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The Public Telecommunications Network: A Concept in Transition

by Eli M. Noam

The traditional centralized model of the public telecommunications networks is being undermined by a host of centrifugal forces, and a new and open network concept is emerging that breaks down the dichotomy between the telecommunications sector and the rest of the economy.

Because a number of far-reaching changes in telecommunications policy originated in the United States and 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 of whether the changes go deeper than the nature of the respective governments in power and whether they reflect something more fundamental—a paradigm shift in the concept of public telecommunications. This article argues that the policy changes are indeed part of a broad transition in the traditional concept of the public network. This concept is being transformed by a multiplicity of centrifugal forces from one that is centralized and hierarchical into a new one that is open and loosely interconnected, resembling a federation of subnetworks much like the system prevailing in transportation. In recent years these two network concepts have spawned their respective strategies for the future organization of telecommunications: the integrated services digital network (ISDN) as a refinement of the centralized notion, and open network architecture (ONA) as a step toward the open system.

A ubiquitous centralized, hierarchical network operated by a monopolist has been the key institutional feature of traditional telephony around the world for almost a century. The operating entity usually was a government administration known generically as a PTT (post, telegraph, and telephone authority). In the United States, A.T.&T. fulfilled much the same function in telephony. The layout of the network is centered on a “switching hierarchy.” Policies are set by “technical experts” rather than by “politicians” and largely outside public scrutiny. In some countries, the employees wore uniforms. Such organizations usually derive their budgets and set investment plans outside normal

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parliamentary appropriations. To be sure, it is a benevolent form of authoritarianism, since it serves the important goal of interconnecting society and operates as a mechanism of redistribution. The centralized public network is not merely a technical system but a social, political, and economic institution based on the sharing of resources and the transfer of benefits toward favored groups. These are often the economically weak and are almost always the middle class.

The origin of the centralized network system for communications preceded electronics by centuries and is embedded in the emergence of postal monopolies. A key date is 1505, when the Hapsburg Emperor Maximilian granted exclusive mail-carrying rights to what one would today call a multinational company, the Taxis family firm from Italy. This concession proved to be an unexpectedly rich source of revenue to the Hapsburgs, who shared in the profits, but it also required vigilant protection from the incursion of other mail systems, of which there was a multitude (2). Neighboring Prussia went one step further and in 1614 established a state-run monopoly postal system (13). Thus, the PTT system was born as a creation by the absolutist state for the absolutist state. While much later this system was rationalized as based, depending on one's point of view, on economies of scale, national sovereignty, cross-subsidies, or public infrastructure needs, the early creators of the postal monopoly system were quite forthright in their mission to make profits for the state and its sovereign. The postal system became a major source of revenue at a time when European rulers had insatiable needs for it. This goose that could lay golden eggs became ardently protected, through the centuries, against encroachment by private competitors and by other states.

When the telegraph emerged in the nineteenth century, it was rapidly integrated into the monopoly system. Later, much was made of the military importance of state control over telegraphy. This may have been significant for the major powers but was less relevant for all of the other countries that also banned private telegraphs. Even for the larger states, however, the strategic importance of the new medium did not necessitate its operation by the state any more than did overseas mail, a key service in the era of imperialism where private delivery under contract was regularly used.

When the telephone made its appearance in 1876, it, too, was soon integrated into the state monopolies once its financial viability became clear. Here, official hagiographies claim that the purpose was to bring telephony to rural areas neglected by commercial interests. This is true in some cases, but in other instances the historical record is different. In Norway, for example, private firms and cooperatives rather than the government were especially active in the countryside. It is also often claimed that the poor quality of private telephone service forced government take-overs. But a look at what happened, for example, in Britain and France, where private operators were put by political means into a financially untenable position by the postal interests and their allies (4), shows that this poor service was the symptom rather than the cause of the struggle for control. At the same time, telecommunications were also integrated into an international system of

collaboration, with the official goal of technical coordination but also, from the beginning, with a cartel's agenda on prices and service conditions (1).

For almost a century, a tightly controlled system of telecommunications has been in place in most developed countries. Its structure was supported by a broad coalition that the PTTs permitted to share in the monopoly rewards in return for political support. This rent-seeking coalition can be termed the "postal-industrial complex." It encompassed the government PTT as the network operator and the private equipment industry as its supplier, 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 in particular to the benefit of the equipment industry, which was provided large markets by huge PTT procurements, especially after World War II. These markets were also almost entirely protected from foreign competition by buy-domestic policies. Within most industrialized countries, equipment manufacturers often collaborated in formal or informal cartels that set prices and allocated shares of the large PTT contracts. The structure of telecommunications in the United States, although private, was not all that different, as it was a near-monopoly, with a full integration of network operation and equipment manufacturing. Its corporate ideology was shaped by A.T.&T.'s patron saint Theodore Vail, himself a former postal man as the head of the U.S. Railway Mail Service.

The system was profitable and reassuring for insiders, and its inefficiencies were hidden by the general downward trend in the cost of electronic technology (which was due, on balance, more to developments by the computer and component firms than by traditional telecommunications firms). The PTTs also set standards for equipment in a way that would often discourage or delay outsiders, and they collaborated with favored domestic firms in equipment development and in export promotions.

In Switzerland, for example, the PTT in 1984 set standards for cordless telephones whose 55 pages of specifications required a virtual Rolls-Royce among such equipment, including 40 duplex channels and automatic scanning. The impact of these rules, which were allegedly passed to protect the users, was that (a) only one company, a Swiss one, could meet the standards quickly (and not surprisingly: it had played a major role in developing the rules); (b) the manufacturers' estimated price to the PTT for a set was above \$600 and monthly rentals came to about \$15 (14). At the same time, one could buy simpler but perfectly adequate cordless telephones in the United States for less than \$75. Swiss users resorted to buying cheaper but illegal foreign equipment in the many stores where they were baldly marked "for export only." Pressured by the PTT, the equipment industry, and the trade unions, the Swiss parliament passed a law to block the buying and selling of unapproved equipment while making it easier to search private residences in order to stamp out the threat.

While the centralized network system operated to the economic advantage of equipment firms who shared in the monopoly rents, it also enjoyed broad public approval because it supported the concept of public service: universal in reach, common-carriage in access, price-controlled as a necessity, and redistributive in charges. As a public service, telephony was outside the

mechanism of the market, even in otherwise free-economy countries. Any change in that status was bound to be controversial, as expansion of the realm of the market into the realm of rights and politics historically has always been painful. Formally or informally, society excludes many transactions from regular market operations.

But it is difficult in practice to stem the encroachment of economic transactions that favor those with superior resources. Surrogate pregnancies, political advertising, salaried soldiers, and private education are controversial but increasingly accepted instances of reassertion of market mechanisms. A relocation of telecommunications from the political domain of public services into the economic system has been similarly objectionable to many. Indeed, the single most powerful argument in defense of the centralized system is a value preference for the principle of state ownership, as distinguished from the make-weight "scientific" arguments of engineering necessities and economic realities. For example, many see the PTT system as necessary to ensure universal service to the entire population. But this view is flawed in its public finance analysis by intermingling questions of how to finance a service with those of its distribution; it also incorrectly extrapolates relatively recent priorities of investments to be the historical norm. In Germany, for example, in 1960 only about 5 percent of households headed by skilled workers had telephones, and the percentage was even lower for unskilled workers. For the self-employed, it was 50 percent (12, Figure 1).

Despite its public popularity, the centralized hierarchical model of the public network has been subject to forces of centrifugalism that have undercut its stability. Technology is one of the reasons, though one should not exaggerate its contributions. It is not microwave and satellite transmission that has suddenly made long-distance competition possible. Where competing systems are today constructed in the United States, Japan, and the United Kingdom, they are mostly buried cables and costly to install. Several other factors have contributed to the disintegration of the hierarchical model, as will be discussed below. It should be said at the outset that to observe these forces of change is not necessarily to advocate many of their manifestations. The traditional network system has no monopoly on social concern, too.

The service economy. The driving force for the restructuring of telecommunications has been the phenomenal growth of user demand for telecommunications, which in turn derives from the shift toward a service-based economy. The large users of telecommunications are corporate headquarters, banks, insurance firms, airlines, health delivery organizations, engineering and consulting firms, law offices, media organizations, and providers of other services. The shift toward a service economy in highly developed countries was partly due to their loss of competitiveness in traditional mass production *vis-à-vis* newly industrialized countries. It was also partly due to the availability of a large pool of educated people skilled in the handling of information. These advantages were reinforced by productivity increases in information transactions through computers and advanced office equipment. Information-based services, including headquarters activities, are

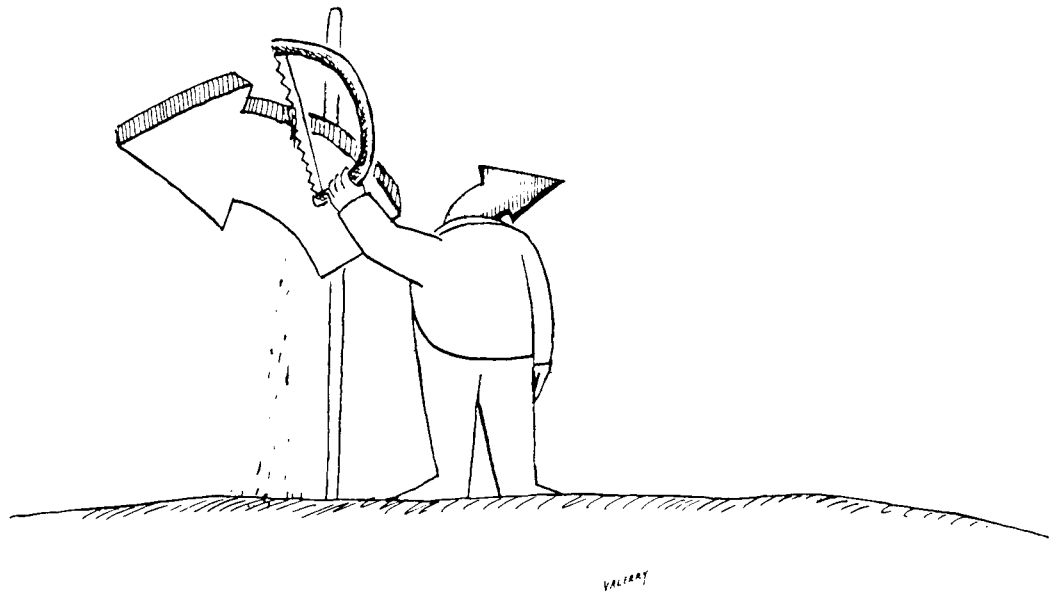
therefore emerging as a major comparative advantage of developed countries. Manufacturing and retailing, at the same time, are becoming far-flung and decentralized.

For all these reasons, electronic information transmission, i.e., telecommunications, became of ever-increasing importance to the new services sector. It also became a major expense item. For Citicorp, the largest bank-holding firm in the United States, telecommunications have become the third largest cost item, after salaries and real estate. This makes the purchase of communications capability at advantageous prices more important than in the past. Price, control, security, and reliability became variables requiring organized attention. This, in turn, led to the new breed of private telecommunications managers whose function was to reduce costs for their firms and who for the first time established sophisticated telecommunications expertise outside the postal-industrial coalition. These managers aggressively seek low-cost transmission and customized equipment systems in the form of private networks of a scope far beyond those of the past (10). These private networks, some of whose operation and administration require hundreds of skilled technicians and managers, are carving out ever-larger slices from the public network. It does not take a large number of private networks to have an impact. In the United States, for example, the largest 3 percent of users typically account for 50 percent of all telephone revenues. These activities are spearheaded by private firms but are not exclusive to them; nonprofit institutions such as hospitals and universities and public organizations such as state and local governments are also actively pursuing similar cost-reduction strategies.

Diseconomies of scale and scope. The growth of technological and operational alternatives has undercut the economies of scale and scope once offered by the centralized network. Economic and technological development has led to an increased specialization and to a divergence rather than convergence of options. In telecommunications, the rapid technological development has spawned a corresponding number of applications. It has become increasingly difficult for the traditional postal-industrial complex to keep up with all of these options and customized needs.

Similarly, the traditional system of research and development cartels that jointly developed standardized national solutions has been unable to cope with the smaller entrepreneurial firms. The pace of technology has created, in addition to the traditional telecommunications industry, a "second" electronic industry with greater independence and an orientation toward direct contract with users rather than through the PTT intermediary.

User differentiation. By their very nature and tradition, PTTs had provided standardized and nationwide solutions, carefully planned and methodically executed. In the old days, sharing a standardized solution was also 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 telecommunications has grown, the costs of non-optimal standardized solutions begin to outweigh the benefits of economies of scale,



providing the incentive for nonpublic solutions. Furthermore, some users aggressively employ a differentiation of telecommunications services as a business strategy to provide an advantage in their customers' eyes, and they therefore affirmatively seek a customized rather than standardized communications solution.

Pluralism of user groups. Another factor contributing to more specialized telecommunications networks is the growing number of groups in society that interlink via telecommunications. As their communications needs as collectives become specialized, private user clusters emerge. 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. Thus, pluralism of association leads to group communications, located conceptually somewhere between private and public network activities.

Loss of control over the user premises part of the network. Users have increasingly gained control over the network segments close to them. This began with equipment on user premises; it continued with the wiring in office and residential buildings. It was natural, as the next step, that several large U.S. landlords began to provide a full array of telecommunications services within their buildings to commercial tenants, thus taking this segment out of the public network. These "shared-tenant services" shift the switching from the public exchange to the landlord's private telephone switchboard (PBX) and move transmission from the public networks to private lines. The shared services, by their economic logic, are not likely to end at the property lines but rather expand to clusters of office buildings and central business districts.

Related is the emergence of local area networks (LANs), which are usually privately established high-volume links serving the data flows within an organization and among its equipment. In some organizations the share of

communication flows using LANs reaches 60 percent. Here, too, expansion is inevitable; some LANs have grown geographically into WANs (wide area networks), even spanning several continents.

Technology of alternative transmission paths. Because there are several transmission technologies, it becomes increasingly difficult for one organization to control them all. Even for local distribution—in the past the segment with the greatest characteristics of “natural” monopoly—several different transmission technologies have emerged, including the use of coaxial cable television networks, stationary cellular radio, microwave multipoint distribution, new fiber optic networks, etc. (7). For the PTT to control all of the transmission paths means to assert control in new areas, some of which are already occupied by other actors, such as cable network operators.

Internationalization of transactions and reduction of transmission costs. The importance of telecommunications and the forces of centrifugalism have been increased by the globalization of commerce and need for international transactions. If one country's PTT exercises restrictive policies, its firms will be disadvantaged internationally, and foreign firms may choose not to domicile themselves in the country. Similarly, those acquainted with options available elsewhere are likely to pressure for change in their own circumstances.

Transaction costs have become fairly insensitive to distance. For satellite transmission, in particular, the marginal cost with respect to distance is virtually nil. Fiber optic links also have low distance-sensitivity of cost. The implications are that communication flows can be routed in indirect ways to circumvent regulatory barriers and restrictive prices. Arbitrage becomes easily possible and with it the incentive for a country to liberalize its regulatory regime to become a communications “haven.” This undermines attempts to set rules for prices and service conditions.

There are also domestic implications. Price and performance of very small aperture earth stations (VSAESs) for direct satellite access have moved in such a way as to begin to permit the economic use of private direct satellite networks without intervening carriers. Such services can also be provided by domestic operators outside the public network's control. Restrictions against the use of such direct telecommunications should prove difficult to enforce.

Satellites permit the easy export of communications services. A satellite firm in one country can link two parties in a second country. Today, the official international organization INTELSAT already provides such domestic service to a number of countries. The spread of private operators who contract with PTTs, or with users directly, seems hard to prevent. It is even possible that an enterprising PTT will use spare capacity to provide domestic service for another country, or between countries, and while this is not likely to soon result in actual invasion of another PTT's territory, it is certainly a step in that direction.

Merging of technologies. Challenges to the centralized network have also come as traditional telecommunications networks and equipment have increasingly become contiguous and overlapping with previously separate

sectors such as computers, office equipment, and broadcasting. For the monopolists, the typical response has been to move into new fields. Examples are entries into cable television, master television antennas, electronic publishing, computer utilities, electronic mail, modems, answering machines, etc. Such moves set up a struggle with interests that had not been previously part of the postal-industrial complex, leading to unsecured boundary regions. They also lead to confrontation with other powerful government entities, which in turn may invade the PTT's traditional turf. In France, for example, the governmental broadcast organization TDF has its own satellites, to be used for DBS direct broadcasting but with the potential for other services that have been previously the domain of the telecommunications monopoly DGT. The DGT, on the other hand, was the most active element in the creation of cable television distribution networks, moving into TDF territory.

Government programs and regional collaborations. Government industrial policies and regional economic collaborations also have implications for telecommunications monopolistic practices. Governments in most developed countries have established support programs in electronics. While PTTs are usually an important practical and regulatory part of this effort (9), industrial policy also creates the means to be used by their future rivals. For example, several European countries support satellite development programs in order to enhance their electronic and aerospace industries through civilian programs, similar to what NASA and the Defense Department have done in the United States. The development of such satellites establishes the imperative for their actual operation and their financial viability, which in turn opens the door to potential future use by new types of carriers. In several other countries, cable television is supported as part of technological development, with the goal to establish fiber optic switched-star cable systems. These systems resemble telephone networks and could be used in the future for nonvideo purposes. In the United States, various local governments are advancing so-called teleports as part of regional developments. These provide the facilities for alternatives to the public network.

Through regional and supranational economic collaborations like the European Common Market, protective domestic arrangements between industry and government have been challenged, and unreasonable domestic standards have been set aside by supranational regulatory institutions on the basis of other agreements on freedom of trade. Germany's tough restrictions against private modems supply were thus challenged successfully by the European Economic Community Commission. Similarly, British Telecom's former rules against the arbitrage of transatlantic telex traffic were overturned in 1986 by the European High Court of Justice.

Multilayer structure of telecommunications. Telephony has gone a long way beyond providing simple switched voice connections. A large number of "value-added services" have been developed and introduced, in particular in data and text areas. Examples are voice-mail, videotex and audiotex, and electronic message interchanges. Conceptually, most advanced

telecommunications services can be analyzed as four layers superimposed on each other: basic transmission, data packet transmission, generic services, and applications packages.

Take, for example, a network connecting automated bank teller machines (ATMs). These services are often provided by a specialized private network operator serving a number of banks. Such ATM networks operate on private lines (basic transmission) leased from the basic network operator, typically the local exchange companies or long-distance carriers such as A.T.&T. These lines are used by data transmission companies such as Telenet, Tymnet, or the former A.T.&T. Net 1000, which all add the packet-switched capability used in interactive data transmission. Their services, in turn, are used by firms who enhance them further into generic value-added services such as on-line data access, electronic mail, voice-mail, and telemetry. Such firms include MCI, GE, Tymnet, A.T.&T. Accunet, and others. Different generic services are then bundled into application packages appropriate for various industries (e.g., finance, agriculture, hospitals) or functions (component part orders, international trade, credit card transactions, manufacturing designs, etc.). While in many instances several of these layers are integrated within the same company, they need not be. Thus, when a bank customer uses an ATM, the communications may involve five or even more functionally different service providers on the same physical segment as well as several firms for the different geographical segments. The underlying banking transaction, in turn, may trigger interbank electronic transfer networks of similar complexity.

Saturation of basic service. One reason telephony has gone beyond providing simple voice connections is that it has saturated its basic market in this area. For a long time, the primary mission of PTTs had been to establish a network that would reach every household: this mission also benefited the supplying industry. However, by the 1980s the goal of universal service was largely achieved in Western European countries. In Germany, the penetration level of 12 percent in 1960 had grown to 75 percent in 1980 (12, p. 32). In France, the level was 16 percent in 1967 (3) and 88 percent in 1985 (5). Having been successful in spreading telephony, the PTTs were left without a clear mission, and the equipment supply industry was in danger of greatly reduced demand. The PTTs then turned their sights to ISDN and videotex and more generally toward advanced business services. This shift is rarely admitted openly, given the traditionalist ideology. For example, videotex is generally described as a consumer information service, whereas its predominant use, outside of France, is in offices. With business customers as the primary growth area, the PTTs must make accommodations in flexibility, diversity, and style, because large users have much greater in-house expertise and assertiveness than the residential users.

The achievement of universal service brings private service providers out of the woodwork. Their earlier entry was both politically and economically unviable when "cream skimming" would endanger the establishment of universal service. Now, the case against them is harder to make.

A breakdown in intra-PTT cohesion and the government-labor support. The traditional organizational integration between the postal and

telecommunications components of the PTTs is becoming subject to strain. Increasingly, the telecommunications employees' identity and salary expectations are those of the high-technology sector; they are constrained individually by civil service status and collectively by having to carry the postal service's deficits. PTT managers begin to recognize that a change in organizational status can give them substantial flexibility and independence. This leads to a willingness to transform telecommunications operations from a government administration into a governmentally held corporation. Institutional change therefore becomes not a PTT-busting measure but is accomplished with the support or acquiescence of the PTT leadership and, importantly, the PTT labor unions and their political allies. Such constellations led to the reorganization of telecommunications in the Netherlands, New Zealand, and Israel. The new corporate structure commands less commitment by the state and inevitably leads to the government's role as a regulatory entity with an arms-length relationship to the network operator, and with a greater willingness to accommodate alternative service providers.

As in a Greek drama, the unity of the centralized network unravels because it reflects 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 create their political constellations, too. If the telecommunications 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, together with the most advanced part of the equipment industry, which consists of the computer, components, and office equipment firms (8). In the United States, classic members of this "second electronic coalition" include American Express, IBM, Time Inc., United Airlines, and Citicorp. Their primary opposition among private firms was A.T.&T., not enough to stem the tide.

In Britain, the new coalition was slower to gather due to the relative weakness of the advanced electronic industry and a defense by the traditional alliance that was more tenacious and ideological than in the United States. However, once the government withdrew its support from the traditional arrangement and instead blessed the service sector by targeting London as the service capital for all of Europe, the postal-industrial complex had to compromise. A similar story can be told for the Netherlands. In Japan, where the first electronics industry has transformed itself better than anywhere else into the second, the changes were smoothest, since the equipment industry did not stand to lose much.

We are merely at the beginning of what will be a lengthy process of change in the network; these centrifugal forces are encouraging the evolution of a new network model of telecommunications characterized by a great deal of openness. There is openness of entry (be it as a carrier, specialized service provider, or equipment vendor), of interconnection into other networks, of

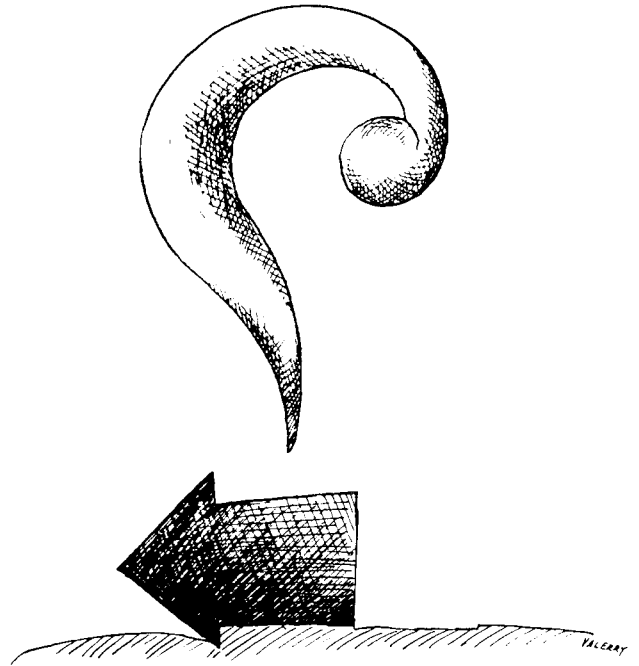
access to other networks, and of standards. The main principles of this open network system are described below.

A network of networks. The future network concept is one of great institutional, technical, and legal complexity. The network environment will consist of an untidy patchwork of hundreds of subnetworks, serving different geographical regions, customer classes, and service types, with no neat classification or compartmentalization possible. It includes a hodgepodge of participants, governmental and private, national and regional, general and specialized, narrow and wideband, terrestrial and satellite, tiny and vast, domestic and multinational. The U.S. experience demonstrates the instability of structural regulation such as compartmentalization of the telecommunications sector along different functional and geographic dimensions, and the assignment of market segments to different carriers. This is due to the overlapping and ever-changing nature of services, the inability to define clear boundary lines, and the incentives for participants to breach restrictions. Hence, the future telecommunications network environment will have carriers engaged in multiple functions, though there will be no shortage of official attempts to establish order.

Substantial absence of central control. The central characteristic of the open network model is an absence of central control, with no single entity in charge of an overall plan (though there will be a significant PTT leadership role and some military planning function). The network becomes a composite of numerous separate planning decisions, moving from the model of the planned system toward an "invisible hand" mechanism. This notion is so alien to the engineering world view of traditionalists in telecommunications as to strike them as bizarre. The traditionalist perspective was that of chain of command, long-range planning, and integration. "The system is the solution" was A.T.&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 a better way to frame the question is: Can there be a stable alternative in economies that otherwise favor a market mechanism and that want to stay on the leading edge of technology and applications?

Nonsustainability of most regulation. Telecommunications is in the process of being transformed from one of the most regulated industries to one of the least regulated. One reason is that the growing complexity of the system makes it increasingly difficult to fashion consistent rules, whether behavioral or structural. The U.S. experience with the Federal Communications Commission's Computer Inquiry decisions gives an early taste of this difficulty.

Second, 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, to be effective, a regulatory mechanism must be draconian, and for that the traditional system has neither the will nor the political support. And yet, there is need for regulatory oversight of the rules under which networks and users interrelate in the future, as detailed below. To bridge this tension will be one of the central challenges for regulatory policy.



Public system as core. The telecommunications system will evolve into a mixed public-private arrangement. The public network will not cease to exist. It is likely to remain the core of the system and its prime standard-setter. It deserves public support for the same reasons that have existed before, but without the exclusivity that characterized it for over a century. This is comparable to the situation prevailing in transportation. A state railroad system exists in most industrialized countries, often subsidized directly and indirectly, but it is supplemented by a mixture of trucking firms, airlines, barges, passenger automobiles, and small railroads. No one advocates a transportation system that bans all private trucks just because they reduce the scope and revenues of public railroads.

Expansionism of the public system. The traditional public system may be losing its exclusivity, but it is gaining the flexibility of moving into new activities. The experience of British Telecom, but also of the semi-independent public systems of SIP/STET in Italy and CNCT in Spain, indicates strong tendencies of the still-dominant carriers to expand vertically into equipment and manufacturing, even internationally, and into computer applications. These tendencies are similar to the developments in the United States, where the scope of activity of the A.T.&T. successor companies is steadily increasing. These new horizons are an attraction to the PTTs as they consent to the loss of monopoly; for policy-makers, they raise regulatory issues on how to deal, in the transition phase, with the still-substantial economic power of independent PTTs.

Technical interconnectivity. Whereas in the traditionalist model, standardization was a key element, the new model is characterized by a stress on 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, standards 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.

Legal interconnectivity. A key requirement for an open network system is that it extend the common carrier principle from users to networks. That is, networks must be able to interconnect into other networks as a matter of right, even if they are competitors. In the United States, the United Kingdom, and Japan, the establishment of interconnection of new networks with the existing and predominant one turned out to be essential. This principle, however, requires clarification of the charges and quality standards for interconnection, and this is likely to remain a regulatory question for a long time.

Right of access. While the right of interconnection deals with networks' linkage with each other, the right of access deals with users' ability to reach, if technically possible, any network they choose to. For example, a landlord's network should not restrict tenants from reaching a carrier of their choice.

Common carrier principles—wider but shallower. In the traditional centralized model, the concept of common carrier access to the public network was an essential element. An open system is more complicated because it includes many private providers who operate on a contractual basis rather than as a public utility and who may wish to restrict the participants on their network. The extent of common carrier status in a future open system is an important policy question to be resolved. While the system is likely to impose similar obligations on many network participants, these will not be as far-reaching as at present on the telephone carriers. It could be argued, of course, that common carrier principles would be unnecessary in the presence of competition. But competition exists also, for example, in airlines or hotels, which in the United States have common carrier obligations without price regulation. The notion of nondiscrimination in usage, particularly for infrastructure-type services, has strong support and makes it unlikely that a system based solely on private and voluntary contracts would be adopted. To apply rules of quasi-common carrier access to private or specialized networks will be another difficult task.

Some of the PTTs and their supporters have argued that their full control over the communications conduit is essential in order to ensure freedom of content. Freedom of speech is said to be possible only under impartial PTT control of access. There are few who would accept this logic for a similar state control over all printing presses or newspaper kiosks. The argument also fails to distinguish between state control over the rules of operation, such as by regulation, and state operation itself. Empirically, in those instances where PTTs control newer types of networks, such as in cable television, there is no evidence of their willingness to extend common carrier-type access to new voices.

Universal service: narrower but deeper. The traditional public network operated with the obligation of universal service, i.e., virtually any interested customer had to be served, regardless of location. In the open network system, the question is whether universal service obligations apply to all participants. The answer is likely to be differentiated by service provided. For some of the more specialized services, the general obligation will not exist. But for "basic" service, it will continue, and the definition of "basic" is likely to expand. The boundary line is likely to be an ongoing issue of policy debate. One main function of the public network will be as the service provider of last resort, under financial arrangements that may involve subsidies by the government and the private carriers.

Internal subsidies. In an open network system, it is unlikely that the traditional system of internal transfers from one class of users to others can be maintained. But this does not spell out the end of transfers as such. There is still ample reason and opportunity to subsidize some categories of service and of user classes, just as in the case of railroads. Revenues for that subsidy can be raised and distributed in the normal way of taxation and budget allocation in which redistribution takes place in society. A monopoly is not a necessary condition for redistribution. Justification of a subsidy exists for reasons of general social policy or regional development and because of the positive benefits that new subscribers provide to previous subscribers. Nevertheless, it is likely that the extent of the subsidies will be reduced once they are in the open and subject to scrutiny, and that subsidies are likely to become targeted toward the poor. The remainder of residential users will be forced to pay more than before. Because they will also increase their usage of the telephone as its functions grow, telecommunications will become a larger household budget item than in the past.

Quality and price differentiation. There will be more choice but less equity. Whereas in the past all subscribers had a fairly similar quality of telephone service and equipment, the open network system will have much variation, depending on the preferences of customers and their willingness and ability to pay. There will also be a much greater differentiation in the cost of communications. Just as two adjoining passengers in an airplane may have paid widely different prices for their tickets, so will telecommunications users pay different rates for similar service. Those with small usage and few alternatives will pay more per volume than large users and more than alert consumers. This reverses the cost relationship in the public network, where business used to subsidize residential and rural service. This does not necessarily spell the end of universal telephone penetration. Given the low elasticity of demand and the increasing importance of telecommunications, the drop-off of subscribers is not likely to be large, despite the negative redistributionary effects.

Excess capacity. The open system is not efficient in the sense of minimizing resources, so there will be more excess capacity than in a centralized system. There is nothing unusual about this, for almost every industry has excess productive capacity, and the competitive effect is usually beneficial for customers. In the telecommunications field with its low marginal costs, competition will cause periodic price instability. One of the functions of future

regulation will be to moderate the worst effects of price volatility and at the same time prevent the likely industry efforts at collusion.

Transnationalism. The traditional centralized system was international 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 in protecting the domestic arrangements. For a long time, national PTT administrations participated almost joyfully in the international sphere, because they could return home with an international agreement that would buttress their domestic positions. But in the age of satellites, internationalism becomes a threat because it is initiated by users and new carriers. International communications are the soft underbelly of domestic service monopoly. In the long run, telecommunications will transcend the territorial concept, and the notion of each country having territorial control over electronic communications will become archaic in the same sense that national control over the spoken (and later the written) word became outmoded.

The two network concepts—centralized and open—are reflected in two major initiatives of their respective proponents, the integrated digital services network (ISDN) on the one hand, and the open network architecture (ONA) on the other. Both are pure expressions of the underlying network philosophies. A similar comparison could be made between the PTT concept of videotex and the distributed system of data bases in the United States.

ISDN has been by far the more prominent strategy. It is, at its most elementary, an integration of voice, data, and telex networks into a unified “superpipe.” Hundreds of papers on ISDN have been published, virtually all of them from a technical perspective and with a near-total absence of acknowledgment of the economic and political issues involved. Virtually no public discussion of the ISDN concept and its investment needs has taken place. Instead, decisions in favor of ISDN have been made outside of public view by engineering bureaucracies in government and equipment firms.

Part of the problem that hinders discussion is that the term ISDN encompasses several subconcepts. As a move to more digitization of the network, it is squarely within the trend of technology. As an upgrading of the networks to higher transmission rate, it responds to the data communications needs of larger users; for residential users, the need is less clear except as to create the proverbial egg (the network) for a future chicken (the applications).

The third element of ISDN, integration, is much weaker in its rationale. To put together separate communications networks into one superpipe is more elegant from a technologist’s view, but from the user’s perspective the cost, performance, and choice of services are what counts. Integration is a standardization process, which is always a trade-off between the cost reduction of streamlining and the benefits of diversity. A process of integration usually reduces options. Users are interested in selecting among choices, while network operators may be more interested in providing standardized options.

If elimination of “wasteful duplication”—which is almost always asserted

rather than quantified—is crucial, then, to carry the argument to its extreme, the entire economy should consist of one giant integrated enterprise. Clearly, there are organizational diseconomies to the reduction of duplication. The implicit assumption justifying the nonduplicating superpipe is that cost functions for telephone and telex networks, for example, are static. Yet economists would expect that where different services are controlled by rival organizations, competition would usually force a dynamic downward shift of the cost curves, in contrast with the monopolistic situation of unified services. The effects of these downward shifts in costs can offset, partly or totally, the absence of economies of scope associated with integration.

Thus, there are practical and theoretical problems with the concept of integration, to which several others can be added (8).

Why, then, is ISDN pursued so vehemently in most developed countries and in their international organizations? Those holding the centralized concept of networks are utterly captivated by ISDN, which at once reaffirms their view of the network as a centrally planned and exclusive system while providing them with a powerful defense against the centrifugal forces of network fragmentation and with profitable business opportunities.

Strictly speaking, ISDN as a technical concept does not rule out as a practical matter that multiple ISDN networks and networklets may coexist, compete, and interconnect. There is no notion of exclusivity in the technical integration. But, attitudinally, ISDN's promoters find anything less than exclusivity hard to accept. After all, the elimination of duplication is the primary rationale for ISDN; to permit multiple integrated networks would defeat the entire purpose.

An ISDN upgrade raises barriers to potential entry by rival network service providers in a variety of ways. It increases the initial capital investment that a potential rival needs to match the upgraded technical capabilities of the major network. Where a trade-off exists between sunk costs and marginal costs, the latter are lowered by the investment, making it more difficult for a rival to match marginal cost pricing.

In addition, the need for heavy initial investment outlays, with their element of start-up subsidy by a public agency, can be used to justify a variety of restrictive policies that protect the monopoly as a source of revenue for the upgrade. Indeed, a highly perverse incentive is built in, because the greater the required subsidy, the greater the political support for a monopoly status that reduces cost to the taxpayers.

For the equipment industry, ISDN is most welcome. After several decades of enormous public investments in the public network, expansion has come to a natural plateau. The implications for equipment manufacturers were clear; the domestic market was close to saturation in terms of standard equipment, and domestic demand was about to decline. Export markets were limited because many of the larger ones are protected against imports. One way to activate the sagging domestic market was therefore to launch an ambitious program of upgrading.

The PTTs have dangled ISDN before equipment manufacturers for its export potential, with a clear call for a quid pro quo in defense of the centralized

network. For example, a high official of the German Bundespost argued to the industry that ISDN is important for the export success of German industry and that it requires the contribution of the Bundespost to play a role in the equipment supply field, a role that had been under attack by the German Monopoly Commission and the Ministry of Economics:

The PTT that takes on the leading role internationally when a new service [ISDN] is standardized gives the communications industry in that country a big head start in this service.

... Anyone who blocks this influence in his own country damages the innovative force of a future technology and ultimately the entire economy (11, p. 22, emphasis in original).

ISDN is not the end of the centralized network's desired expansion. As presently conceived and defined by international standards, ISDN has a narrow bandwidth and is therefore incapable of, for example, transmission of regular television program services. To make possible broadband services, currently supplied by broadcasting or cable television, the next step for expansion of the PTT network is into "integrated broadband networks" (IBNs), the technology for which is presently being developed and tested in pilot projects. At that point PTTs would overlap with cable networks and broadcasters. Cable networks, on the other hand, can serve as alternative transmission means for other telecommunications services since they already provide a wire reaching into many households (6).

While ISDN is the archetype for the centralized network model and its dynamics, the open network model, too, has moved into its next phase, that of open network architecture (ONA). This concept, at present not well known, must be distinguished from the similarly named "open systems interconnection" (OSI) of the International Standards Organization. ONA is a framework, established in the FCC's Third Computer Inquiry, for opening the core of the public network, i.e., of central switching. It conceptually disaggregates switching into its component functions and permits separate access, interconnection, substitution, and competition with each of them. Different communications services use different configurations of building blocks of the central switch, and ONA permits outside parties the use of building blocks of their choice and the resale of the new service combinations thus created.

At present, central offices depend on giant and complex switches and on extraordinarily difficult software. ONA creates a modular approach and enhances the abilities to tailor and modify features. ONA is part of a movement toward the network of a distributed rather than a hierarchical architecture. In this, it follows the lead of computing, which also started as a highly centralized operation and moved toward a distributed structure.

As proponents further refine their two network models, will these developments lead to a stable environment? The centralized model is challenged by the centrifugal forces described above, while the open network concept is viable only if economies of scale and scope are not of a magnitude

so as to implode the entire network of networks right back into one network after its competitors have failed. But the latter seems unlikely; even if many of the new ventures in network services collapse, the genie of diversity is out of the bottle. Communications are becoming too varied, complex, and significant for one organization to do it all well. Similarly, the notion that, in the age of information, all communications flows in societies operating largely on the market principle would pass through one streamlined superpipe controlled by a single organization is hard to entertain on technical, economic, or political grounds, except by reference to the present balance of power.

But these conditions are not likely to prevail, as has been argued above. Once the notions of the centralized network are breached in some respects, the process is hard to contain. This development is inevitable not because it leads necessarily to a superior result but rather because the centralized network is an anomaly, even if a familiar one. As long as the economic system of industrialized democracies is based on markets and private firms, the exclusion of major economic parties from a major field of endeavor is an unstable affair at best. Thus, it is hard to maintain a lasting dichotomy between telecommunications and the rest of the economy. To differentiate them vaguely as an infrastructure service is not useful. Telecommunications, unlike a lighthouse or a road, is not a public good in the classic sense: users can be excluded and charges can be assessed, breaching the major condition for a public good. The traditional public network was an appealing concept to many as an almost romantic sanctuary amidst the cold rationality of capitalism. It was a notion of sharing, interconnecting, and reaching every member of society. Yet these are also the concepts of authoritarianism of both the far right and left. Certainly, the historical origin of the system, rooted as it is in seventeenth-century European absolutism and representing today a near-perfect example of state monopoly capitalism, does not support those who presently view its defense as a progressive act. Thus, in the future the telecommunications field will more closely resemble the rest of the economic system and will be less a part of the political decision sphere. It may be much more complex and perhaps less efficient in some aspects than the old system, but it will be a truer reflection of the underlying complex society.

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