Toward the Pluralistic Network of the Future

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Integration and Diversity

The modern telecommunications network has grown into the central linking institution of the information-based economy. As it continues to evolve from a medium for point-to-point voice communications to a powerful structure which carries a broad range of information, it is shaped by two basic but conflicting tendencies:

(a) the trend towards technical integration — which technologists understand and emphasize

(b) the trend towards institutional and business diversity — which economists, in particular, stress.

These two forces are to some extent substitutes for each other. To advance technologically, one can upgrade a telecommunications systems by more powerful integration, such as through integrated narrowband or broadband networks, and benefit from their economies of scale and from technical standardization. Or one can choose a more competitive diversity and benefit from its dynamism and cost-consciousness.

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Generally speaking, Europeans have stressed ISDN-style integration, whereas the US mostly followed the path of diversity, the comparative advantage of its society. Japan has been somewhere inbetween.

Evolution in the USA

The United States has been forced to contend with the need to reconcile diversity and integration earlier than other countries. It is therefore important to understand the direction its telecommunications system is likely to take in the 1990s.

Let us first look at what did **not** happen in the 1980s. The transformation of telecommunications in the U.S. from monopoly towards a more pluralistic system was accompanied by grave predictions of doom and gloom: residential rates would skyrocket; universal service could no longer survive; service quality would fall; productivity would suffer; research and development would decline; employment would drop; AT&T would dominate; etc., etc. However, most of these fears did not materialize.

For example, despite scenarios of several hundred percent in rate increases, local rates in real terms rose from 1985 to 1990 at an annual rate of 4.7%, while interstate long distance rates declined by 6.0% annually in the same period. According to the FCC, overall telephone rates (long distance and local) rose from 1984 to 1990 by a total of about 17%, below the rate of inflation (CPI) of 27%, during that period. That number does include the sometimes substantial savings from lower equipment costs. Rates did not rise as much as initially feared, in part because costs were contained through lower

interest rates and taxes, higher productivity, and lower equipment prices.

Partly because of low income programs and other protections (for example, lifeline service in New York costs only $1 a month for potentially 1.5 million low income households), overall telephone penetration did not decline but actually increased, from 91.4% in 1983 to 93.3% in 1990.

Labor productivity rose since the AT&T divestiture by almost 40%, though at some expense of employment, which dropped from 953,000 in 1984 to 879,000 in 1990, partly because of the labor-saving trend of modern electronics. Total R&D employment increased. AT&T's long-distance market share steadily declined each term, reaching around 67% in 1990. The market, though flat in dollar terms, grew strongly in terms of traffic, increasing by 13% annually and doubling usage from 37 billion minutes in 1984 to 75 billion in 1990. Americans make substantially more phone calls per capita (1700) than users in other countries — two and three times as many as the British (800), Japanese (550), Germans (500) and French (400).

Telephone rates were favorably affected not only by competition but by technological advances. Central exchange equipment costs declined steadily, from $230 per digital line in large exchanges in 1983 to $144 in 1988 and to as low as $100 in 1990. However, in the equipment market the U.S. trade reversed from a slightly positive balance in 1983 to an over $2 billion deficit in 1989. This was partly due to the general strength of Asian countries in consumer electronics, and partly the result of the divestiture-induced severing of AT&T's vertical integration of equipment and local exchange network services that had closed most of the U.S. market to other suppliers.

The upgrading of the network proceeded after liberalization. For example, local Bell operating companies increased their fiber use in the network by 32% in 1990 and 28% in 1989 to 2.7 million fiber miles. Urban fiber carriers deployed some 55,000 fiber miles, and the interexchanage carriers increased their fiber trunk lines by 12%, to 2.1 million fiber miles. According to the U.S. Department of Commerce, in 1989 96% of all lines were electronically switched, half of them digitally.

In ISDN, the U.S. is probably two or three years behind the high level of activity of several European countries. On the other hand, fully digital lines which do not correspond to the CCITT 2B+D standard (and are therefore not considered "pure" ISDN) have become frequent. Usage of high capacity digital lines such as T-1 and DS-3 lines is high, and numerous private ISDN networks exist.

A Federated Network of Networks

Many of these developments were gradual adjustments to the post-AT&T divestiture market structure in telecommunications. And while they are important, they hold less long-term significance than the transformation of the public network from a centralized telecommunications system to a federated network of networks, a change that has quietly taken place at the same time.

A driving force behind this transformation has been the growth of private networking. They are "private" not in the sense of ownership — virtually all networks in the U.S. are privately owned — but rather in terms of not being open to general users. Though

largely outside the public view, private networks have been rapidly deployed. Most observers still view private networks as atypical arrangements at the margins of the fixed public network. But in the future, we may well observe a reversal of what the public network implies. While in 1980 virtually 100% of U.S. network investments were made by public network carriers, in 1986 this figure had already dropped to 66%; the remainder was accounted for by large users and private networks. Large companies run network operations requiring many hundreds of employees. According to Citicorp, for example, telecommunications has become its third largest expense item after personnel and real estate. In 1988 the Federal Government contracted for its own private network, FTS-2000; valued at $25 billion, it was the largest-ever American civilian procurement.

These intra-organizational networks are also extended, in time, to group networks. First developed were clearinghouse networks for financial institutions, followed by networks for travel agents, insurance companies advertisers, etc. Next were industry-specific networks linking entities in frequent business contact. Ford, for example, is creating a vast system linking its own far-flung operations with its suppliers, dealers, and others, internationally as well as domestically. (See *Siemens Review*, 2/91, William Dixon, "How Ford is Building A Communications Superhighway") Such networks provide relatively secure, cheap, and customized communications. They also tend to have service features which go beyond simple transmission, providing "added value" such as electronic data interchange (EDI) or other software-based transactions.

This abundance of networks will make it increasingly difficult to define in the future what "the network" is. The distinctions between private and public, basic and enhanced, terminal and network equipment, national and international, are fading. It is therefore

best to think of the future network as a **federation** of networks that must interact. The traditional network was based on the notion of sharing of resources in terms of technology, economics, and politics. But the evolution of networks abandons this arrangement. It may be more resource efficient to share, but by the same logic one should not buy a car but instead hire a taxi. In other words, efficient capacity utilization is not the only force driving a system.

The Pluralist Network

The movement of the network from a centralized to a pluralistic network of networks has implications.

1. "Electronic neighborhoods" emerge

A few years ago, it became fashionable to speak of communications creating the "global village". There was something inspiring in this image, communal and peaceful. But there is nothing village-like in the unfolding reality. Instead, groups with shared economic transactions are extending national groupings into the international sphere. The new group networks do not create a global village, but instead create the world as a series of electronic neighborhoods. In the past, neighborhoods had economic and social functions. In New York for example, there are Chinatown, the Garment District, Wall Street, Madison Ave., or the Theater District. Elsewhere, there are regions with specialized production. Solingen and Sheffield for cutlery; Lyons for silk; Hollywood for films; Silicon Valley and Route 128 for microelectronics. Production clusters create

economies of aggregation that substitute for the economies of scale and scope of the giant multi-product firm. Physical proximity used to be a key. But now, group networks can serve many of the functions of physical proximity. They interconnect specialized producers, suppliers, buyers, experts, and markets. They create new ways of clustering, spread around the world.

2. Networks become transnational

As the cost of transmission continues to drop, networks will not be territorially organized. Territoriality was based on the need for a network architecture that primarily minimized cost by minimized transmission distance. It led to the creation of the 'German network,' or the 'French network.' This technological and economic territoriality suited governments everywhere, because they, too, were based on territorial jurisdiction, and could thus exercise control and ownership over "their" network. Now, as many networks increasingly become pluralistic group affairs, territoriality will become secondary. When the computers of brokers and investment banks in New York are interconnected by a continuous network and interact with those in Tokyo and London to trade and clear transactions, one cannot say anymore that they are using national systems. Nor can one say that there is a New York or Tokyo market, because there is no physical locus for the transaction anymore. **The network becomes the market.**

3. Networks become quasi-jurisdictions

Group networks must mediate the conflicting interests of their members. They have to establish cost shares, sometimes creating their own de facto taxation and redistribution

mechanisms. They determine major investments, set standards, decide whom to admit, and whom to expel. As a network may become more important and complex, control over its management becomes fought over. Constitutions, bylaws and regulations are passed. Arbitration mechanisms are set up. Financial assessment of members takes place. **Networks become new types of jurisdictions.**

4. From the group networks to the personal networks.

If the trend is from national public networks covering the entire population to a pluralist system, why not expect still further disaggregation? This additional step means individualized networks, or **personal networks** (PNs), analogous to PCs. While the notion of PNs may seem extravagant, twenty years ago nobody anticipated personal computers and nobody expected computers to end up on everybody's lap either.

What does a personal network entail? It means an network arrangement that fits an individual's communications needs, based on virtual networks, provided by a whole range of service providers and carriers, and packaged together technically and through customized rates to satisfy an individual's primary communications needs: access to friends and family; work colleagues; frequent business contacts, both domestic and foreign; data sources; transaction programs; video publishers; telemetry services such as alarm companies; bulletin boards, etc.. Contact to and from these destinations would move with the individuals, whether they are at home, at the office, or in transit.

These intra-firm, group, and future personal networks exert an enormous and increasing centrifugalism on the network. To reconcile these pressures with the needs to inter-operate, and inter-communicate represents the main challenge for U.S. policymakers for the next decade.

The key task for the U.S. is to balance its institutional diversification with technical integration. As the U.S. continues its diversification, it is confronted with the fallout from such a policy. American policy will have to pay much attention to the question of how the various pieces of the network of networks will fit together. The past ten years have been preoccupied with the preparation and clean-up operations of the AT&T divestiture and of market liberalization. This was the agenda of the 1980s, and it will hopefully continue. But it will also be inevitable for the U.S. to move in the 1990s beyond this agenda, and to assure the functioning of a network based on diversity. It is a unique undertaking because it has never been done before.

This does not mean to recreate a monopoly system, but rather to provide the system with tools of integration where they are not self-generating by market forces. Competition will often be enough. But there are issues where the peculiarities of a system of interconnected competitors may require to take a more active role in providing integration. For example:

1. Modularizing the Network

As various discrete networks grow they must interoperate in terms of technical standards, protocols, and boundaries. It is therefore necessary to have a system of

interconnection. Interconnectivity does not happen by itself; that is the lesson of decades of American experience. This leaves a highly controversial and complex role for regulators, as they are asked to overcome barriers to interconnection. One recent example is the granting to interconnectors in New York State of so-called collocation rights to the public networking. Another example is the U.S. Department of Transportation's recently proposed interconnection and access rules for four computerized airline reservation systems which are among the country's largest private information networks. The proposal mandates that all computer reservation systems must be available from a single terminal, and that system vendors could not prevent users from adding their own compatible software or hardware designed to manipulate the information. This path of future policy is either to initiate these various interconnection arrangements on an ad-hoc basis, or to systematize them under some basic ground rules. A systematized structure of interface points and standards would create, in effect, modularity in the network.

Such modularity would also mean, in the longer term, an unbundling of a modulariztion of large hardware and software such as switches. Users and the packagers of networks could connect various modules together, replacing some with others and structuring customized networks that are capable of interoperability. One could also envision "software collocation," where software applications by independent service providers would be placed into the central exchange. This could open up a scenario of exciting applications.

2. Protecting common carriage

Telephone carriers are starting to offer pathways for interactive and mass announcement services and soon for video transmission over fiber. This trend blurs the distinctions between telephony and mass media such as television and cable TV. Not only are telephone carriers entering the video distribution business, but cable and other media firms are about to offer telecommunications services themselves. These different communications industries have worked under differing regulatory rules of the road.

Telephone carriers have traditionally operated under common carriage principles, i.e., without discrimination among users based on the **content** of their messages and with no influence or responsibility over the content transmitted. In contrast, private networks, and cable TV and broadcast firms, are not common carriers.

In a pluralistic network, information flows may be subject to restrictions that do not exist under common carriage. For example, a private network may create rules against discussing certain issues, or institute a monitoring that governments or public telephone administrations could not conceivably impose. The interconnection of public and private telecommunications and television networks requires a reconciliation of differing regulatory systems, which may be one of the thorniest issues for the near future, because media issues are always highly controversial.

3. Restructuring Subsidies

The pluralistic network will make it increasingly difficult to maintain the traditional system of internal transfers from one class of users to another. It required a monopoly to do so in the old way. But one can still assist some categories of users if one wishes to

do so, and all political signs point to a continuation of support, for example for the rural population. Yet in the pluralistic network environment this will have to be done not through internal redistribution but in the normal manner of taxation and budget allocation, e.g. by a telecommunications value-added tax, a "universal service fund," and other devices. These changes, too, will be difficult.

4. Maintaining Service Quality

Quality issues are becoming more important. As modern societies become dependent on reliable communications networks, they are greatly vulnerable to service breakdown, as evidenced by recent software-based failures in parts of the American long-distance and local networks.

It is often believed that competition is good for network quality, but this is not necessarily so. First, user choice need not necessarily be used to select higher quality, if a low price is preferred.

Furthermore, the network system becomes non-transparent to end users. In a transmission chain of several carriers, which one is to be blamed for faulty quality? This difficulty to identify the culprit can encourage "free riding" by a carrier and to the lowering of the quality of its own link. This, in turn, can lead to a quality downgrading by other carriers, since it may make less sense to provide quality at a level higher than the weakest link of a transmission chain. Thus, competitive forces and the absence of an end-to-end responsibility may reduce quality.

5. Subsidizing critical mass

In some cases it is not optimal to wait for demand to materialize prior to the introduction of a network or network service. Demand is a function of price and benefits, both of which are in turn functions of the size of the network. Hence, early development of a network may require internal or external support in order to reach a critical mass of users.

This suggests that it may make sense, in some instances, to jump-start the early stages of network development. In the past, this was mostly done by the monopoly network provider. However, it is less likely for the initial risk to be undertaken by a partial network in a network of networks if a potential failure were entirely paid for by itself while potential gains would be shared with other interconnecting entrants. In an environment of multiple interconnecting networks, risky start-ups may be undertaken less. A situation of market failure exists, to use the economists' term. And where such a situation occurs, it may be necessary for governments to provide the incentives to establish a critical mass of users.

6. Privacy protection

The pluralistic network environment expands the number of points of access to users. A competitive environment may enhance privacy especially if it is possible for a user to select a service provider which offers the desired level of privacy protection. However, the greater openness of a competitive system and the complexities of its multiple networks mean a greater openness of information. It is easier to restrict the dissemination of confidential information in a monopoly setting. This means that a

pluralistic environment must include protections against the leak of information.

I³SDN--The Future Network Environment

These measures are steps in the larger effort to reconcile the forces of integration and diversification. If properly accomplished, the result will be the network of the future--pluralistic, modularized, flexible, and transnational. The pathways of change lead beyond the particular technologies they employ -- ISDN, the intelligent network, ATM, SONET, etc. -- to a network system that might be called the "triply integrated" digital and modularized network, or I³SDN (Fig.1).

> **Regular ISDN** service integrates the various narrowband telecommunications services such as voice and data.
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> **I²SDN**, the doubly integrated network, joins two types of integration, across services and across carriers. It is still primarily a telecommunications network with narrowband, point-to-point communications. It is also integrated across national frontiers.
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> **I³SDN**, the triply-integrated network, integrates narrowband and various broadband media such as cable TV and broadcasting, provided by different carriers. This goes far beyond the concept of all communications, including video, flowing over one fiber-super-pipe.

The vision of the single super-pipe is often expressed as a scenario in which there is no room for alternative telecommunications carriers, or of rival transmission media such as cable television, because they have become unecessary. Yet such a disappearance of other carriers and media is highly unlikely. Given the forces of diversification discussed above, the contrary trend should be expected.

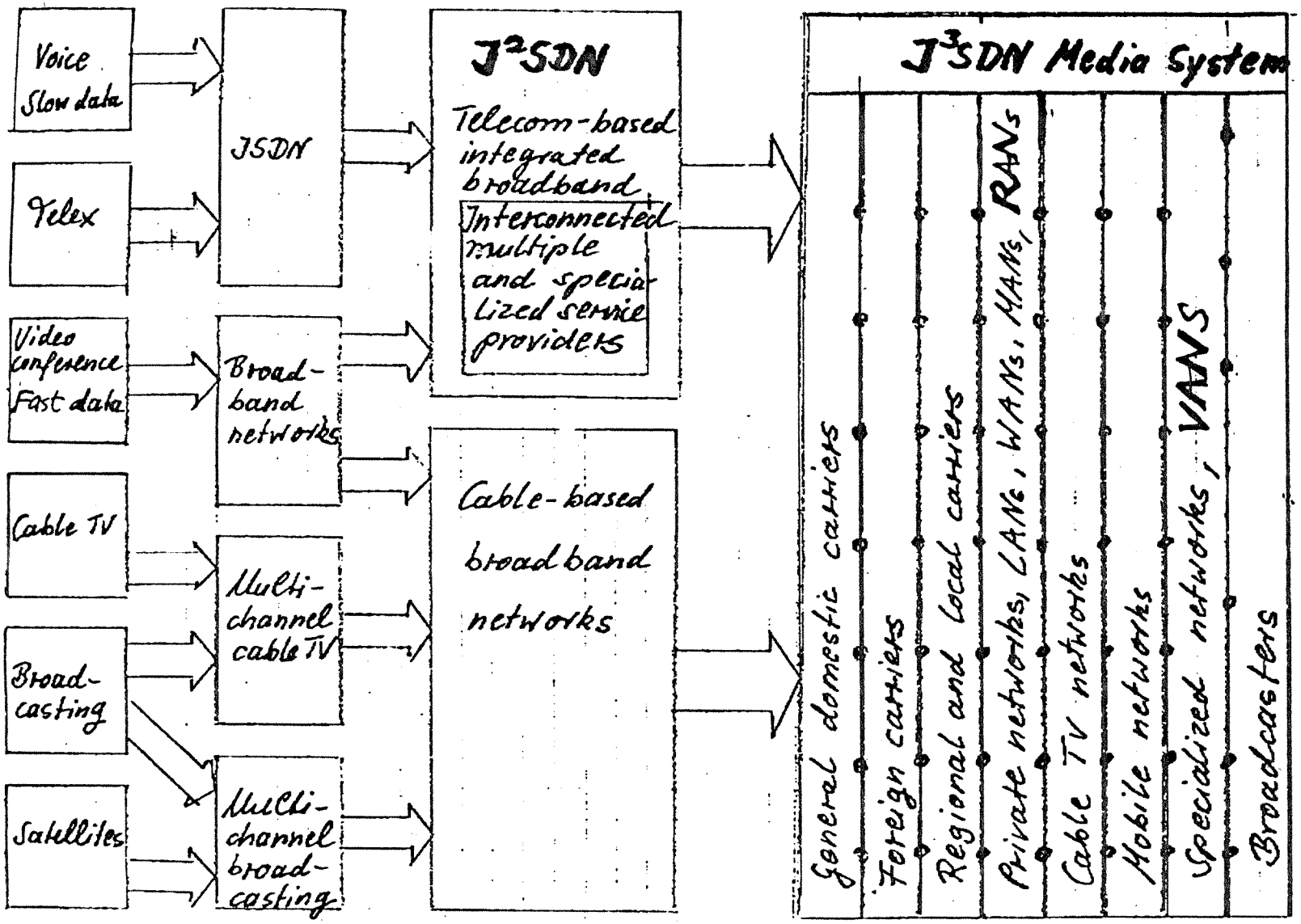
What is needed instead, is an I³SDN that interconnects and integrates the various networks into an interoperating whole, under multiple control, with numerous disparate components and segments.

An I³SDN is not a national affair. It contains service elements and pluralistic user groupings across the globe. In moving to I³SDN, new regulatory policies will have to coalesce internationally, raising problems of coordination among networks of different stages of institutional evolution. New supra-territorial arrangements may have to be fashioned.

Technologists and business managers, although in the past at times traditional in outlook when it came to the recasting of the telecommunications structure, will be in the vanguard of this change as they replace the old version with the new. Policy makers, on their part, will move from a ritualistic affirmation of the economic significance of telecommunications, and provide the necessary tools of integration for the new network environment.

These issues will, no doubt, lead to significant controversies, and occupy the US and other nations for years to come. None of the tasks is beyond our grasp in terms of

complexity or political feasibility. But they require an end to the nostalgia for the simplicity of the golden age, and a look forward to a very different network environment, one of modularity, user choice, and open interconnectivity. In the end, a global pluralistic network will be created to provide the technological options needed for a diverse and open world and an information-based economy.


Voice
Slow data
Telex
Video conference
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Cable TV
Broad-casting
Satellites
ISDN
Broad-band networks
Multi-channel cable TV
Multi-channel broad-casting
J²SDN
Telecom-based integrated broadband
Interconnected multiple and specialized service providers
Cable-based broadband networks
J³SDN Media System
General domestic carriers
Foreign carriers
Regional and local carriers
Private networks, LANs, WANs, MANs, RANs
Cable TV networks
Mobile networks
Specialized networks, VANS
Broadcasters
Traditional
Early 1990s
Late 1990s