering orders and verifying their accuracy, while McKesson's response can be entirely automated. In addition, the terminals give higher visibility to McKesson; they serve as a permanent sales representative on the client's premices. McKesson is currently upgrading this connection by allowing the hand-held terminals to interface with the retailer's PC, which, through direct modem connection, can supply additional information about the company's products or the client's order.

It also allows McKesson to further differentiate its products by bundling more information and services with them. For example, the market information gathered through this ordering system enables McKesson to offer marketing advice to its retailers, or to analyse the effectiveness of various shelf lay-outs. McKesson will even be able to sell some of these services, developed at little or no extra cost on top of an existing system.

This ordering system also creates "switching costs" for the retailers who use it. Switching to another supplier would be costly since they would need to adopt a new system, reorganize their operations, and learn to use another order entry device. Therefore, the retailers who use this system become increasingly dependent upon McKesson.

Finally, it creates entry barriers for McKesson's competitors. To compete, they would need to offer retailers a similar service. This catch-up would be not only very costly, but also very difficult, because once retailers use one system, they are unlikely to want multiple order terminals, or to learn several different systems.

Link-up with suppliers

Symetrically, companies can extend their information systems toward their suppliers. We do not need to dwell on this arrangement, because its dynamics are similar to those of downward links to customers. Major automobile manufacturers have extended their networks in this way. They require their parts suppliers to conform to electronic standards they dictate and to make available on-line information about their product specifications, prices, and stock on hand.

This is the telecommunications foundation of the "just-in-time" procurement system. It allows the buyer to order parts only when needed, cutting down its inventory costs, and to review automatically the offerings of a variety of suppliers to check for the lowest prices.

2. Controlling the Competitive Edge

Most of the competitive strategies we just described technically could be implemented over the public network. However, most of them were developed around private networks. Those private networks are often a very complex mix of equipment, networks, and services. For example, to support its worldwide needs for voice, data, and video transmission, Hewlett Packard built its own network integrating a variety of elements: (1) leased lines for data and voice transmission; (2) Telenet's packet switched data network, with gateways to other X.25 public networks in the US and abroad; (3) HP's own X.25 network, progressively replacing the public packet networks it uses; (4) both analog and digital satellite links for long-distance data and video transmission; (5) private satellite earth stations in the US and abroad; (6) public switched voice telephone networks in the US and abroad; (7) private microwave and fiber optic links for voice and data transmission around HP's Bay Area headquarters; (8) HP's own switches and multiplexers, increasingly able dynamically to allocate the bandwidth available on these various links to HP's many voice, data, and video applications.

To be sure, such networks are not strictly *private* networks, since they rely extensively upon a variety of public networks. They may be more accurately described as *privately controlled* networks (although we will continue to use the less cumbersome *private network*). Indeed, as should become clearer through this paper, what really matters is who controls the configuration of and access to the network, not whether a specific link is an optical fiber that belongs to HP, or a T1 rented from AT&T. Managing such complex networks is not an easy task, and it often would be easier to rely on a single public network operator to provide a complete, integrated telecommunications service. However, most companies think the benefits are worth the trouble they take managing their own networks.

Indeed, Hewlett Packard is not alone. An increasing number of large US companies are setting up networks under their own control, bypassing the public network to varying degrees. A recent study by the US General Accounting Office (GAO) indicated that between 16 and 29 percent of large-volume telephone company customers are bypassing their local telephone companies, and that up to 53 percent of the large-volume customers are considering plans to initiate or increase such bypass activity.[14] If anything, these figures underestimate the true extent of bypass, since they relie on voluntary surveys of companies that have no incentive to advertise the fact that they bypass.[15] Because they are only concerned with bypass of the Local Exchange Carriers, these studies also underestimate the extent to which companies are installing private networks that reach far beyond the local level.

Below are a number of reasons why companies are turning to private networks to fill their telecommunications needs. Whereas the last section emphasized the link between the use of private networks and their strategic impacts on competitive position, this section focuses on the choice between publicly-controlled and privately-controlled network facilities in achieving the competitive impacts detailed in the last section.

Cost

Bypass studies generally point out that private networks can provide services similar to those of the public network at a lower price. Some of the companies we investigated also stressed the fact that the cost of operating a private network were less dependent on usage, giving them more certainty in their planning.

However, in-depth reviews of companies' network-based strategies revealed that cost issues, although important, were seldom the determining factors motivating the development of a private network. When cost was stressed, it seemed to be because it was the easiest factor to quantify, and the easiest rationale to support private networks plans. Indeed, the other factors we now turn to, although somewhat harder to pin-point, would probably have justified going ahead with private networks even if they had been more costly than comparable public network solutions.

Availability

In a number of cases, the public network simply could not deliver the capabilities and features the company wanted. For example, the Bechtel Group would have prefered to use the public Integrated Services Digital Network (ISDN) to connect its various Computer Aided Design and Engineering (CAD/CAE) workstations. Indeed, because Bechtel's business fluctuates greatly both in volume and location, a public ISDN would have permitted easy reconfigurations of the consulting firm's network to changing job locations, as well as painless down-sizing of the network during business downturns. However, ISDN is not yet available, and Bechtel had to develop its own Information Systems Network (ISN), a proprietary and private substitute.

Even when the public network offers the required features, companies sometimes choose to implement private solutions because they can install them faster.

Capacity and Transmission Speed

For companies which need to transfer large amounts of data, the public networks sometimes simply cannot handle the traffic, or provide the required data rates. Hewlett Packard decided to build its own X.25 network because at the time, public data networks could not offer data rates higher than 2.4 kbit/s. For a company that routinely needs to transmit files as large as 20 Mbytes, that would have meant spending over 20 hours to transmit a single file. These data rates were also much too slow to handle interactive terminal traffic on advanced applications, such as interactive CAD. On average over the past four years, HP's private X.25 traffic has been comparable in size to that of public networks such as Tymnet or Telenet.

Quality and Reliability

Some companies choose to develop their own networks when the public network cannot guarantee the quality or reliability they require. Reliability is often critical to the success of the business strategies that rest on their network, as in the case of McKesson. McKesson's competitive advantage rests largely on its promising next-day delivery of all orders received before 4:00 pm. To keep this promise, McKesson cannot afford a failure of its information system. This is why it has built a highly reliable information center, including non-stop tandem processors and independent power back-up.

Such a system, however, is only as reliable as its weakest link; recently, the weakest link in McKesson's network turned out to be the public network. McKesson relied entirely on AT&T's

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14 U.S. General Accounting Office, *Telephone Communications: Bypass of the Local Telephone Companies*, (GAO/RCED-86-66), August 1986, p 36.
15 Peter Huber, *op. cit.*, at appendix E: "A survey of Bypass Surveys".

Digital Data Service (DDS) lines to connect its order processing center with its distribution centers. In February 1986, five days of intermittent outage on AT&T's DDS network left McKesson with 26 circuits out of service, and most distribution centers experienced degraded connections. Network availability in February dropped to 95.1%, from the usual 99.7% monthly average, causing a number of missed deliveries. This, added to installation delays, unavailability in some places, inconsistent service, maintenance problems (one site's malfunctions can spread to others), and high costs convinced McKesson to replace its DDS-based network with a private end-to-end bybass satellite network. This links McKesson's headquarters and data center with its 125 main distribution centers, each equipped with a micro earth station (VSAT).

The need for tighter control

Of all the reasons companies invoke to justify their need for a private network, perhaps the most important and pervasive is their desire to have tight control over their telecommunications resources. This growing need for control is directly related to the changing status of information networks, from a utility to a competitive resource. If a firm's competitiveness rests upon its network, it can no longer afford to leave it under someone else's control.

Companies believe that private networks offer more security than public ones. For example, Syntex, a pharmaceutical company, uses its network intensively to link its researchers, for applications ranging from molecular modeling to statistical analysis of a drug's field trials. It believes a private network better protects from intrusion by outsiders, be they competitors or hackers.

Companies are better able to monitor private networks, keeping track of changes in their communications patterns so as to plan better for the future. They want to control their networks to be able to reconfigure them quickly when needs change. They want to be free to experiment with their networks to develop new products and services.

Most importantly, if a company's network and network applications underlie its competitiveness, it matters that the network's critical features be private, even proprietary. Competitors could more easily replicate a strategy built upon public network resources and off-the-shelf telecommunications systems, whereas it is more difficult to catch up with a company that relies on proprietary network applications.[16] The network-based reservation systems put in place by the major airlines underscore this point. Using telecommunications to generate competitive advantage involves considerable risks when defining the appropriate system, fine-tuning it, or testing its market. Companies that go through with this effort need to be able to defend the advantage they gain, and one way to do so is to keep tight control over the network that forms its core.

Of course the best balance of public and private networks, proprietary and off-the-shelf equipment and services, will depend upon specific strategies. The particular shape and characteristics of the networks installed by companies will reflect the strategies they are built to support, and the elements of control they integrate. The next section looks at some of the issues this raises for the US telecommunications network as a whole.

3. Building Babel Brick by Brick?

Like companies' private networks, the telecommunications infrastructure being built in the United States is a complex assembly of pieces. It combines public monopoly networks at the local level with competing long-distance common carrier networks and private networks with inter-organization networks. Some segments of this global network are heavily regulated, some completely escape regulation; some parts are accessible to all while others can be used only by their owners. In contrast to Ma Bell's traditional hierarchical network, it is in Peter Huber's highly evokative phrase, a "geodesic network," where new nodes "are created by private exchanges, shared-tenant systems, carrier POPs, VAN PADs, mobile terminal switching offices, and communicating computers," and new links are being formed constantly between these nodes.[17]

The private networks companies are putting together constitute a growing part of this geodesic network. Thus, the private choices imbeded within these individual networks increasingly affect the national network as a whole, for two sets of reasons. First, as described above, the design, construction, and operation of these private networks follow a logic rooted in the competitive needs of individual firms, in stark contrast to the more traditional logics, with such goals as universal service and connectivity, that governed the evolution of the public network.

16 See Peter Keen, *op. cit.*, p 113.

17 Peter Huber, *op. cit.*, p 1-31.

Second, it is unclear whether, ultimately, the various pieces will add up to a coherent information infrastructure, one able to see the US economy through the current economic transformation.

Peter Huber's investigation rightly identifies the decentralization of network control as the critical phenomenon in the sweeping changes currently affecting the US network. Unfortunately, he stops short of carrying the analysis through its logical next step, to find out where the dispersion of decision power that comes along with decentralization will lead. Rather, he assumes that, simply because it is technologically possible, history and the market will inevitably bring the various network components together into a neat coherent (infra)structure. But if geodesic domes are stable, self-standing structures, it is precisely because they are made of regular and highly standardized polygonal cells, asembled together in a consistent fashion. Try to build a geodesic dome out of a few bricks, cinder blocks, various pieces of 2x4 lumber, several sheets of plywood, and some sheetrock: if it doesn't immediately crumble, it will probably end up looking like the tower of Babel.

This transfer of initiative and control from central public hands to decentralized private hands indeed raises a number of new and complex issues for the future of the US telecommunications network as a whole. An exhaustive review of these issues is beyond the scope of this paper, but, as a first step toward a more thorough discussion of the consequences of this shift, we outline here some of its consequences on innovation and connectivity.

A consequence of businesses' increasing role is the "privatization" of innovation.[18] The firms that now bypass the public networks were once the public network's most demanding customers. It was McKesson and Bank of America, not households, who used to push AT&T to innovate. The innovations they prompted were then integrated within the public network, for the benefit of all. Today, by contrast, the network innovations required by the strategies of individual companies will be implemented within their private network only, to their exclusive benefit, for reasons that make solid business sense for these companies.

One might argue that the companies which build their own networks can now innovate much faster precisely because they do not have to attract the attention of a giant AT&T monopoly before they can implement new strategies. One might argue further that some of the innovations they will demand from their telecommunications equipment and service suppliers will be made available by those suppliers to other clients, and that through that channel, the public (or at least other companies) will benefit from competition. This was the case when MCI developed its Datatransport network integration service specifically for Security Pacific, later to offer it to all its other customers.[19]

It remains unsure whether, ultimately, the resulting telecommunication infrastructure will serve the needs of its users better than one built more traditionally. However, this change in the innovation channels will undoubtedly affect the evolution of the network, and it deserves thorough analysis and discussion.

Interconnectivity is another important issue raised by the increasing role of business telecommunications users. Central control over the network used to guarantee compatibility between all network components. To those who used the network, this standardization brought a number of benefits: a network becomes more valuable as more and more users connect to it. These "network externalities" have two main sources. First, the functions of any part of a network are affected by the various elements connected to it, and the capabilities of all the elements of an integrated system add to each one of its components. Second, the sheer size of the user community yields system scale economies, increasing with the coverage of the network.[20]

As long as the diverse components of the telecommunications network were provided by a

18 By 'innovation' here we mean the development of the technologies that underly the network and their commercialization in the form of network facilities, as well as the development and commercialization of the applications (services) which run over the networks.

19 One could also argue that there is no need for publically-provided advanced network services because each firm's needs are specific and will be better served by individually tailored solutions. Although the point seems to be without much practical justification, since custom-tailoring could be accomplished off of a public advanced services base, C.C. von Weizsaecker nonetheless argues this in the case of VANs, in *The Economics of Value Added Network Services*, University of Cologne, July 1987.

20 Paul David, *Some New Standards for the Economics of Standardization in the Information Age*, Center for Economic Policy Research, Publication No. 79, Stanford University, Oct. 1986.

single entity, standardization --and the network externalities that came along with it-- were imposed upon the network users. Now that independent user firms themselves assemble the components of the network they use, the decision how best to deal with those network externalities is their own. They assess the benefits of adopting a standard in the light of their individual strategic objectives. Economists have shown how markets are relatively poor mechanisms to achieve standardization,[21] and how this reliance on individual firms' decisions can inhibit the adoption of new, more efficient network technologies.[22] Indeed, the increasing role business users play in network construction seems likely to hinder global connectivity for a number of reasons.

Corporate patterns of network integration roughly follow three stages. At first, companies generally seek to integrate their internal operations. In a second stage, they extend their networks to their suppliers and/or customers. Only at a later stage do they worry about hooking up with the rest of the world.

As they integrate their internal operations, their immediate and most pressing goal is to satisfy their own needs. In particular, rather than wait for universal standards to be agreed upon, they often come up with their own solutions. Such was the case of the Bechtel Group, when it had to link its various engineering workstations. It would have prefered to use a public ISDN, but since that was not yet available, Bechtel developed its own networking standard, ISN. Interestingly, the concept of Bechtel's ISN is quite similar to ISDN: for example, it shares existing twisted pair phone wiring with voice traffic. However, Bechtel's ISN standard differs significantly from ISDN's, as it transports the data and signaling information on one channel, and uses transmission speeds that vary between 19.2kbit/s over local clusters and 4Mbit/s over longer distances.

As they extend their internal network toward their customers, companies have a strong competitive interest in building some level of incompatibility between their own network and those used by their competitors. Thus they make it difficult for competitors to hook up with their network, and can better "lock-in" their customers. For example, McKesson has built some incompatibility into its automated ordering system by using non-standard terminals and proprietary interfaces. In many respects for companies that offer their clients on-line services, their market *is* their network.[23] An incompatible market is well protected from competitors.

Connectivity becomes increasingly important when companies want to link up with others outside their familiar circle of clients and suppliers. They would need to do so, for example, to offer a system that combines various applications, such as electronic fund transfers and trade management. Without set standards, linking up with other organizations requires clout, the kind of market clout McKesson has over its retailers, or General Motors over its parts suppliers. In other cases, potential network partners are likely to belong already to other Inter Organization Networks (IONs), that follow quite different standards. To link up with a number of partners in different industries, a company would probably need to use a number of IONs, each one using different equipment or different protocols, each one with its own fixed costs.[24]

Companies's attitudes towards interconnectivity change as they go through these three stages: from relative indifference while they concentrate on the construction of their internal networks, to the pursuit of selective -- and exclusive -- interconnections with their suppliers and customers, finally to a desire for the kind of broad standardization that will connect them to the rest of the world (Even in this last stage, universal connectivity may be limited to prevent the rest of the world from accessing the internal network except as the firm controlling access dictates). However, the historical sequence of choices firms make largely constrains the options they will have in the future. In particular, early adoption of incompatible network technologies can become handicaps at a later stage. For this reason, the evolution of the telecommunications network is "path-dependent": the chain of individual decisions, as they are imbedded within the network, matters to what the network will look like ultimately.[25]

21 Paul David, *op. cit.*, p. 19.

22 Joseph Farrell and Garth Saloner, "Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation", *American Economic Review*, December 1986, pp. 940-955.

23 Manley Irwin, *The Fusion of Telecommunications and Corporate Strategy*, paper delivered at the Conference on Telecommunications and Business, Ottawa, Canada, November 1986.

24 Deborah Estrin, *Interconnection of Private Networks: A Link Between Industrial and Telecommunications Policy*, paper presented at the 14th Annual Telecommunications Policy Research Conference, Airlie, VA, April 27-30, 1986.

25 Paul David, *op. cit.*, p. 31.

As we wonder whether the US network infrastructure ultimately will provide universal connectivity, there are clearly two sets of questions. First, how much technological incompatibility are the individual decisions of private businesses building into the US telecommunications network? And second, how much of an obstacle to interconnection will individual firms' strategic objectives be? That is, even when interconnection is technically possible and socially desirable, will individual business strategies favor it or prevent it?

Perhaps one can reasonably assume that purely technical problems can be overcome: advanced computers can support cost-effective translation and protocol conversions to interconnect various private networks.[26] Perhaps one can further assume (less reasonably?) that certain business interests will foster network interconnection. Nonetheless, the shape and characteristics of the resulting network will largely depend upon who promotes, designs, implements, controls and operates such interconnections. In this qualitative sense also, the evolution of the network is "path-dependent". Whom a network will serve, and who will be the losers in the interconnection process, will vary accordingly to the path that led to its construction.

Take the example of a network installed for electronic funds transfer at the point of sale (EFT/POS), that allows supermarket customers to use their bank cards at the checkout counter. The network will probably look very different depending on whether the interconnection between banks and retailers is implemented by (1) the bank, which tries to make money on the financial transaction, or (2) the retailers, who try to cut the transaction cost and offer convenience to their customers, or (3) a VAN supplier, who tries to make money on the value added connection, or (4) a PTT, which tries to generate network revenue while keeping in mind such goals as universality and public service.

Presumably in each case, the resulting EFT/POS network will favor some and disadvantage others. Presumably also, these various paths will affect the future usefulness of the network: for example, whether supermarkets will be able to piggyback on the same network to link-up with their suppliers or conduct market research, will certainly depend on who built the network.

Similar questions will come up again and again as the US information infrastructure continues to emerge. It is not only banks and supermarkets who will need a network connection, but also commodity brokers and trading companies, hospitals and HMOs, farmers and biotech companies, factories and design labs, car insurers and garages; in short, an entire economy which has come to depend on the transmission and processing of information. American telecom policy choices dictate that market forces will decide whether, when, and how each one of these innumerable individual connections will be established. We have hinted at some of the implications of such a process. The contrast with other national approaches to network construction, to which we now turn, sheds additional light on these issues.

26 D. Estrin, *op. cit.*, p 16.

4. Foreign Connections

The network infrastructure in Japan and Europe is likely to evolve in dramatically different ways from the U.S., with consequences for innovation, connectivity and long-term economic growth that may stand in marked contrast. The public network in Japan, for example, and the domestic markets for telecommunications equipment and services are undergoing real change. The bureaucratic regulatory apparatus with jurisdiction over the development of networking is also in flux, although the consensual goal of protecting and promoting Japan's competitive position in the dale and application of information technology remains a constant. Even private network building is occuring, at least among the largest Japanese financial, trading and manufacturing enterprises. A complete review and interpretation of these developments is beyond the scope of this paper; indeed, we have only just begun to collect data on private networking in Japan.[27] Here, we broadly outline some of the changes occuring, draw very tentative conclusions about the comparative evolution of the network infrastructure in Japan, and end this section with a contrast to the French evolution (particularly as embodied in the French experience with Teletel).

An understanding of the evolution of networking in Japan has to start with Japan's principal network architect and supplier of network services. Until April, 1985, Nippon Telegraph and Telephone (NTT) was Japan's domestic, public, common carrier communications monopoly. Since its formation in 1952, NTT -- nominally under the direction of the Ministry of Posts and

27 The OECD-BRIE Japan Telecommunications User Group currently consists of, among others, NEC, Toyota and Tokyo Marine and Fire Insurance Co.

Telecommunications (MPT), and explicity so since April, 1985 -- has also engaged in joint R&D and systems engineering to develop the underlying network technologies (e.g., microelectronics, software, optoelectronics, and network equipment) for Japan's public-switched communications infrastructure with a favored 'family' of major Japanese electronics companies.[28]

In its role as network developer, NTT has essentially carried on a sub-rosa industrial policy, enabling (through R&D and procurement) favored Japanese telecommunications companies to develop and commercialize new technologies in a protected and subsidized, risk-minimalized way.[29] The development and spread of network technology in Japan owes much to this 'developmental' NTT role.[30] As Japan evolves to advanced services, NTT will continue to play a critical developmental role, to be described below, even as it becomes a private market actor under Japan's newly revised telecommunications laws.

It has been almost two years since the Nippon Denshin Denwa Kabushiki Kaisha Law (the new NTT Law) went into effect in April, 1985. On that date, NTT became a private company, initially held 100% by the government, which began at the end of 1986 to sell off the first block of 12.5% of NTT stock (with the approval of the Diet, up to two-thirds of the shares may eventually be sold). NTT is now one of the largest companies in the world, with about almost $75 billion in assets and annual revenues topping the $36 billion mark during the last fiscal year (ending March 31, 1987).[31] Moreover, as of June, 1987, NTT had moved aggressively to established over 60 major, affiliated companies in activities ranging from software development and equipment sales, real estate and finance, to a variety of Value Added Network (VAN) information services firms.

In contrast to the more fragmented development of advanced services characteristic of private network efforts in the U.S., the aim of NTT's ambitious Information Network System project (INS), is to create by the year 2000 a fully integrated, digital communications infrastructure for Japan, linked by broadband fiber optic cable and microwave equipment.[32] INS is Japan's full-blown vision of ISDN. In essense, INS aims to put a digital, broadband infrastructure in place in anticipation of its uses, while simultaneously developing those uses through model programs and pilot projects targetted at business and residential users. INS is a remarkable engineering prototype which may well succeed in giving the Japanese an edge in understanding and developing future telecommunications applications and the products with which they will be implemented.[33]

NTT is extending a fiber-optic trunk network that was put into place over the past two years, with plans to have 60-70% of the total trunk network fiber optic in 10 years. NTT also intends to move aggressively to revamp the local loop network by installing fiber-optics and digitizing it as part of the INS evolution -- with perhaps 10% of local exchange lines fiber-optic within a decade. From September, 1984 to March, 1987, NTT operated fully digital, model INS systems in the Mitaka-Musashino and Kasumigaseki areas of Tokyo.[34] The trials involved a total of 2000 users and 250 so-called information providers (those providing specific enhanced information services like airline reservations and voice mail over the model network).

In contrast to the experience with advanced services in the U.S., most participants in the INS

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28 The major family members are NEC, Fujitsu, Hitachi and Oki, but others like Sumitomo Electric were included depending on the particular product. As part of its network maintenance function, NTT continues to run nine very advanced electronics R&D and systems engineering laboratories, many of which are noted the world over for the extraordinarily high caliber of research (e.g. NTT's Atsugi Microelectronics Lab).

29 See the discussion in Borrus, Bar et.al., *Telecommunications Development*, *supra*, n.5.

30 By 'developmental' we mean the self-conscious pursuit of economic growth and market advantage. On the idea of Japan as a developmental state, see Chalmers Johnson, *MITI and the Japanese Miracle*, (Palo Alto: Stanford University Press, 1985).

31 Data from NTT Statement of Income and Balance Sheets.

32 The data on INS is from NTT and the Telecommunications Association of Japan. See, especially, the latter's newsletter, *New Era of Telecommunications in Japan*, 42, June 15, 1987.

33 This was the judgement of the NSF's Japan Technology Evaluation Program (JTECH) in *JTECH Panel Report On Telecommunications Technology In Japan*, (Science Applications International Corporation, May 1986). See Chapter two in particular.

34 The INS Model systems comprised two networks, a metal cable-based, digital subscriber line system operating at 64kbs, and a broadband fiber-optic network.

trials showed a strong interest in a wide-range of video communication applications, ranging from high-quality full-motion to slow-scan. Among business users, communications processing services were extensively tested. Among the major conclusions from the model experiments was the concensus on the necessity to establish a nation-wide INS network as early as feasible, and to operate public demonstration centers staffed by consultants to help acquaint both business and residential users with INS capabilities.

Several parallel projects -- some of them implemented in pilot form in the model INS -- are also underway to develop equipment and services that can take advantage of the INS infrastructure. These include interactive visual communications networks (NTT's Video Response System or VRS) integrated voice-data and voice-video equipment, optical scan document terminals and fast mini-faxes, and optical instrumentation and control systems for industrial and office applications. It is estimated that the entire INS project will require between $80 to 120 billion in investment over the next 15 years. Estimates of the markets for INS-related private investment and products (including terminal equipment and information services) approach $250 billion. Given the huge size of these markets, INS offers enormous leverage for NTT to continue its developmental role to the advantage of Japanese users and information network producers. That leverage will be multiplied because of the liberalization of competition in the provision of services and in private network construction, to which we now turn.

Services Competition

The new Business Communications Law re-regulated common carrier communications and the VAN market in Japan, opening the former to domestic, and the latter to foreign competition. The law permits common carrier competition to NTT by Japanese nationals, but bars foreign owned or controlled corporations from the domestic common carrier market. The law also has opened the door to domestic (and perhaps foreign) competition in international telecommunications services, altering Kokusai Denshin Denwa's (KDD) status as Japan's sole tiny provider of such services. Of parallel note is an August, 1986, revision of the Radio Law which opens the land mobile services and radio paging markets to competition (with some foreign participation, especially by Motorola in consortium with several Japanese companies in the cellular mobile radio market.

Several new common carrier entrants have begun to build and operate competing domestic networks, and several others are waiting in the wings. Table 1 summarizes these new competitors to NTT.

Table 1: NTT's Common Carrier Competitors

Carrier	Technology	Ownership
Daini Denden Kikaku (DDK)	Microwave	Kyocera Sony, Ushio, Mitsubishi, Secom, 220 others
Teleway Japan	Optical Fiber	Japan Highway Authority, Toyota, Mitsui, Sumitomo 46 others
Japan Telecom	Optical Fiber	Japan National Railways, Nittu, RailwayConstruction, Nippon Densetsu, 300 others
Japan Telecommunications Satellite Co	Ku-band - Satellite	C Itoh, Mitsui, Hughes Aircraft (30%).
Space Communications Corporation	Ku-, Ka band Satellite	Mitsubishi, others
Tokyo Telecommunications Network (TTNet)	Optical Fiber	Tokyo ElectricPower, Mitsui, Mitsubishi
Lake City Cablevision	Coaxial	LakeCity Cablevision
Osaka Media Port (OMP)	Optical Fiber	Osaka Municipality, Sumitomo, Mitsui, Mitsubishi, Kansai Electric Power, 25 others
Railway Communications Co.	NA	In formation, after the privatization & break-up of Japan National Railways.
Nippon Idou Tsushin	Cellular Radio	Toyota, Teleway Jap. Tokyo Electric Power others

Source: Telecommunications Bureau of the Ministry of Posts and Telecommunications; New Era of Telecommunications in Japan

Unlike in the U.S., several of these new carriers, including TTNET and Osaka, are local services providers. Most of the long-distance carriers initially are focusing on the lucrative Tokyo-Osaka route, which carries about one-quarter of Japan's total telecommunications traffic, and accounts for about 40% of NTT's service revenues.[35] Some of the new long distance and local carriers have begun to team up to provide end-to-end bypass of NTT for

35 NTT data as cited in "Deregulation, Japanese-style," *Financial Times*, March 29, 1985.

leased circuit connections. DDK, Japan Telecom, Teleway and TTNET all now offer leased line services, and the first three began to offer public switched services in October and November of 1987. The other networks are in planning or construction. Just as has been the U.S. experience, it will take many years of careful nourishing before any of these new entrants become appreciable forces in Japan's telecommunications market. Indeed, for the 4-6 months of operation through April, 1987, the new carriers each reported loses of $15-20 million on sales of $0.5 to just over 1 million.

The new Law also permits competition among foreign and domestic Japanese firms in enhanced communications services like VANs on lines leased from common carriers. The VAN carriers are further classified into General and Special carriers, the latter of which operate large-scale, mostly nation-wide VANs the capacity of which exceeds applicable MPT ordinances. As of mid-1987, there were eleven registered Special VAN carriers, three of which had some foreign participation.[36] The General VAN carriers -- those which meet the applicable MPT limitations on size and area of coverage -- numbered over 400 as of September 1987, of which about 10 were substantially under foreign control or affiliation. Ovwer 80% of these providers have annual sales of less than $7 million.

MPT data claim that the VANs market in Japan reached Y980 billion (about $7 billion at current exchange rates) at the end of fiscal 1986, and growing at about 20% per year. However, the data need careful interpretation. Included, for example, are revenues derived from resale of leased lines, which was the most frequently used of the services labeled as VANs. Following resale, in approximate order of use were, database, file transfer, real-time and remote batch processing, packet switching, electronic mail and PC communications services. Overall, about 70% of the VAN carriers are engaged in data processing services, with the rest split evenly between voice, video and ISDN-type services. In terms of applications, about 70% are serving the retail/wholesale distribution trades, and another 10% are serving the financial sector.

It is, however, the financial and insurance sectors, followed closely by the distribution industry (including the trading companies) and the large manufacturers, which have made the most extensive use of *private* networking in Japan. MPT data suggests that over 10% of all Japanese companies are currently engaged in private networking, but over 90% of companies with 1000 or more employees have implemented networks compared to only 9% of firms with less than 300 employees. Again, these data sets must be taken with some caution since it appears, for example, that simple LANs and sophisticated company-wide networks are both included in the data in an undifferentiated way. Still, the private sector now accounts for about 35-40% of the total $8 billion telecommunications equipment market in Japan, and while the bulk of that is interconnect terminal equipment, it does suggest that private purchases of network facilities are not insubstantial.

Moreover, in some cases, it appears that businesses are making very sophisticated use of private networks and VAN services to deliver increasing competitive advantage in their markets.[37] Companies ranging from the trading houses to trucking companies, parts distributors, and financial houses are increasingly using network facilities and services to analyze, interpret and respond to data collected on-line about customer needs and market trends. Though the mix of facilities and services are different -- more application-specific VANs and less proprietary facilities -- some of the larger retailers, distributors and manufacturers are beginning to emulate the kind of strategic advantages we examined with McKesson in the U.S.

Critically, unlike in the U.S., the Japanese government will continue to play a key policy role in promoting the development of network facilities and the use of advanced services to help Japanese firms gain the competitive advantages that are available. We have already seen the role that NTT's INS and related projects will play in this regard. MPT will also continue to ensure that strategic coordination occurs in the development of timely standards that can facilitate the progress of network creation and use. In addition, MPT will promote the development of advanced facilities and services through a variety of promotional schemes like its fiscal 1988 ISDN General Preparation Plan. The Plan calls for, among many other provisions, cutting in half the legal depreciation schedule for analog switches to promote transition to digital facilities, and providing government aid equal to half the expense of

36 Data on VANs is from the Ministry of Posts and Telecommunications. See, in particular, the "Report on Networking in Japan," of MPT's Network Development Promotion Council.

37 The following paragraph is based on data in "Japan sets an example with automated services," *Financial Times*, October 23, 1987, p.18.

construction of ISDN facilities in both public and private networks. Several of the MPT advisory committees have recommended other similar programs, ranging from the development of a formal curriculum for educating network managers to direct subsidies for the adoption and use of advanced networks.

And MPT will not be alone in its promotion of network development in Japan. There will be a continuing battle for policy control over development in the information industries between MPT and the Ministry of International Trade and Industry (MITI).[38] The bureacratic battle has led to ambitious additional technology and product development projects under each Ministry's control and under joint control. A critical strategic consequence is a massively increased Japanese government commitment to applied R&D in telecommunications -- the benefits of which will be broadly disseminated throughout Japanese industry.

Given all of this activity in Japan, we can not help but wonder whether the combined use of domestic promotion, strategic coordination and private market activities, will result in greater benefits to the economy and businesses in Japan, than the sole market-based orientation of the U.S. -- particularly in the areas of connectivity and innovation, as well as in the generation of competitive advantage for a broader segment of the economy, that concern us in this paper. The same questions are raised in the case of emerging practices in Europe, as the next example from France makes clear.

The French Connection

Télétel, the French videotex service, illustrates a related set of some of the trade-offs.[39] The French Direction Générale des Télécommunications (DGT) has built the Télétel network around nodes of the public packet-switched network TRANSPAC. To reach Télétel services, business and home customers use a simple terminal, the Minitel, loaned by the DGT. Using their Minitel, they dial-up the nearest TRANSPAC node over the telephone network, then are connected to the service of their choice through TRANSPAC.

Since it was first tested in 1980, Télétel has grown spectacularly. As of January 1987, there were over 2.2 million Minitels and an additional 50,000 PCs with Minitel emulation software in use, generating over 3.5 million connect hours traffic per month. Between January and December 1986, the number of Télétel services doubled from 2,000 to over 4,000, ranging from electronic banking, electronic ordering, tele-shopping, and travel reservations, to messaging, games, and database access.[40]

Télétel was initially offered by the DGT in anticipation of future use, not as a response to expressed market demand. Among the motivations for this move was the DGT's desire to generate revenues --by boosting traffic-- and to retain control over the emerging information services. To that effect, the DGT has made the Minitel terminals widely available, provided an initial service (the on-line phone directory replaced the printed version), and encouraged third parties to offer information services (by providing software and billing assistance). DGT support makes it extremely easy to offer a Télétel service: simple servers can be implemented on a personel computer equipped with a modem. As a direct result, Télétel soon offered a number of very different services in a standardized fashion over a single integrated network.

The centralized approach adopted in France highlights some of the arguments about innovation and network externalities developed in the previous section. Widespread use of Télétel has fostered a number of innovations, in hardware, services, and network infrastructure. Four French terminal makers today offer 14 different types of "Minitel" terminals, ranging from the simplest dumb terminal distributed by the DGT, to sophisticated voice/data integrated workstations with storage and processing capabilities, that support both Télétel and Ascii standards. Advanced hardware "server" products are offered by major computer vendors in France, to implement Télétel services able to support from 15 to 3,000 simultaneous Minitel accesses.[41] The markets open by Télétel have fostered a thriving industry for sophisticated software: a large number of information services are based on multitasking, unix-based programs, and a number of them now integrate expert

38 On the political battles surrounding telecommunications reform in Japan, see Chalmers Johnson, "Miti, MPT and the Telecom Wars: How Japan Makes Policy for High Technology," *BRIE Working Paper* #21, September, 1986.

39 For a description of Télétel, see: Jeffrey Hart, "The Télétel/Minitel System in France", *Telematics and Informatics*, (forthcoming: spring 88).

40 Data from *Telematique News*, A publication of DGT/Intelmatique, spring 1987.

41 "Comment Monter un Serveur Videotex?", *01 Informatique Magazine*, April 1987.

systems and artificial intelligence features. Finally, the tremendous surge in demand for X.25 data transmission services has forced the DGT to speed up the construction of the TRANSPAC network, and to redesign a number of its network management procedures. Télétel has also prompted the development of innovative pricing schemes for data transmission and services, which prefigure those that will be used for the coming Integrated Services Digital Network (ISDN).

These innovations result in large part from the large scale implementation of Télétel. the DGT single-handedly created a large market that made it profitable for equipment providers to design new workstations and servers, and for software industry to develop innovative services. These innovations were prompted by the cumulated demand of all Télétel users, more effectively than if each one had used a different network service. Finally, innovations generated in one area of the Télétel network immediately benefit all those connected to it. When a new Télétel service comes on line, anybody who has access to a phone line can use it ; when a more flexible pricing scheme is developed, all benefit from it.

Far from being restricted to home customers, Télétel services are increasingly used by businesses, whose applications best capture the system's network externalities. Indeed, the functions of any part of the Télétel system are enhanced by the capabilities of all the system's components. For example, because their clients, suppliers and banks all have access to the Télétel network, retailers can use this single system to transmit orders to their suppliers, check a customer's credit or directly debit his bank account (Minitels can be hooked up with credit/debit card readers), and offer a tele-shopping service. Such synergies among the various part of the system promote innovation and make Télétel all the more valuable. Télétel's wide coverage provides both market access and scale economics. For example, a company deciding to provide an electronic mail service over the Télétel network has instant access to 3 million customers, and can expect to spread its fixed cost over a large base. Télétel also offers system scope economies, as the same network, server and terminal facilities can be used for a number of different services, that can be delivered to different user communities.

From the point of view of business users, if the Télétel system has great appeal, there are also important trade-offs. For example, had McKesson been a French company, it would probably have implemented its ordering service on Télétel. Thus, it could have easily reached all French retailers. However, it would have been harder to lock-in clients able at any time to scan the prices and delivery times of other suppliers, undoubtedly also connected to Télétel. Moreover, a public network infrastructure such as Télétel also makes it possible for small businesses better to compete with larger companies, as they can develop network-based strategies which, in the US, are reserved to those who can afford private networks. McKesson has little competition to fear on the basis of information services from smaller companies ; in France, the DGT's network policy systematically helps small competitors.

Other trade-offs, of a more pervasive nature, come from the distribution of control and initiative in the construction of the network. The DGT's predominant role profoundly affects the shape and characteristics of the Télétel infrastructure. For example, the DGT initially adopted a transmission norm for the Minitel interface that dictates an inbound data rate of 1,200 bauds and an outbound rate of 75 bauds. The official justification for such a choice is that 75 bauds is more than enough for data entry from a keyboard (especially when using the impractical Minitel keyboard), while incoming data screens require higher speeds. Although the DGT does not readily acknowledges this was intentional, the 75 bauds outbound rate also forces Télétel users to spend much more time on-line, and has considerably helped Télétel to reach its current 3.5 million connect hours/month, resulting in a tremendous boost in DGT revenues. This configuration also prohibits any efficient use of the Télétel network for most data applications.

Such restrictions on what can be done over the network result from the path that led to its development. In particular, solutions that were both technologically and commercially feasible were abandonned or ruled out because of who had control over network design and construction. For example, at the very beginning of Télétel's development in the early 1980s, an engineer from Telic-Alcatel (the major maker of Minitel terminals) decided to start his own company to market a device that could add some minor processing and storage capabilities to the basic Minitel terminals. This product was to allow users of Télétel databases to prepare their search off-line, and make the most efficient use of their 75 bauds transmission capability once on-line. Savings on connect time would have rapidly compensated for the purchase price. However, the product never received approval from the PTT, and the start-up company failed.[42] Because of user pressures, the DGT progressively has had to allow systems of this sort and PC-based Télétel access. To date however, even the most advanced Télétel terminals still remain limited to 300 bauds for outbound traffic.[43]

5. Virtuous Development Paths

It is quite clear that in the short term the US telecommunications environment, its combination of deregulation and dynamic technological innovation, is serving US corporations well. They have been able to build advanced private networks, mobilizing telecommunications resources that enhance their competitive position.

However, this environment was in large part created by policies that focused on static economic questions: questions about natural monopoly, economic or uneconomic bypass. Beyond those, it is important to look at the "dynamic" implications of current arrangements, and in particular at how the newly emerging private networks will affect the evolution of the US network as a whole. The question is an important one. At stake is not simply the strategic position of individual companies within the national market, but the future of the information network infrastructure that will have to support the national economy as a whole over the next several generations.

The dynamic implications of current arrangements matter because, as we have seen, government regulatory and administrative decisions about telecommunications within several different national settings, provide critical determinants of firm choice and alter the dramatic strategic potential of the new digital networks. Over time, government and industrial choices surrounding network implementation can cumulate to produce development paths that can not be retraced and that represent dramatically different opportunities for learning and earning in a economy.

As we argued at the outset, it is possible to envision cumulative paths of virtuous development in which widespread opportunities for learning and earning feed back upon themselves to produce rapid rates of technological advance and competitive economic growth for an economy. It is also possible to envision vicious development paths in which comparatively slower knowledge and wealth accumulation lead to much slower rates of productivity growth and comparative deterioration in standards of living in an economy.

Virtuous development paths do occur. The 25 year U.S. domination of microelectronics and computer technology from the mid-1950s to the early 1980s, created by early defense and space R&D sponsorship and procurement and heavy market competition, provided one such virtuous path for the U.S. economy.[44] Japan's domination of mass market product manufacturing, from consumer electronics to automobiles, may be providing a contemporary example. The parallel question we pose here is, which of the different approaches to digital networking in the industrialized countries is likely to occupy a virtuous development path associated with information technology?

Digital network integration is emerging rapidly in the U.S. as a result of efforts in the market to take advantage of deregulation. At least over the short run, the largest users in the U.S. are likely to gain the advantages associated with integrated digital networks ahead of their competitors abroad. However, the distinctive pattern of deregulation in the U.S. has also had costs which the more cautious approaches in Japan and Europe may well avoid. Those costs may include a hierarchically accessable and fragmented national network infrastructure which may be characterized by substantial dysfunctional connectivity problems, a slower development of integrated digital services for small business and residential users, and the loss through 'privitization' of Bell Labs (and of Ma Bell) as a source of publicly available research, development and innovation in network-related technologies and applications.

By contrast, Japan's new telecommunications laws and ambitious development plans constitute a developmental reregulation of the sector which is quite extraordinary in its self-conscious strategy. In the past, compared to the U.S., Japan has been relatively slow to develop new services and equipment -- with the exception of facsimile. Digital data services were developed only in the 1980s, and digital equipment for, and installation in Japan's public phone network has similarly lagged behind developments in the U.S.

However, Japan's current developmental re-regulation of telecommunications augurs drastically accelerated development of the sector. It may well

42 Story based on various conversations with staff of Telic-Alcatel's *Direction Stratégie Produits*.

43 "Comment Monter un Serveur Videotex?", *op. cit.*

44 On the microelectronics industry, see Michael Borrus, *Chips of State: Microelectronics and American Autonomy*, (Boston: Ballinger, forthcoming, 1988).

provide a substantially faster nation-wide, broadband integration of digital communications -- right up to each subscriber's door -- than may well occur in the U.S. or Europe. If accomplished in conjunction with the widespread promotion of use of advanced networks, more rapid standardization, and publicly subsidized development and diffusion of the underlying technologies, Japanese small and medium-sized business users and home consumers may have substantially more complete access to a wider range of information services than will the Europeans and all but the largest U.S. users.

The French example suggests that Europe may well choose yet a third development path in pursuit of the opportunities networking technology makes possible. The prinicpal role of the PTTs in Europe guarentee a fair measure of strategic coordination and government promotion of advanced networking capabilities. But that very same PTT role places decided limits over competition in the markets for services and network facilities development (as we saw with Teletel). While market competition in the provision of VANs is likely, network choices are likely to be more restricted than in Japan, and far more restricted than in the U.S.

Whether any of these three approaches -- market-led in the U.S., liberal re-regulation in Europe, or developmental re-regulation in Japan -- offer the possibility for a long-term occupation of a virtuous development path is very much an open question. For the present, there are no clear-cut answers. For example, it appears that the route the US has embarked upon, placing increasing control in the hands of large corporate telecommunications users, may create interconnection problems. However, countries that insist on establishing universal interconnection standards before they allow firms to use the advanced telecommunications may stifle innovation. More importantly, they may delay the construction of their information infrastructure so much that while they bicker about the details of the ISDN standards, their national firms will be driven out of world markets by US firms relying on a superior -- though not perfect -- telecommunications infrastructure.

At this point in time, the preceding and its precise opposite scenario are equally plausible. That makes it all the more urgent to analyze in detail the implications of different national telecommunications policies for the construction of national information networks. We believe that detailed analysis is likely to reveal that some measure of strategic policy-making in the U.S. would help to capture for the national economy opportunities associated with digital networking which may be overlooked by the market. The hand of the market may be invisible, but the path of its motion is not at all transparent; conscious decisions to shape such critical pieces of the economy as the information network infrastructure could help guide the invisible hand down a virtuous development path.