Chapter 1

ISDN in Perspective

Eli Noam
Professor of Finance and Economics
Columbia University
New York

Eli Noam is a Professor of Finance and Economics at Columbia University in New York City and founding Director of the Columbia Institute for Tele-Information (CITI). He was Commissioner for the New York State Public Service Commission from 1987 to 1990. He has published extensively, has taught at the Columbia Law School and Princeton, and was an Advisory Board member for the federal government's FTS-2000 telephone network.

The old Greeks divided history into four-year segments called olympiads, each concluded by 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 Telegraph and Telephone (CCITT). There was a general lack of understanding about the notion of narrowband integration, and some show attendees joked that the acronym meant, "Innovation Subscribers Don't Need." Despite its critics, ISDN was a reality four years later at Telecom '87. The first equipment and services were being demonstrated, and there were great expectations for the future. At the recent Telecom '91, though, the concept was increasingly questioned in response to the emergence of the next generation of fiber networks.

How should these changing perspectives be evaluated?

Is narrowband ISDN an idea whose time already has come and gone?

The term "ISDN" encompasses several subconcepts, which consequently led to some confusion about its primary rationale. It is, first, a movement toward end-to-end digitalization. As such, it continues development that began several decades ago and was accelerated by the development of computers and the movement from analog to digital electronics. Digitalization has revolutionized everything in its path—from data processing to telecommunications transmission and switching, as well as consumer electronics. And it 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 providing users with a higher data transmission rate for accessing the telecommunications network. In past decades, the increased merging of computers and communications, coupled with users' greater information needs, have led to a vast increase in data communications traffic. Data communications in the United States rose almost forty-fold between 1970 and 1985.

Whereas good-quality, regular analog voice-grade switched communications links can typically support a transmission rate of about 9.6 kb/s, basic rate ISDN provides a much higher total transmission rate of 144 kb/s 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 that it consolidates several services and networks. The argument is that this integration is more efficient. This point was, to some extent, oversold by technologists who claimed cost savings and economies of integration without the hard data to back up their claims. Conceptually, their arguments about the benefits of integration were often sloppy, as the simplified model in Table 1 shows.

Table 1
Cost of Providing Voice and Data Service to Business and Residential Users

	Voice	Data	Combined
Business	8	9	16
Residential	11	12	21
Combined	16	20	35

Suppose there are two services—voice and data, and two kinds of customers—companies and residents. It might, for example, cost $8 to provide voice service and $9 to provide data service to these companies. Integration of those two services would cost $16, a saving of $1. 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. There are, however, at least two problems with such a conclusion.

Cost is Not Everything

The first problem is that cost is not the only consideration. Price also is important. Suppose that the same price is charged for all four categories; that is, \$35/4 = \$8.75. This scenario would mean that companies would pay a higher price to obtain each of the two services after integration. Companies would hence prefer the old, non-integrated arrangement—or they would prefer partial integration, across voice and data services at the company level, since \$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 instituting 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 cannot be sustained because 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 integration becomes clear when one looks at the benefits 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.

To sustain an integrated system will mean cross-subsidies of 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, 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

Table 2
Benefits of Voice and Data Service to Business and Residential Users

	Voice	Data	Combined
Business	9	10	19
Residential	11	6	17
Combined	20	16	36

Table 3
Net Costs of Voice and Data Service to Business and Residential Users

	Voice	Data	Combined
Business	1	1	3
Residential	0	- 6	- 4
Combined	4	- 4	1

trend: merging various narrowband services, then television-type services, office automation and computers. At the same time, though, there also is 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 were ready to offer services, where they were permitted to do so by law. This trend was most pronounced in the U.S. and Japan, but also has reached Europe and some other areas of the Pacific.

Telecom '87 showed ISDN moving ahead in centralized telecom countries such as France and Germany, which have focused on integration rather than institutional diversification. In the United States, ISDN was much more in limbo, largely because of the decentralized nature of U.S. telecommunications after the AT&T divestiture. At that time I was a commissioner on the New York State Public Service Commission, which regulates intrastate telecommunications. Concerned about lagging development, I initiated a regulatory proceeding that led the commission to order an ISDN trial for New York State to help overcome institutional centrifugalism. The trial aimed at two integrations, one across services and the other across carriers. At that time only the United States and Japan had viable competitors, so the CCITT had never emphasized the problems of multicarrier ISDN.

The PSC's 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 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. The commission concluded that the barrier to users' demand for ISDN service was its fragmentation into islands and the absence of far-flung coverage. The PSC therefore asked for a trial, and the industry formed a joint task force to work out the interconnection of 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 Eastman Kodak, Citicorp, Merrill Lynch, Young & Rubicam and Shearson Lehman. By the time the trial ended in 1992, it had led to the testing of equipment interoperability and network-to-network specifications. The hardware questions, vexing as they were, were less difficult to overcome than the interorganizational cooperation and coordinated management issues. The trial created sturdy working relationships among the participants. It is expected to lead to a regular commercial offering. It cost telephone ratepayers virtually nothing and limited the government's role to that of catalyst, not planner. Would such a collaboration occurred by itself? According to trial participants, it was unlikely in the short or medium term because rivalries had led to barriers to cooperation.

At the same time, ISDN hardware and applications forged ahead. At Telecom '91, Japan's Nippon Telegraph and Telephone Public Corp. (NTT) exhibited interconnected videotelephones. Germany, France and Japan demonstrated regular ISDN service.

During Telecom '91 it also was evident that ISDN had problems. Terminal equipment was still expensive or did not exist, and conflicting standards persisted across companies and jurisdictions. Because software developers prefer to work on services where there is a large installed equipment base, the number of applications was limited. In some countries, tariffs were high, because 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, users can choose from switched 56 kb/s, fractional T-1 and fractional switched multimegabit data service (SMDS).

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

How can one evaluate these contradictory criticisms? If 64 kb/s are more than needed for voice, each B channel presumably could be used 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. The technology and economics of fiber networks have progressed enormously. Even so, it will be years before broadband networks are a reality. Just because a problem is solved in the laboratory does not mean that its realization in the network will soon follow. The story of narrowband ISDN demonstrates how slow the process actually is. It took more than 10 years of international standards discussions, and they are still incomplete. Similarly, it takes a long time to develop, build and market cheap terminals, and to introduce services and applications useful to customers. It also takes years for customers to adjust their procedures to the new offerings. And don't forget the politics involved. First, there are the conflicts of industrial development and trade between different countries. Second, there are the politics of competition among different equipment vendors. Third, there are media conflicts within each country. Media policy touches very fundamental issues involving some of societies' most powerful institutions of mass influence and 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: Who will pay for the expensive upgrade of the networks to full fiber and how much will they pay? Fifth, there are new and complex interconnection questions and access charge issues that must be resolved.

Clearly it will take a long time to move from the lab to widespread penetration; even successful technology tests are a long way from reaching ubiquitous penetration. 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% of switches and transmission systems are replaced annually, and the rate is half that for the local loop. Then there are the mundane, but very real, problems of actual rewiring and splicing the sensitive optical fiber.

Is Narrowband the Answer?

Narrowband ISDN (N-ISDN), on the other hand, requires relatively little redesign. Much of the core network already is being digitalized. On the subscriber loop side, such digitalization does not usually require rewiring. It requires a different line card in the central office, and loading coils must be removed for some lines. For about 30% of American rural loops, the wire cannot handle ISDN and must be replaced. Most significant is the need for new digital terminal equipment to replace the analog equipment in place. Replacing analog terminal equipment is an expensive element of N-ISDN, but also is a necessary transition. N-ISDN is a way to migrate to end-to-end digitalization. Even if networks become broadband, they will best function digitally, and this transition will be helped by a base of digital N-ISDN terminal equipment and software applications. Thus, narrowband ISDN should not be seen not as the solution to all communications needs, but as a step to a fully digital and broadband network, a way to travel down the learning curve in equipment and applications, and a way to create a critical mass of users. Standards and protocols should permit broadband networks without making the installed narrowband digital base obsolete. N-ISDN (basic rate interface) 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 and users will flock to the network.

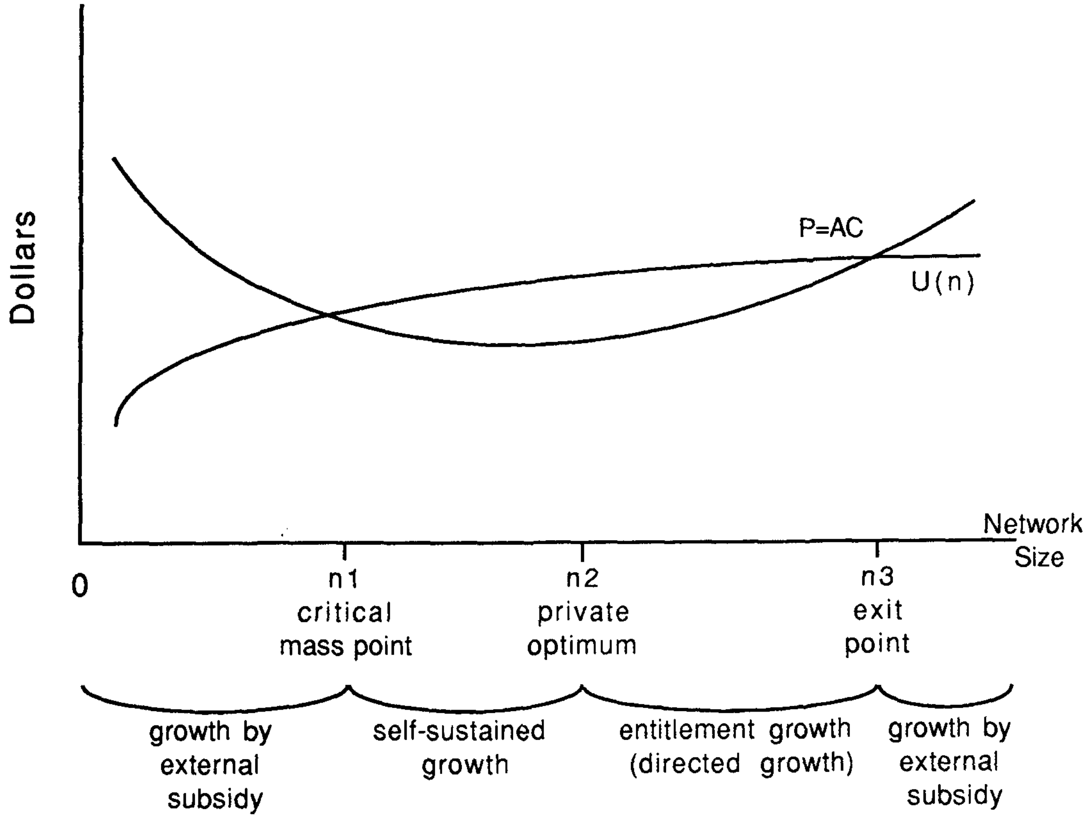
The main problem is to create a critical mass, which may mean supporting ISDN development for several years until there is enough use, equipment and services for it to sustain itself. Japan is one country that has made such a commitment. In 1989, 4% of subscribers had ISDN access; in 1991 that number rose dramatically to 80%. In 1989, a little more than 3500 lines served about 700 subscribers; in 1991 approximately 9000 subscribers were served by 53,000 installed ISDN lines.

The absence of initial support does not mean that end-to-end digitalization will not emerge by market forces. It is likely, however, to mean uncoordinated development. Without ISDN over the public network, 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 between two and four types of terminals for users. Users cannot buy equipment at the corner store or from a specialized vendor and there are great incompatibility problems. Regular facsimile equipment, for example, cannot be used without a codec, which requires a substantial extra fee each month. Furthermore, most small and medium-sized users would not be part of such ISDN islands. These users in particular would benefit from public ISDN.

Yet when it comes to investment in a compatible public ISDN a fundamental problem exists. Figure 1 shows the size of the network on the horizontal axis, and the 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. Owning a videophone obviously 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 those early stages someone 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. It is possible in a monopoly environment to subsidize the early system and to recover the early subsidies later. In a competitive arena, however, 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. It, therefore, will be difficult for the first carrier to recoup early investment. It pays to be the second rather than the first entrant, which is a disincentive to early investment. In a truly competitive local exchange service environment upgrading the networks would be a structural problem, which points to the need for interindustry initiatives. This point is more future-oriented, though, since such local loop competition currently is very

Figure 1



limited, and leaves a window for near-term upgrade investment and recoupment.

Support Plus Coordination

ISDN development requires years of support and coordination. It is not likely to happen by itself. In Brussels, the European Community has established guidelines for tariffs, numbering, availability and services. In Germany, Deutsche Bundespost Telekom is giving users a credit of approximately U.S. $500 to subscribe to ISDN and buy an ISDN personal computer adapter card. It is a strategy similar to the one that France Telecom used to spread its Minitel videotex service. In the U.S. there has been increased awareness of infrastructure problems as the country struggles to make sure that its telecommunications do not fall behind the rest of the world. A recent report by the National Telecommunications and Information Administration concluded that the U.S. is not an ISDN leader and is in fact lagging behind several European and Asian countries, including France, Germany, Singapore and Japan (Table 4).

The National Institute of Standards and Technology (NIST) initiated the

Table 4
Percentage of Narrowband ISDN Coverage* in the United States and Other Large Countries** (Selected Years)

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; Commuincations 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.

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

These steps toward ISDN are only one phase of integration. Fiber is gradually improving its position technologically, economically and politically to migrate further toward end users. And yet, as 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 I³SDN.

Regular ISDN service integrates the various narrowband telecommunications services such as voice and data. 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 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 network goes far beyond the concept of all communications, including video, flowing over a single fiber link. The vision of the exclusive superpipe is often expressed as a scenario in which there is no room for alternative telecommunications carriers or rival transmission media such as cable television providers, because they have become unnecessary. Yet, such a disappearance of other carriers 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 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 must 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 formulated that 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, the free flow of information across the various parts of the network must be protected. If some of the elements of the network system restrict use for certain kinds of content, the entire information flow will be restricted, because at each interconnection point one may have to institute content tests. Physical interconnection of transmission conduits therefore goes hand in hand with common principles on content flow.

These issues will definitely 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, and it is a step that cannot be readily skipped.

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