The Future of the Public Network: From the Star to the Matrix

The increasing complexity of telecommunication systems makes it difficult to structure consistent rules.

■ Eli M. Noam

Regulatory emphasis in telecommunication parallels the stages of the industry itself. The monopoly phase was accompanied by price and profit regulation. The breach of monopoly was tracked and sometimes facilitated by regulation focusing on industry structure. Now, the next stage is being reached, in which the network is rearranged from a centralized star into a matrix of interconnected but decentralized networks. This moves the focus of regulation away from traditional consumer protection to also include network protection — mediating, where necessary, the compatibility of the various carriers, network operators, users, and equipment manufacturers.

There are technical, legal, economical, political, and international aspects to such compatibility regulation that traditional state regulation did not require. This is one reason why state regulation has been a follower rather than a leader for 20 years, a nostalgic home guard often left to clean up the rubble after the battlefront moved on. It is time, therefore, to conceptualize a direction for telecommunications, and to set a regulatory agenda based on the future rather than on the past.

■ ORIGINS AND CHANGES

Because several of the changes in telecommunications policy originated in the US under a conservative political regime, they are often viewed as the product of particularly American business interests, wrapped in a Chicago economic ideology. But more recently, several other industrialized countries have begun to adopt similar policies, or at least to discuss changes that previously seemed unthinkable. This raises the question whether the changes go deeper than the nature of the respective governments in power, and whether they reflect a more fundamental change.

For almost a century, a tightly controlled system of telecommunication was in place in most advanced countries. Its structure was supported by a broad political coalition that can be termed the "postal-industrial complex." In most countries, it included the government PTT as the network operator — and the equipment industry as its suppliers — together with residential and rural users, trade unions, the political left, and the newspaper industry whose postal and telegraph rates were heavily subsidized. The system worked particularly to the benefit of the equipment industry. Through their huge procurements (especially after World War II), the PTTs provided large markets for the industry. In each country, "buy domestic" national policies established substantial protection from foreign competition. Often, domestic equipment manufacturers collaborated with each other in formal or informal cartels that set prices and allocated shares of the large PTT contracts. In the US, the structure of telecommunication, although private, was not all that different from the PTT model: a near monopoly, with an even closer collaboration of the network operator and equipment manufacturing. Its corporate ideology was shaped by the patron saint of AT&T Theodore Vail, a former postal man himself as head of the US Railway Mail Service.

Despite its public popularity, the centralized model of the public network has been subject to forces of centrifugalism that have undercut its stability. Technology is one of these forces, but one should not exaggerate its contributions. Instead, the driving force for the restructuring of telecommunication has been the phenomenal growth of user demand, which in turn, is based on the shift toward a service-based economy. This was partly due to the loss of competitiveness in traditional mass production vis-a-vis newly industrialized countries. It was also partly due to the growth of a large pool of educated people who were skilled in the handling of information. Services based on information processing therefore emerged as a major comparative advantage of developed countries. At the same time, manufacturing and retailing were ever more far-flung and decentralized.

Telecommunication became increasingly important to the new services sector, and a major expense item. Price, control, security, and reliability were now variables requiring organized attention. This, in turn, led to the emergence of a new breed of private telecommuni-

cation managers whose function was to reduce costs for their firms, and who for the first time established sophisticated telecommunication expertise outside the traditional network complex. These managers aggressively sought to establish low-cost transmission and customized equipment systems in the form of private networks of power and scope far beyond those of the past.

The emergence of technological and operational alternatives undercut the economies of scale and scope once offered by the centralized network. In the past, sharing a standardized solution was more acceptable to users because the consequential loss of choice was limited and outweighed by the benefits of the economies of scale gained. As the significance of telecommunication grew, however, the costs of nonoptimal standardized solutions began to outweigh the benefits of economies of scale, providing the incentive for nonpublic solutions. Furthermore, some users began to employ a differentiation of telecommunication services as a business strategy to provide an advantage in their customers' eyes; therefore, they affirmatively sought a customized rather than a general communications solution.

Another factor contributing to more specialized networks was the growing number of user clusters that interlinked via telecommunication. Early examples were travel agents and airlines, automobile parts suppliers, and financial institutions, which established group networks that combine some economies of scale with customization.

The unity of the centralized network began to unravel because it reflected the realities of the past. It still has politics on its side, however, and the support of several of the primary organized constituencies in industrialized countries. But the new interests also created their political constellations. If the telecommunication system is seen as consisting of four major constituencies — equipment suppliers, network operators, employees, and users — the traditional postal-industrial coalition joined primarily the first three, allied with the small-user part of the fourth. Now, another grouping is emerging: the alliance of large users (including transnational firms) with the most advanced part of the equipment industry, consisting of the computer, components, and interconnect firms. In the US, this "second electronic coalition" includes a wide array of firms, e.g., American Express, IBM, Time Inc., United Airlines, and Citicorp. Their primary private-sector opposition was AT&T — not enough to hold the line.

In Britain, the new coalition was slower to gather due to the relative weakness of the advanced electronic industry, and due to a defense by the traditional alliance that was more tenacious and ideological than in the US. However, once the government withdrew its support from the status quo and instead blessed the service sector by targeting London as the service capital for all of Europe, change came rapidly. A similar story can be told for the Netherlands. In Japan, where the traditional telecommunication equipment industry transformed itself better than anywhere else into the leaders of the electronics age, the changes were the smoothest since the equipment industry did not stand to lose much.

■ THE NETWORK AS A MATRIX

The lengthy process of change in the public network has just begun. Centrifugal forces are encouraging the evolution of a new telecommunication network model that is characterized by a great deal of openness in terms of entry (for carriers, specialized service providers, or equipment vendors), interconnection into other networks, access to other networks, and standards.

The future network is one of great institutional, technical, and legal complexity. It will be an untidy patchwork of dozens or even hundreds of players, serving different geographical regions, customer classes, software levels, and service types, with no neat classification or compartmentalization possible. To the tidy mind of traditionalists, this is heresy. Carriers will be engaged in multiple functions, although there will be no shortage of official attempts to establish order by segmentation.

The major characteristic of the open network environment is substantial *lack of central control*, with no single entity being in charge. This notion is alien to the engineering world view of traditionalists. Their perspective was that of chain-of-command, long-range planning, and integration. "The system is the solution" was AT&T's battle cry. To leave this system to the vagaries of hundreds of uncoordinated and selfish actors seems to invite disaster. Can it work? Perhaps this is not the right way to frame the question. Can there be a stable alternative in economies that otherwise favor a market mechanism, and that want to stay on the leading edge of applications? In any event, the transition will be lengthy, and the traditional dominant carriers will still exercise market leadership for a time.

Telecommunication is in the process of moving from one of the most regulated to one of the least regulated industries. There are several reasons for this. First, the increasing complexity of the system makes it difficult to structure consistent rules. The US experience with the FCC's computer decisions provides an early example. Secondly, rules are not likely to be enforceable. The subject of the regulation — streams of electrons and photons, and patterns of signals that constitute information — are so elusive in physical or even conceptual terms, and at the same time so fast and distance-insensitive that a regulatory mechanism must be draconian to be effective. The traditional system has neither the will nor the political support for such enforcement. This means that *telecommunication will move significantly out of the realm of the political process.*

The traditionalist system was in-

ternational in the sense of a collaboration on the level of government organizations. It held together well because of a similarity in views — the values of engineering and bureaucracy — and because of a common interest to protect the domestic arrangements. But, in the age of satellites, international communications are at the front of softening the service monopoly. In the long run, *telecommunication will transcend the territorial concept*, and the notion of each country having territorial control over electronic communication will become archaic in the same sense that national control over the spoken (and later the written) word became outmoded.

In the traditionalist model, standardization was a key element, whereas *the new network model is characterized by interconnectivity.* The difference is that between *ex-ante* and *ex-post.* To reach or maintain agreements on standards, except for very broad issues, will become increasingly difficult as the number of interests and participants multiplies. Instead, standard setters or coalitions will emerge around which other actors will cluster, since incompatible services will not usually be attractive to users. But the system may not be fully convergent. Some parallel series of varying network standards are likely. Fortunately, electronics are flexible; a brisk industry of information and protocol arbitrage from one standard to another will emerge.

A key requirement for an open network system is that it extends the common-carrier principle from users to networks. That is, networks can interconnect into other networks, even if they are competitors. Both in the US and the UK, the establishment of interconnection of new networks into the existing and predominant one was an essential element of change. This principle requires, however, a clarification of the charges for interconnection, and its extent is likely to remain one regulatory question that will not go away for a long time.

While the right of interconnection deals with network linkage, the users' right of access is critical and protects a user's ability to reach (if technically possible) any network. For example, a landlord's building network should not be able to restrict tenants from reaching a carrier of their choice. Similarly, networks should also be able to reach any tenant.

In the open network system, the question is whether *universal service* obligations apply to all participants and toward all users. The answer is likely to be differentiated. For some of the more specialized services, the obligation will not exist. But for "basic" service, it will continue, and the definition of basic will expand. One main function of the public network will be to serve as the provider of last resort, under financial arrangements that may also involve explicit subsidies.

The open system is not efficient in the sense of minimizing inputs. There will also be more *excess capacity* than in a centralized system. There is nothing unusual about this: almost every industry has excess productive capacity. The effect is to spur suppliers into user-oriented action to make themselves attractive. In the telecommunication field, with its low marginal costs, competition will cause periodic price instability. One of the functions of future regulation will be to help in moderating the worst effects of price volatility.

■ ISDN AND ONA

The two network concepts — centralized versus open (star versus matrix) — are reflected in two major initiatives of their respective proponents: ISDN and ONA. Both are pure expressions of the underlying network philosophies. ISDN has been by far the more prominent strategy. It is, at its most elementary, an integration of voice, data, and video networks into a unified super-pipe. The term ISDN (Integrated Services Digital Network) encompasses several subconcepts. As a move to more digitalization of the network, it is squarely within the trend of technology. As an upgrading of the networks to a higher transmission rate, it responds to the data communication needs of large users; for residential users, the immediate need is less clear except to create the proverbial egg (the network) for a future chicken (i.e., applications).

The third element of ISDN is integration; it is much weaker in its rationale. To put together separate communication networks into one super-pipe is more elegant from a technologist's view; however, from the user's perspective, the cost, performance, and choice of services is what counts. Integration is a standardization process, which is always a trade-off between the cost reduction of streamlining and the benefits of diversity.

Strictly speaking, ISDN as a technical concept does not negate multiple ISDNs and subnetworks to coexist, compete, and interconnect. There is no notion of exclusivity in the technical integration. However, for many of its PTT advocates, the elimination of duplication is the primary rationale for ISDN. To permit multiple integrated networks would defeat the entire purpose.

While ISDN is the archetype for the centralized network model, the matrix model has also moved into its next phase: that of open network architecture (ONA). ONA disaggregates switching into its component functions, and permits separate access, interconnection, substitution, and competition among all of them. ONA also provides greater ease in establishing layers of software-defined networks superimposed on the networks' basic transport functions. ONA permits outside parties the use of their choice of building blocks and the resale of new service combinations. In that sense, ONA is part of a movement toward the network of a distributed rather than a hierarchical architecture. It follows the lead of computing, which also started as a highly centralized operation and moved toward a distrib-

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T1 Testing

If ISDN will affect test equipment sales, how will it affect the technology itself? Here, vendors and users take almost polarized views. To the user, more complex technologies need simpler boxes to test them; to vendors, the early divergence of ISDN implementations means that simple go/no-go testers will be harder to build and less reliable. The promise of yet more data transmission, along with other digital-based information forms, also suggests that the user requirements for circuit quality in the future will be higher.

On the positive side, ISDN is likely to be more suitable for internal, in-service testing. The primary-rate service, if it is to provide full 64-kbps unrestricted communication on the B channel, will require ESF delivery technology. The D channel has its own built-in error statistics and monitoring facilities, and can be used to synchronize error detection and reporting systems end-to-end, i.e., providing that standards for this can be developed in time to avoid a thousand incompatible and proprietary implementations.

Users want wideband, integrated, digital services. They are willing to pay the high service costs because the economies of scale justify them for many applications. But a part of that high cost may be a higher-than-expected investment in test equipment and qualified service/test personnel. Without it, the complex environments of the future — with increasing numbers of CPE-resident switching systems, cross connects, private spans, and wiring systems — will certainly produce an environment in which reliable service is a happy accident. □

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uted structure. ONA disaggregation is technically compatible with the ISDN's integration, since they both operate along different dimensions. Their ideologies are at odds, however, at least for traditionalists who seek to protect monopoly.

Even if many of the new ventures in networks and services collapse, the genie of diversity is out of the bottle. Communication is becoming too varied, complex, and significant for one organization to do it all well. Similarly, the notion that, in the age of information, all communication in societies operating largely on the market principle would pass through one streamlined superpipe of a single organization is hard to entertain on technical, economic, or political grounds — except in reference to the present balance of political power. But these conditions are not very likely to prevail. Once the notions of the centralized network are breached in some respects, the process is hard to contain. The process is inevitable, not because it leads necessarily to a superior result, but because the centralized network is an anomaly.

As long as the economic system of Western industrialized democracies is based on markets and private firms, the exclusion of major economic parties from an important field is an unstable affair. It is hard to maintain a dichotomy between telecommunication and the rest of the economy. Thus, telecommunication in the future will resemble much more the rest of the economic system. It may be much more complex, and perhaps less efficient in some ways than the old system, but it will be a truer reflection of an underlying pluralistic society. □

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