ISDN IN PERSPECTIVE

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The old Greeks divided history into four-year segments called olympiads, each concluded by the athletic games at Olympia. Today's telecommunications are marked by similar periods, bracketed by the International Telecommunication Union's huge Telecom exhibitions at Geneva. At Telecom '83, Integrated Services Digital Networks were still in the conceptual stage and were being discussed by the Consultative Committee on International Telephone and Telegraph. There was a general lack of understanding about the notion of narrowband integration, and the wisecrack that the acronym stood for "Innovation Subscribers Don't Need," was making the rounds. But four years later, at Telecom '87, ISDN had become a reality. The first equipment and services were being demonstrated, and there was expectation of a great future. Yet more recently, at Telecom '91, there was an increasing questioning of the concept in response to the emergence of the next generation of fiber networks.

How should one evaluate these changing perspectives? Is narrowband ISDN an idea whose time has come and gone?

Then term *ISDN* encompasses several subconcepts; in consequence, some confusion exists about its primary rationale. It is, first, a movement toward end-to-end *digitalization*. As such, it continues a development of several decades, accelerated by the development of computers, from analog to digital electronics. Digitalization has been moving from data processing to telecommunication transmission and switching, as well as to consumer electronics, and is about to spread to broadcasting and motion picture technology. The evolution of the network toward digitalization precedes ISDN, and the development of ISDN lies squarely within this trend.

The second element of ISDN is that of upgrading user access to the telecommunication network to a *higher data transmission* rate. In past decades, the increased merging of computers and communications, together with the greater information needs of users, have led to a vast increase in data communications traffic. Data communications in the United States rose during the period from 1970 to 1985 almost forty-fold.

Whereas good-quality, regular analog voice-grade switched communications links can typically support a transmission rate of about 9.6 kbps, basic rate ISDN provides a much higher total transmission rate of 144 kbps for two band channels and one signaling channel. Although analog technology does not stand still, the data transmission superiority of ISDN over the existing public network is clear.

The third rationale for ISDN is the consolidation of several services and networks. It is argued that this integration is more efficient. This point was, to some extent, being oversold by technologists who claimed cost savings and economies of integration, without demonstrating them with hard data. Conceptually, their arguments about the benefits of integration were often sloppy. The simplified model of Table 1 demonstrates that.

Table 1 Cost of Providing Voice and Data Service to Firms and Residents (Schematic)

	V	D	(V + D)
F	8	9	16
R	11	12	21
(F + R)	16	20	35

Suppose there are two services-- voice and data, and two kinds of customers-- firms and residents. For example, it might cost \$8 to provide voice service to firms, and \$9 to provide data service to firms. If one integrated across those two services, the cost would be \$16, for a saving of \$1. A full integration across all four categories results in a cost of \$35, for a savings of \$5 over four separate provisions. From this observation one might jump to the conclusion that full integration is economically superior. But there are at least two problems with such conclusion.

The first problem is that not only cost, but also price is important. Suppose that the same price is charged for all four categories, i.e., \$35/4 = \$8.75. This would mean a higher price for firms in obtaining each of the two services after integration. Firms would hence prefer the old, non-integrated arrangement. Or they would prefer a partial integration, across voice and data services at the firm level, since a cost of \$16 would still be cheaper than 2 x \$8.75. To maintain full integration would therefore require either preventing users from dropping off the common network, or the institution of differentiated pricing. The latter is possible only if arbitrage can be prevented. Thus, where there is exit or arbitrage, and under certain relative costs, one cannot keep the integrated system together; it is "nonsustainable." Its presence depends on the relative costs. Even with economies of scale and scope, full integration may not be a stable solution.

The second problem with the integration argument becomes clear when one examines the benefit side. If Table 2 represents the benefits for the various services, then Table 3 shows benefits' net of costs. The net benefits of full integration is positive (in Table 3, it is $1); but total benefits are still larger if one integrates only partly, excluding residential data service. Therefore, even with positive total benefits, full integration might not be optimal. To integrate fully would mean that three services subsidize the fourth.

Table 2 Benefits of Voice and Data Service to Firms and Residents (Schematic)

	V	D	(V + D)
F	9	10	19
R	11	6	17
(F + R)	20	16	36

Table 3 Net Costs of Voice and Data Service to Firms and Residents (Schematic)

	V	D	(V + D)
F	1	1	3
R	0	-6	-4
(F + R)	4	-4	1

To sustain an integrated system will require cross-subsidies to the residential data service, which might in turn require the protection of a traditional monopoly system. And this would reduce the potential for a more competitive environment. Hence, policies favoring ISDN and competition can under some circumstances be in conflict with each other.

This conflict is an example of a broader and more fundamental tension in the evolution of telecommunications between its two main forces of change: integration and centrifugalism. Integration is part of the broad technological trend: merging various narrowband services, then television-type services, office automation, computers, etc. But at the same time, there is also a second trend at work, that of institutional diversification. Whereas in the past virtually all telecommunications traffic was handled by a single carrier, a growing number of alternative providers was ready to offer services, where permitted by law. This trend was most pronounced in the U.S. and Japan, but has also reached Europe and some of the Pacific.

Telecom '87 demonstrated ISDN moving ahead in centralized telecom countries such as France and Germany which focused on integration rather than institutional diversification. In the United States, ISDN was much more in limbo, largely because of the decentralized nature of its telecommunications system after the AT&T divestiture. At that time I had become Commissioner on the New York State Public Service Commission which regulates intrastate telecommunications. Concerned about the lagging development, I initiated a regulatory proceeding, which led the Commission's Order of an ISDN trial for New York State. The emphasis of this trial was to help overcome institutional centrifugalism. The trial aimed at two integrations, one across services and the other integration across carriers. Because at that time only the United States and Japan had multiple carrier systems, the international organization CCITT had not emphasized the problems of multi-carrier ISDN.

It therefore became necessary to work out the details of such an arrangement. Our proceeding encountered some opposition, much of it contradictory in nature. Large users were opposed to ISDN experimentation, because they feared they would be required to subsidize the service. Small users had similar fears that residential rates might rise. The telephone companies argued that the best course would be to wait for market forces to create demand for ISDN. But we concluded that the barrier to users' demand for ISDN service was its fragmentation into islands, and the absence of far-flung coverage. We therefore asked for a trial, and the industry fairly rapidly got together in a joint task force and worked out inter-connecting ISDN operations. The trial encompassed three cities across the state, and included two long distance carriers (AT&T and MCI); four local telephone carriers (NYNEX, Rochester Telephone, Alltel, and the competitive local carrier Teleport Communications); two equipment manufacturers (AT&T and Northern Telecom); and several large users, including Eastern Kodak, Citicorp, Merrill Lynch, Young & Rubicam, and Shearson Lehman. By the time the trial concluded in 1992, it had led to the testing of equipment interoperabilty and network-to-network specifications. The hardware questions, vexing as they were, had been less difficult to overcome than the "soft" ones of inter-organizational cooperation and coordinated management. The trial created sturdy working relationships among the participants. It was expected to result in a commercial offering on a regular basis. It cost telephone ratepayers virtually nothing. And it limited the role of government to that of catalyst, not planner. One might speculate whether such collaboration would have occurred by itself. According to the participants, this was unlikely in the short or medium term, because rivalries had led to barriers to cooperation.

At the same time, ISDN hardware and applications were forging ahead. At Telecom '91, NTT exhibited interconnecting video-telephones. Germany, France, and Japan demonstrated regular ISDN service.

But is also became evident that there were problems with ISDN. Terminal equipment was still expensive or did not exist, and conflicting standards persisted across companies and across jurisdiction. Because software developers prefer to work on services where there is a large installed base of equipment, the number of applications was limited. There were still conflicting standards across companies and across jurisdictions. In some countries, tariffs were high, because the carriers did not want to encourage migration from profitable leased digital lines to ISDN. For some users, there were non-ISDN digital alternatives-- in the United States, for example, switched 56 kbps, fractional T1, and fractional switched multimegabit data service (SMDS).

More fundamentally, there was also criticism on the technical level that ISDN was not an effective solution. To some, it was too fast; to other, it was too slow. The 64 kbps was more than necessary for voice encoding, because 32 kbps could do the job, and even 8 kbps had promise. A Stanford professor has apparently successfully encoded voice using only 4 kbps. Thus, an ISDN B-channel may have more capacity than necessary for standard voice. Yet, at the same time, the opposite criticism was also expressed, that fiber optics transmission and switching would permit broadband networks capable of multi-megabit streams. The question was therefore raised whether one should not leapfrog narrowband ISDN and move directly to broadband ISDN.

How can one evaluate these contradictory criticisms? If 64 kbps are more than needed for voice, one could presumably use each B channel for multiple voice channels, or for simultaneous use for data, text, video, and telemetry. It is more difficult to deal with the fiber broadband issue. No doubt, technology and economics of fiber networks have progressed enormously. Even so, it will still take years for broadband network to become a reality. Just because a problem is solved in the laboratory does not mean that its realization in the network will be soon follow. The story of narrowband ISDN demonstrates how slow the process of introduction actually is. It took more than ten years of international discussions of standards, and they are still not complete. Similarly, it takes a long time to develop, build, and market cheap terminals, and to introduce services and applications that are useful to customers. And it takes years for customers to adjust their procedures to the new offerings. And then there are the politics: first, the conflicts of industrial development and trade between different countries. Second, the politics of competition among different equipment vendors. Third, media conflicts within each country. Media policy touches very fundamental issues involving some of societies' most powerful institutions of mass influence, and therefore take a long time to sort out. In the

United States, for example, the prospect of broadband networks by telephone companies is opposed by cable television firms. Fourth, there is the politics of income distribution, i.e. the question of who will pay for the expensive upgrade of the networks to full fiber, and how much. And fifth, there are new and complex questions of interconnection and its access charges that need to be resolved.

Thus, it will take a long time to move from the lab to widespread penetration; even successful technology tests are a long way from reaching ubiquity of penetration. And even when fiber is introduced in serious fashion to the local loop, it will take many years and much money to convert the network. Capital constraints are real, and upgrades have always been gradual, perhaps 10% annual replacement of switches and transmission systems, and half that rate for the local loop. And then there are the mundane but very real problems of actual rewiring, splicing, etc. of the sensitive optical fiber. In contrast, narrowband ISDN requires relatively little redesign. Much of the core network is already being digitalized. On the subscribers loop side, such digitalization does not usually require rewiring. It requires a different line card in the central office, and for some lines a removal of loading coils is necessary. For about 30% of American rural loops, the wire cannot handle ISDN, and needs replacement. Most significant is the need for new terminal equipment that is digital rather than analog. The replacement of analog terminal equipment is an expensive element of narrowband ISDN, but it is also a necessary transition. N-ISDN is a way to migrate to an end-to-end digitalization. Even if networks will become broadband, they will best function digitally, and this will be helped by the base of digital N-ISDN terminal equipment that will have been created. Thus, one should use narrowband ISDN not as the solution to all communications needs, but as a step to a fully digital and broadband network, as a way to travel down the learning curve in equipment and applications, and as a way to create a critical mass of users. Standards and protocols should permit broadband integration without obsoleting the installed narrowband digital base. Narrowband (basic rate interface) ISDN already is being aggregated into megabit channels (primary rate interface). Once the digital terminal equipment becomes cheap, the advantage of an end-to-end digital service will assert itself. Users will connect their information systems to network functionalities.

The main problem is to create the critical mass, and this may mean supporting the development of ISDN for a number of years until there is enough use, equipment, and services for it to become self-sustaining. Japan is one country which has made such a commitment. In 1989, 4% of subscribers had access to ISDN, whereas in 1991 the number was 80%. In 1989, a little over 3,500 lines served about 700 subscribers, whereas in 1991 some 9,000 subscribers were served by 53,000 installed ISDN lines.

The absence of initial support does not mean that the end-to-end digitalization will not emerge by market forces. But it is likely to mean an uncoordinated development. Without a "public" ISDN, private alternative digital systems emerge. For example, I have had digital service for five years, first by the private digital system of New York State, and now by the private digital system of Columbia University. Both are proprietary systems (AT&T and ROLM, respectively). The equipment interfaces are non-standard; and consequently, in each case there are only 2-4 types of terminals for the user to choose from. There is no option to buy equipment at the corner store or from a specialized vendor. There are great incompatibility problems. For example, regular fax equipment cannot be used without a codec, which requires a substantially extra fee each month. Furthermore, most small and medium sized users would not be part of such ISDN islands.

Yet when it comes to investment in a compatible "public" ISDN a fundamental problem exists. Figure 4 depicts the size of the network on the horizontal axis, and costs and benefits on the vertical axis. The average cost per subscriber at first declines because of learning curves and shared costs. Benefits increase because use is more valuable if there are more people with whom one can communicate. The ownership of a video phone is more valuable if there are 10,000 people to call rather than only two. In the early stages of network expansion, costs are higher than benefits. In that early stage somebody must subsidize the difference. Beyond point N1, there are positive net benefits, and the network becomes self-sustaining. N2 is the optimal size; governments can require expansion up to N3 where exit will take place. The problem is that while in a monopoly situation it is possible to subsidize the early system and to recover the early subsides later, in a competitive system some carriers can let the first entrant make the initial investment to create critical mass, and then simply interconnect and force profit down to cost. Therefore it will be difficult for the first carrier to recoup the early investment. It pays to be the *second* rather than the first entrant, and this provides a disincentive to early investment. Therefore, in a truly competitive environment of local exchange service there would be a structural problem of upgrading networks, and this points to the need for inter-industry initiatives. However, this point is more future-oriented. At present, such local loop competition is very limited, and leaves a window for near-term upgrade investment and recoupment.

[INSERT FIGURE 4]

The main point is that the development of ISDN requires years of support and coordination. ISDN is not likely to happen by itself. In Brussels, the European Community has established guidelines for tariffs, numbering, availability, and services. In Germany, DBP Telecom is giving users a credit of approximately US $500 if they subscribe to ISDN and buy a ISDN personal computer adapter card. It is a strategy that is similar to the one that France Telecom used to spread its minitel videotex service. In the US there has been increased awareness of infrastructure problems in the need to make sure that its telecommunications do not fall behind. A recent report by the National Telecommunications and Information Administration concludes that the US is not a leader in ISDN and that it is behind several European and Asian countries, including France, Germany, Singapore and Japan.

[INSERT TABLE 5]

The National Institute of Standards and Technology (NIST) initiated the North American ISDN Users' Forum (NIU), a series of events that brings together users, carriers, and vendors. In February, 1991, US industry representatives agreed to the technical standards (National ISDN Number 1) which should pave the way for more widespread deployment in 1992.

These steps towards ISDN are only one phase of integration. Fiber is gradually improving its position technologically, economically, and politically to migrate further toward the end user. And yet, as we discussed earlier, integration is only one trend of change. The pathways of evolution create diversification. Combined, the two forces lead to a network that might be called the "triply integrated" network, or I^3SDN.

Regular ISDN service integrates the various narrowband telecommunications services such as voice and data. *I^2SDN*, 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 also bridges national frontiers.

I^3SDN, 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 a single fiber-link. The vision of the exclusive 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 unnecessary. Yet, such a disappearance of other carriers media is highly unlikely and undesirable. Given the forces of diversification, the contrary trend should be expected.

What is needed instead, is an I^3SDN that interconnects and integrates the various networks into an interoperating whole, under multiple control, with numerous disparate components and segments. An I^3SDN is not a national affair. It is pluralistic, flexible, and transnational. In moving to I^3SDN, 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. Similarly, basic rules will have to be fashioned which bridge the differing regulatory regimes applicable to separate media. At present, broadcasting, cable television, telephony, video recordings, satellites, computer communication, and other technologies operate under separate approaches. But, in a world of integrated digital networks, where voice, data and video are intermingled streams of bits that interact in an electronic realm of numerous networks, the different regulations now associated with different media will be unworkable. New arrangements must be found.

In an I^3SDN system, one must protect the free flow of information across the various parts of the network. If some of the elements of the network system restrict use for certain kinds of content, the entire information flow is being restricted, because at each interconnection point one may have to institute content tests. Physical interconnection of transmission conduits goes therefore hand in hand with common principles on content flow.

These issues will, no doubt, lead to significant controversies. But they require a look forward to a very different network environment, one of modularity, choice, and interconnectivity. ISDN is an important step in that evolution, a step that cannot be skipped.

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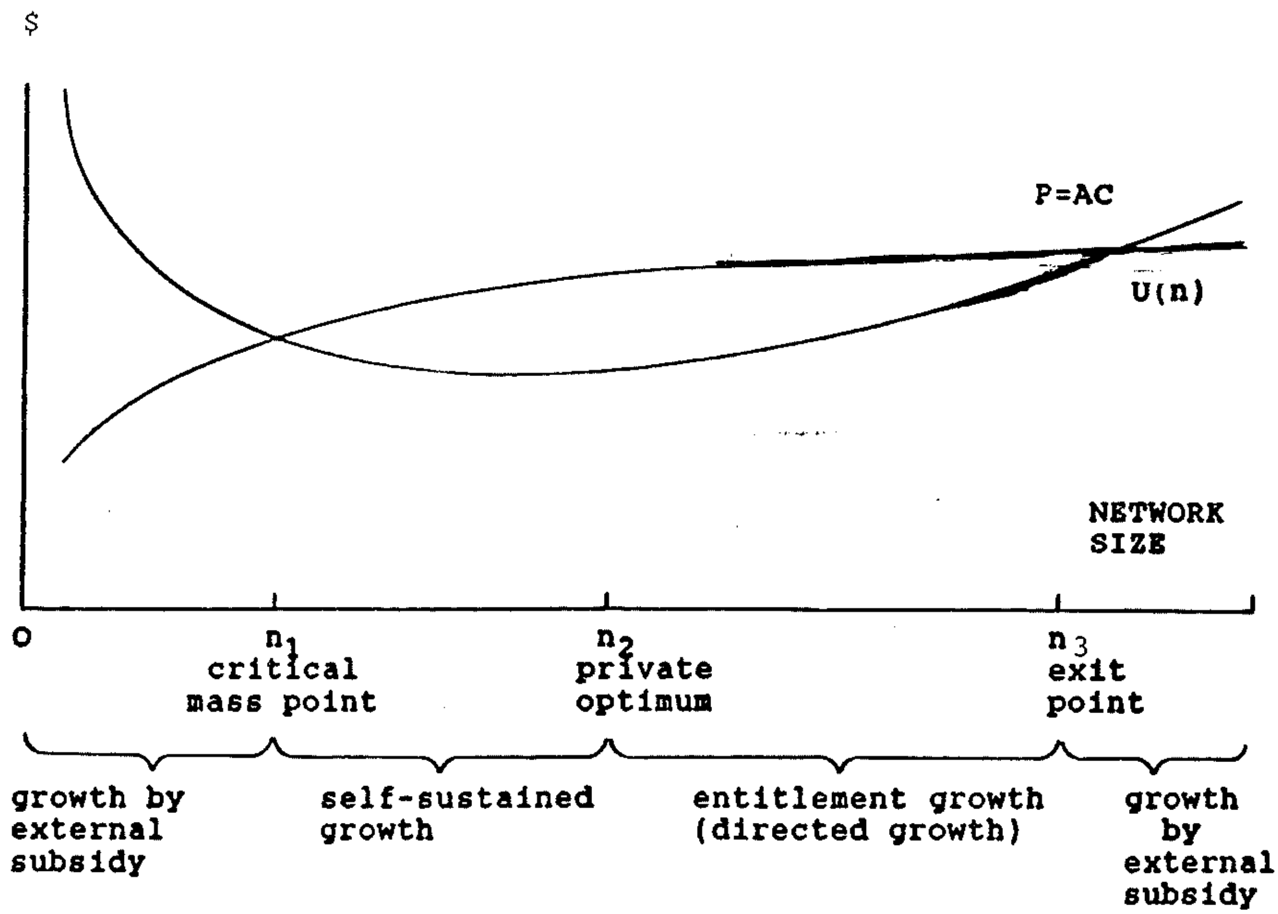
FIGURE 4



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P=AC
U(n)
NETWORK SIZE
O
n1 critical mass point
n2 private optimum
n3 exit point
growth by external subsidy
self-sustained growth
entitlement growth (directed growth)
growth by external subsidy

TABLE 5

COUNTRY	1989	1990	1993	1994	1995
Singapore	100.0%	100.0%	100.0%	100.0%	100.0%
France	NA	~100.0	100.0	100.0	100.0
Germany	NA	NA	100.0[a]	100.0[a]	100.0[b]
Japan	69.0	76.0	92.0	100.0	100.0
United States[c]	.1	.5	NA	49.8	NA
Canada	NA	NA	NA	NA	NA
Italy	NA	NA	NA	NA	NA
United Kingdom	NA	NA	NA	NA	NA

* Coverage is defined as percent of equipped access lines.

** These countries represent the seven largest OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Applies only to former West Germany.

(b) Applies to reunified country.

(c) FCC data; includes RBOCs only. The FCC also reports 1.9% of central offices converted to ISDN in 1989; 24.2% by 1994.

SOURCE: *MESA Study*, Table 6; Telephony, Jan. 7, 1991, at 32; Communications Week, Feb. 4, 1991, at 35; FCC, *Trends in Telephone Service*, at 19, Table 14 (Aug. 7, 1991); Wallace, *RBHCs revise schemes for ISDN rollout*, Network World, Apr. 29, 1991, at 1.

Percentage of Narrowband ISDN Coverage* in the United States and Other Large Countries Selected Years**

Source:

The NTIA Infrastructure Report: U.S. Department of Commerce Telecommunications in the Age of Information, NTIA 91-26, 1991, p. 185.