The Political Economy of ISDN: European Network Integration vs. American System Fragmentation,

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I. Introduction

"Integrated Services Digital Network" is one of those tedious subjects -- accounting rules of depreciation similarly come to mind -- which are at once complex, obscure, and important. Deterred by the dense technological jargon that surrounds ISDN, virtually no social scientist, let alone commentator or politician, has ventured within analytic striking distance of the subject beyond noting its significance in the broader context of global telecommunications, (Schiller, 1984.) [Dan Schiller, "The Emerging Global Grid: Planning for What?," paper presented to teh Final Plenary Session of the 14th IAMCR Conference and General Assembly, Aug. 27-Sept. 1, 1984, Prague, Czechoslovakia.] In consequence, there has been no public discussion of the worldwide reorganization of the ubiquitous and universal telephone network. Instead, decisions on this major infrastructure are investments made almost entirely outside the public view by engineering bureaucracies in government and established equipment manufacturing firms. This is not to say that the basic concept of ISDN is necessarily flawed. What is remarkable, however, is the process of decision-making in which political and economical questions of national and international communications systems, together with large commitments of public funds, have been transformed into expert discussions of technical specifications.

By now, hundreds of technical papers on ISDN have been published. Yet a search of the literature in several languages has not located any published studies (or references to them) that deal with ISDN as a major economic outlay with costs and benefits that need to be investigated. A recent book by a participent to the International ISDN negotiations in CCITT's Study Group XVIII--to be elaborated later--provides detailed accounting of the discussion that lasted several years, (Rutkowski, 1985.) Remarkable is the near total absence in these negotiations of references to considerations of the cost or economic issues involved. But ISDN ceases to be an R & D project and becomes a major social investment, it must also meet non-technical tests, and its impact on industry structures and its relation to general telecommunications policy must be analyzed. The need for such discussion is at least raised by one recent author, (Newstead, 1986.) [Tony Newstead, "ISDN: A Solution in Search of a Problem?", Comment, in Telecommunications Policy, March 1986, p. 2-4.] End-user organizations, which would be a natural catalyst for such analysis, have not come forth with economic studies of ISDN either, partly because they recognize that economics play only a minor role in the decision process, and partly because private sector telecommunications managers, too, tend to come from a technological background and identify with its definition of the questions.

This study will not be able to close the gap by providing conclusive empirical economic figures on ISDN. It will, however, supply a more theoretical economic discussion that must precede any empirical numbers crunching, and provide a limited amount of cost figures. This is followed by a discussion of the history and politics of ISDN, and by a juxtaposition of the concept of ISDN-type integration with the opposite trend in America --network fragmentation --and with its most recent manifestation, open network architecture.

II. The Concept of ISDN

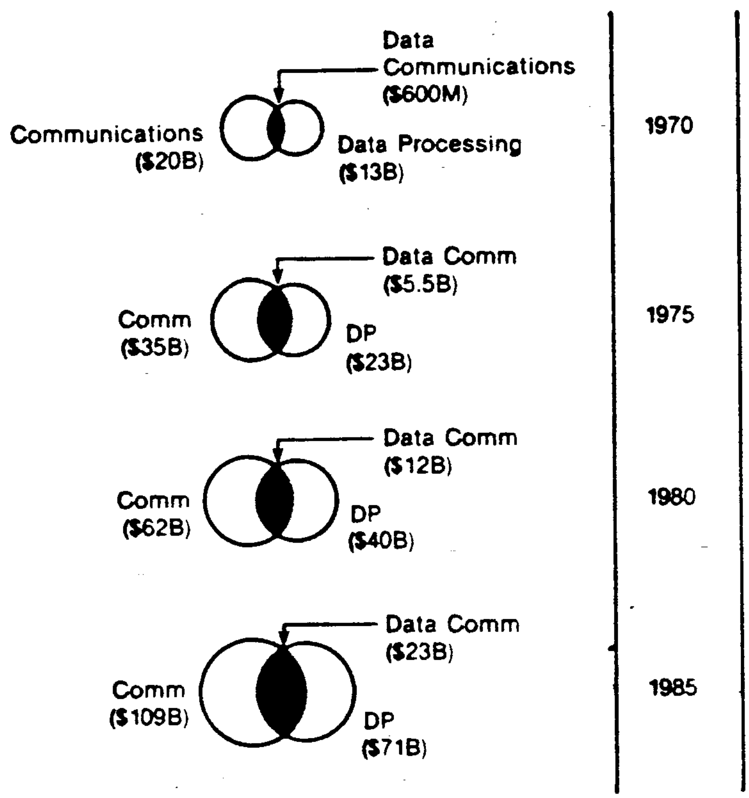
The term "ISDN" encompasses several sub-concepts, and thus some confusion exists about its primary rationale. It is, first, a movement towards digitization. As such, it continues a development of several decades, accelerated by the development of computers, from analog to digital electronics. Digitization has been moving from data processing to telecommunication transmission and switching, similar to its spread to consumer electronics, and soon to broadcasting and motion picture technology. The development of ISDN lies squarely within that trend.

The second element of ISDN is that of upgrading 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 by users, has led to a vast increase in data communications traffic. The attached Figure 1 illustrates that data communications increased during the period from 1970 to 1985 almost forty-fold, while communications and data processing increased about five-fold, (Dept. of Commerce, 1983.) [Dept. of Commerce, NTIS. "Primer on Integrated Services Digital Network (ISDN): Implications for Future Global Communications," NTIA Report 1983-138, Sept. 1983 Washington.] This raised the importance for data communications links of a high capacity, greater than could be provided on analog networks.

Whereas the regular analog voice grade switched communications links support a transmission rate of about 2.4 kilobits/sec., international ISDN recommendations provide a much higher total of 144 kbps for two channels of 64 kbps (B channels) and one "signalling" channel (largely for housekeeping functions) of 16 kbps (the D channel). Although analog technology does not stand still --late generation modems can upgrade the data capacity of analog lines to 19.2 kbps-- the data transmission superiority of ISDN over the existing public network is undisputed.

The third element of ISDN is <u>integration</u>, and is much weaker in its rationale. ISDN claims to put together separate communications networks into one unified super-pipe. From the technologist's perspective, this is a more elegant solution than

Figure 1. Growth of data communications industry.



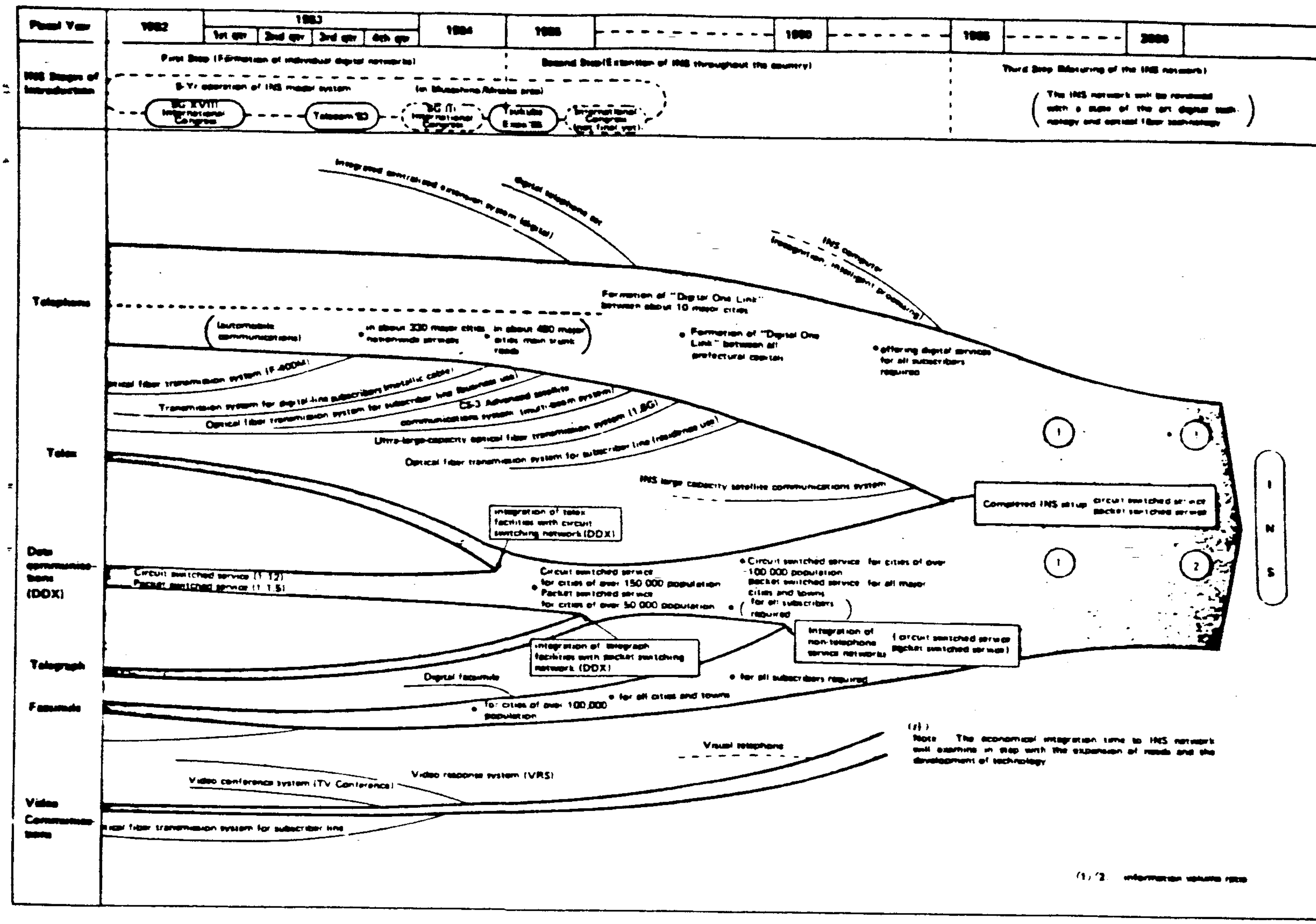
Source: U.S. Department of Commerce, NTIS, "Primer on Integrated Service Digital Network (ISDN): Implications for Future Global Communications," U.S. Department of Commerce, 1983, p. 5.

duplication and multiplication. Figure 2 depicts the planned Japanese digital integrated service (known as INS), into which all communications streams flow.

Almost all ISDN studies start out invoking the wasteful existence of several parallel telecommunications networks -- if they bother to articulate a rationale at all. Some historic perspective is necessary; parallel networks existed from the moment that the telephone emerged more than a century ago as a voice network separated from the already existing telegraph -- the data network of its time. Eventually, telex networks replaced much of the telegraph; still later, the advent of computer communications led to specialized data transmission, an in particular to "packet-switched" networks which move digital data better than the standard telephone networks. The advances in computer technology also led to tremendous increases in performance and reduction in the cost of electronic components for telecommunications equipment; but they were based on the on-off of digital pulses used in computers rather than on the peaks and valleys of analog signals on which telecommunications was based. Soon, the superior performance and cost of ditigal technology spilled into the telephone network, first into its core of interexchange trunks, then to interexchange switches, and then toward the periphery to local exchanges.

This digitalization often led to the establishment of integrated digital networks (IDN) for various data services. But it did not yet reach the subscriber loop and subscriber equipment

Figure 2.



Japan's Information Network System (INS) implementation may begin in earnest during next two years with telex and packet networks integrated, and services in Tokyo, Osaka, Nagoya, and at the Tsukuba Science & Technology Fair. Full ISDN is targeted for 1995. [NTT chart]

Source: International Networks, vol. 2, no. 4, April 1984, p. 8.

itself, (though it came in many instances to within a few hundred feet from them, to so-called A-D converters.) Thus, subscribers in need of digital data communications of more than slow speeds had to operate over special lines outside the public switched analog network. ISDN represents the completion of network digitalization by going the last mile and reaching subscribers and their equipment. It thus provides the capability to dispense with parallel lines for analog voice and for digital services and instead put them together in one integrated stream of bits -- digitized voice, digitized data -- ISDN.

As long as ISDN simply implies digitalization, it is hard to find fault with this development which is part of a broad technological trend. ISDN, however, is more than technological upgrading in that it is also part of a business and polical strategey to consolidate telecommunications in one standardized network. "Integration" is thus not simply an issue of technology.

III. Economies of Scope

The classical arguments in favor of integration are the benefits of "economies of scale" and the joint production benefits of "economies of scope." The latter occurs since the duplication of equipment and personnel is eliminated; similarly, less spare capacity is necessary to handle peak demand loads in integrated production than in providing for them separately. Let us denote C as cost, and assume two services, voice service V and data service D. Economies of scope exist if the joint cost is less than the two separate costs, i.e. if the following inequality holds:

$$C(V + D) < C(V) + C(D) \qquad (1)$$

That this relation exists is generally asserted by ISDN proponents as a matter of *a priori* reasoning, though it has not been empirically demonstrated in publicly available studies. The same logic --that substitute and complementary products are cheaper if jointly provided-- applies similarly to such product pairs as orange juice and beer, beer and aluminum cans, aluminum and aircraft, and aircraft and communications. Ultimately, if one wants to eliminate all duplication, the economy should consist of one giant integrated enterprize. Thus, the significance of economies of scope is not necessarily as simple a matter as it may appear at first. For their proper evaluation, quantification of the magnitudes involved is necessary, plus an evaluation of its cost.

Furthermore, the question is not how to best structure a *new* network, but whether to restructure an already *existing* network. In the short term, virtually all capital in the networks V and D is sunk, whereas a modification for the integrated network (V + D) requires new investments I, as well as the premature retirement R of some equipment used for the separate networks. Hence, the test for integration should be expanded to require

$$C(V + D) + C(I) + C(R) < C(A) + C(B) \qquad (2)$$

The adjustment costs C(I) and C(R) can be, in the short term, quite large, and offset the pure economies of scope. In the longer term, their significance diminishes as equipment gets replaced naturally. But there are costs to a very gradual integration, too, because it requires parallel technologies of different generations to coexist for a long time.

Another problem with the argument of economies of scope is its implicit assumption of static cost functions. That is, costs are defined by the relations C(V), C(D), and C(V+D) without a provision for change. However, analog voice and digital data networks are partial substitutes. Data can be transmitted over the voice network after passing a modem that transforms it into an analog signals. Voice, similarly, can be digitized and be transmitted over a digital network. Some information can also be transmitted either by voice or data form, depending on the costs involved. Hence, separate specialized networks, when under separate control, can provide a competitive environment that can lead to cost reductions and technical innovation. In other words, the cost curves in a separate environment are dynamic; what starts out as the cost relation C(V) and C(D) can become under rivalry C'(V) and C'(V), with the assumption that

$$C'(V) < C(V) \quad \text{and} \quad C'(D) < C(D) \qquad (3)$$

The integrated network should then be more accurately be required to meet the condition

$$C\ (V + D) < C'(V) + C'(D) \qquad (4)$$

which is much less obvious to exist than the relation (1).

It is, of course, true that institutionally almost no country's telecommunications systems permits competitive networks under separate control. But this is not to say that no rivalry exists at all. Most studies of organizational behavior within government bureaucracies would lead to predict that different network services will have their own advocates and constituencies, both inside and outside the organizations. Hence, at least a bit of competition between different networks could exist even in a monopolistic situation. Institutionally, newer data networks can also be structured differently than traditional ones. In France, the Transpac packet switching network has been organized with partial ownership participation of users. (check) But such rivalry would be much lessened in an integrated system.

Another problem with economies of scope is their lack of generality when the number of services is large, as demonstrated with the orange juice example, above. For example, suppose that instead of two networks V and D there exist n different types of data networks -- for example for different transmission rates, different error rates, etc., denoted by D(1), ...D(n). Similarly, let there be a third type of telecommunications network, used for transmission of television programs, and denoted by "TV". Then we have the separate cost functions

C(V), C(D)1.......C(D(n), C(TV)   (5)

It is far from clear where the economies of scope exist. Even if we assume that each service has economies of scope with its immediate neighbors, this does not prove that a total integration across the entire spectrum of networks would produce economies of scope over stand-alone provision. To prove total integration, one would have to show economies of scope between every pair of services, for example between voice and television. But that particular service pair is not fully integrated anywhere -- minor experiments aside -- which would indicate an absence of economies of scope.

Thus, the question of integration then becomes one of choosing clusters of services to integrate, such as [V, D(1), D(3)], or [V, D(2), TV]. It is far from obvious which groupings of service networks are the optimal ones. Should high-speed data be integrated into broadband cable systems, as is the case in some American cable systems? (Noam 1986). [Noam, Eli, "The 'New' Local Communications: Office Networks and Private Cable," Computer Law Journal, Vol. VI, (1986), pp. 901-42.] Or should it be part of an intermediate integration of data networks? Should it be integrated with voice service, even at a high cost? Should it stand on its own? Or should it simply not be provided? None of these questions is answered by the simple reasoning that avoidance of duplication is cost-efficient. As the various telecommunications services are bundled into packages of various integration, invariably some services will be dropped. Integration is a standardization process, which is always a trade-off between the cost-reduction of conmpatibility and the benefits of diversity. A process of integration is hence usually a process of reduction of options.

Furthermore, even where total integration may be cheaper than stand-alone services, the integration may not be stable -- "sustainable" -- if some of the services could drop out of the integrated package. To understand this, it is necessary to distinguish between three cost concepts: first, the stand-alone cost of service of type i, denoted by C(i), Second, the cost of operating i as part of a service package, which is C(I(i)). Third, the incremental total cost IC(i) of adding i to the service package.

$$CI(i) = C[(1) \ldots (n)] - C[(1) \ldots (n-1), (n+1) \ldots (n)] \quad (6)$$

CI may be lower than the cost of integration, due to positive externalities of i on the other services, if it acts, for example, as a backup. Suppose, for example, that the cost of providing i is 10 as a stand-alone service, and 20 as an integrated service because of technical problem of integration. This would suggest that integration is uneconomical. However, total incremental cost of the integrated service may be only 5, due to the positive externalities on the other services. Thus, integration would be economically efficient, but it would not be a stable solution. If each network could act independently, i would drop out of an integrated network, since this would reduce its cost from 20 to 10. Its positive network externalities to the overall service would then be lost to the remaining network. Thus, the integrated system, if it is voluntary, is unstable, or "unsustainable."

The sustainability argument for integration, presented here in very simple terms, is one not made specifically by the telecommunications authorities because it is based on the more rigorous and general theory of industrial organization, (Baumol et. al, 1983), [W.J. Baumol, J.C. Panzar, and R.D. Willig, Contestable Markets and the Theory of Industry Structure, New York, Harcourt Brace Jovanovich, 1982], with which they are only gradually becoming familiar, though this is beginning to change, (Wieland 198x). [find] In any event, the sustainability argument is a theoretical one, and depends on the underlying cost characteristics: it may or may not exist for telecommunications networks.

IV. Economies of Scale

We now widen the discussion to economies of scale, the intellectual ancestor of economies of scope. This concept, probably the single favorite idea in the intellectual armory of telecommunications authorities, states that the cost of providing additional users continuously decreases, and that it is thus cheaper to service all users by one large entity. The concept, closely related to the vague notion of "natural monopoly", has been questioned on empirical grounds as to its actual existence beyond a certain size, (for a review of the empirical literature, see Meyer, 1980.) [J.R. Meyer et. al., The Economics of Competition in the Telecommunications Industry, Cambridge: Oelgeschlager, Gunn & Hain, 1980.] It can also be challenged along the lines used above, namely that the inefficiency of monopoly more than offsets its economies of scale. In the American context, for example, the system of rate-of-return regulation had built-in incentives towards an over-capitalization, known as the Averch-Johnson effect. Competition can move cost curves downwards, which may result in greater efficiencies than in relying on a movement along a downward sloping static cost function.

In the context of integrated service, economies of scale are used to argue that the integration of services creates cost efficiencies by bringing various new communications services to the population at large. Whereas it would be uneconomic for a residential or small business user to have digital data links, this would become affordable in an integrated universal network. By making such services prevalent, their cost per user drops, benefitting also the earlier large users.

If strong economies of scale exist in ISDN, one policy implication could be to subsidize the early stages of its growth. Even if its cost cannot be recovered for a while, eventually costs come down while benefits rise. Early users deserve a subsidy, because their participation lowers the cost for previous and subsequent users; otherwise they may well never sign up and start chain of economies of scale down the cost curve. (For a discussion of network externalities, see Katz & Shapiro, 1985.) [Michael Katz and Carl Shapiro, "Network Externalities, Competition, and Compatability", American Economic Review, June 1985, Vol. 75, No. 3, pp. 424-440.] This argument is a plausible one for a subsidy, though it does not prove a case for integration or for governmental control. But it is true for almost all start-up operations, in any line of business, whether public or private. To judge the justification for subsidy in the ISDN context one needs to have information about the size of the economies of scale.

The need for a start-up subsidy can be used to justify a variety of restrictive policies:

(a) prohibition against alternative network options -- certainly private, but also public -- in order to gain the economies of scale and avoid a loss in revenue that is termed "cream skimming;"

(b) a tariff structure that reduces the required subsidy as much as possible, by increasing revenues through a rate system that charges according to the <u>value</u> of the service to different users, i.e. their elasticity of demand, rather than on the basis of cost. Value to user --- which is not a pricing criterion for economic efficiency -- means discrimination between different users in the price charged, even if the cost of providing them with service is identical. One operational way to differentiate between users on the basis of the service's value to them is to charge on the basis of actual usage rather than on the basis of cost. To be effective over time, price discrimination requires market power, although such power need not be governmental. A volume-based pricing system was employed by IBM years ago when it required the use of IBM-produced punched cards to go with rented IBM computers -- thus creating a usage-metering and pricing system -- and by Xerox Corp., when it rented its equipment and charged according to the metered number of copies. The optimal discriminatory policy is known as "Ramsey-pricing," i.e., charging according to the inverse of the demand elasticities of different customers.

The two policies are interrelated. The establishment of price discrimination that is not based on cost leads to incentives for arbitrage and for competitive alternatives. Hence, it becomes more important than ever to stem these threats of "cream skimming" by prohibitions against competitive networks or reselling.

In other words, the start-up subsidy necessary for the service becomes an argument for protection against competition and maintenance of monopoly. Indeed, a highly perverse incentive is built-in, because the greater the rquired subsidy, the greater the political support will be for a monopoly status that reduces its cost to the taxpayers! An expensive project helps raise not only the economic but also the political barriers to entry. This encourages the introduction of successive large projects that remain in the red long enough to justify barriers against cream skimming.

V. Scale and Scope

Economies of scale is used as an argument for the expansion of network integration to all classes of participants in the public network. As with most of the pro-integration arguments, this is true only under certain conditions. The theoretical problem with the argument can be demonstrated with the following little model. Assume again two types of networks, voice (V) and digital data (D), and two types of users, firms F and residents R. Service can be provided separately, or jointly across services (V + D) or across user classes (F + R), or across both services and user classes. Table 1 demonstrates schematically a situation in which economicies of scale and scope exist, and yet the integration is uneconomical. Each number corresponds to the cost of providing a service of type i to user class of type j.

Table 1

Costs

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

In Table 1 economies of scale exists in the vertical columns, where integration across customers lowers costs for voice service V from 8 + 11 = 19 to 16 and for data service D from 9 + 12 = 21 to 20.

Similarly, economies of scope exist horizontally in the rows of Table 1. For firms they reduce cost from 8 + 9 = 17 to 16, and for residents from 11 + 12 = 23 to 21. Furthermore, full integration -- both across services and customers -- combines economies of scale and scope and lowers total costs to 35, where they would be 40 in total separation, and 36 and 37 in partial integrations. This would argue for total integration. The economies of integration (scale and scope) is greater than each of the sub-economies. Both horizontal or vertical integration are cost reducing.

This analysis, however, is purely based on cost considerations, and is devoid of any discussion of revenues, benefits, and demand. If the price for each of the four sub-categories is arrived at by simply dividing total cost equally, the price for each sub-service would be 35:4 = 8.75. This means that firms are now charged for the integrated voice service 2 x 8.75 = 17.5, rather than the 16 of partial integration, or the 17 of full separation. Thus, they pay more than before.

Of course, it would be possible to structure a pricing scheme that would distribute the cost savings to all types of usages. This would mean price discrimination according to usage type or user category, or both. Yet such price discrimination would establish incentives for arbitrage. Under certain circumstances no price vector could exist that would not make it preferable for some service to be provided separately (non-sustainability). [add.]

A second problem exists if one considers, realistically, that the different service types are of varying benefit to their users. For example, the benefit of data services users may actually be quite small to residential users. Let us assume for illustration that the benefits of the four categories are given by Table 2. These benefits also establish the maximum willingness to pay.

Table 2

Benefits

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

In this situation it will increase welfare -- defined as benefits minus costs -- to integrate voice and data on the firm level, since benefits are 19, while costs are 16, (from Table 1.) But it would not cover cost to integrate the residental service, whose cost is 21, while maximum revenue would be only 11 + 6 = 17. Similarly, it would make sense to integrate voice services for firms and residents, but not for data. Any inclusion of residental data service would have a deficit of 16 - 21 = -5. This could be done through an outside subsidy, as by using the total cost gains of integration (8 + 9 + 11 + 12 - 35 = 5) to offset the deficit, or by charging some or all users and services above cost, up to the limit of their willingness to pay.

Of course, this means that three of the service types do not pay less due to integration; to the contrary, they are likely to be called upon to pay more than before, since earlier they paid less than their benefit, i.e. had a consumer surplus. On the other hand, the fourth service is benefitted. An otherwise lost benefit of 5 is gained, though at a cost of a subsidy of 5.

Another pricing policy would be to eschew a subsidy from one user type to another, and to limit it to a subsidy within a category. This could be done by requiring the residental user to obtain a package of the two services, or none at all. Maximum total payment would be 21, from Table 2, 11 + 6 = 17. Cost of the package would be 21, from Table 1. This would not be sufficient, and hence an additional subsidy of 4 would be necessary, either from outside governmental services, or, more likely, from the other user category. This then creates the incentive to go beyond partial integration to full one, in order to find more services or user surplus for purposes of subsidy.

But in terms of welfare, is this the optimizing policy? Suppose that instead of integrating all four services, one integrates only three and forgets about data service for residents. This would generate costs of 28 (for the three separate services), and benefits of 30, for a total net welfare of 2 (30 - 28), whereas in the fully integrated system net benefits are only 36 - 35 = 1. In other words, societal benefit may not be improved by a cross-subsidy to a user whose benefits from the service is only small, even where one can show economies of both scale and scope. Thus, technical efficiencies by themselves do not prove societal benefits of integration in the absence of consideraiton of user benefits (i.e., of demand conditions). And it is not enough to show that there are <u>**some**</u> benefits to residential users from data service, which is what ISDN boosters do with anecdotal evidence. Instead, it is necessary to illustrate the magnitude of these benefits relative to their cost.

This discussion can be extended beyond a 2 x 2 matrix to additional types of telecommunications services as additional user categories. What is intended here is only a schematic sketch of economic arguments that can be made more rigorously. Economic reasoning suggests that a trade-off exists between variety and literature and that an optimal product diversity exists. (Lancaster, 1975; Salop, 1979; Hemenway, 1975; Spence, 1975.) [Lancaster, K., "Socially Optimal Product Differentiation," <u>American Economic Review</u>, Vol. 64, pp. 567-85.] [Salop, S.c., "Monopolistic Competition and OUtside Goods," <u>Bell Journal of Economics</u>, Vol. 10, 1979, pp. 141-56.] [Hemenway, D., <u>Industrywide Voluntary Product Standards</u>, Cambridge: Ballinger, 1975.] [Spence, A.M., "Monopoly, Quality, and Regulation," <u>Bell Journal of Economics</u>, Autumn 1975, pp. 417-429.] There can easily be too much standardization or inefficient standardization. For a formal model for such standardization see Farrell and Saloner, 1985/86. [Farrell, Joseph and Saloner, Garth, "Standardization, Compatability, and Innovation," <u>Rand Journal of Economics</u>, Vol. 16, No. 1, Spring 1985, pp. 70-83.] [Farrell, Joseph and Saloner, Garth, "Standardization and Variety," <u>Economics Letters</u>, January 1986, pp. 71-4.]

Other contributors to the standardization literature are Arthur, 1983; Kindleberger, 1983; Wilson, 1984; Besen and Johnson, 1986; Katz and Shapiro, 1985. [Arthur, W.B. "On Competing Technologies and Historical Small Events: The Dynamics of Choice Under Increasing Returns," Mimeo, Stanford University, 1983.] [Kindleberger, C.P. "Standards as Public, Collective and Private Goods," Kyklos, Vol. 36 (1983), pp. 377-397.] [Wilson, C., "Games of Timing with Incomplete Information," Mimeo, New York University, 1984.] [Besen, S. and Johnson, L., NEED CITE (1986)] [Katz, Michael L. and Shapiro, Carl, "Network Externalities, Competition, and Compatability," American Economic Review, Vol. 75, No. 3, June 1985, pp. 424-40.]

An important cost of systems standardization such as sought for ISDN is that it tends to lock equipment manufacturing, systems development, and user applications into a pattern revolving around the one standard which may soon be obsolete technologically; however, for any one agent to move to another standard may prove prohibitively expensive. Hence, standards include an element of discontinuity and retardation of innovation For example, the keyboard of typewriters and other input terminals has remained with the traditional "QWERTY" key system, even though studies have shown that a different configuration (Dvorak) of keys increases typing speed and reduces errors, (David, 1984). [David, P.A. "Understanding the Economics of QWERTY, or Is History Necessary?," Mimeo, Stanford University, 1984.]

Such discontinuities exist in particular, when, as in a network, positive externalities are generated by each participant. To leave the standardized system is costly, because those departing lose the benefits conveyed by the other members. Only large agents could then be expected to move on their own towards a new technical specification. However, because their departure imposes a cost (lost positive externalities) on the remaining adherents to the network, the decision to move to another standard may be blocked by administrative fiat as imposing a social cost.

Similarly, the early announcements of new standards is not necessarily the efficient information-enhancing act it is proclaimed to be by its proponents. Instead, it can be the act of a monopolist or of oligopolists aimed at preventing users from moving towards superior technology which they would otherwise choose, by signalling to them that they will lose the benefits of leaving the coalition of the major standard that the monopolist controls, (Farrell and Saloner, 1986.) [Farrell, Joseph and Saloner, Garth, "Installed Base and Compatability: Innovation, Product Preannouncements and Predation," MIT Working Papers, No. 411, Feb. 1986.]

The theoretical analysis of the past sections demonstrated that the case for ISDN, on economic grounds, has not been made persuasively. Empirical figures have not been presented in support of ISDN which would prove advantageous of integration in light of the issues discussed above. However, the battles over

ISDN have never been fought on the grounds of economics. To understand why, one has to go back to the history of the ISDN discussion. This will be done in the next section.

VI. History

Debates over ISDN proceeded in 3 phases, mirroring three key conflicts in the information sector.

A. IBM vs. the Computer Industry

In the early 1970s the integration of computer and communications technology progressed in earnest and lead to the need for interconnection standards. IBM, the market leader, introduced in 1974 such a standard which it called Systems Network Architecture (SNA), by which it sought to interconnect all of its equipment, present and future, and link it to the communication network. However, it found itself opposed by much of the rest of the computer industry, which feared that IBM's control over the standards would give it a serious competitive advantage. In the ensuing dispute, IBM withdrew from the industry study group on interface standards, (Curtis, 1984). [Terry Curtis, "Looking Deeper into the ISDN," Working Paper, Annenberg School of Communications, University of Southern California, Spring 1984.]

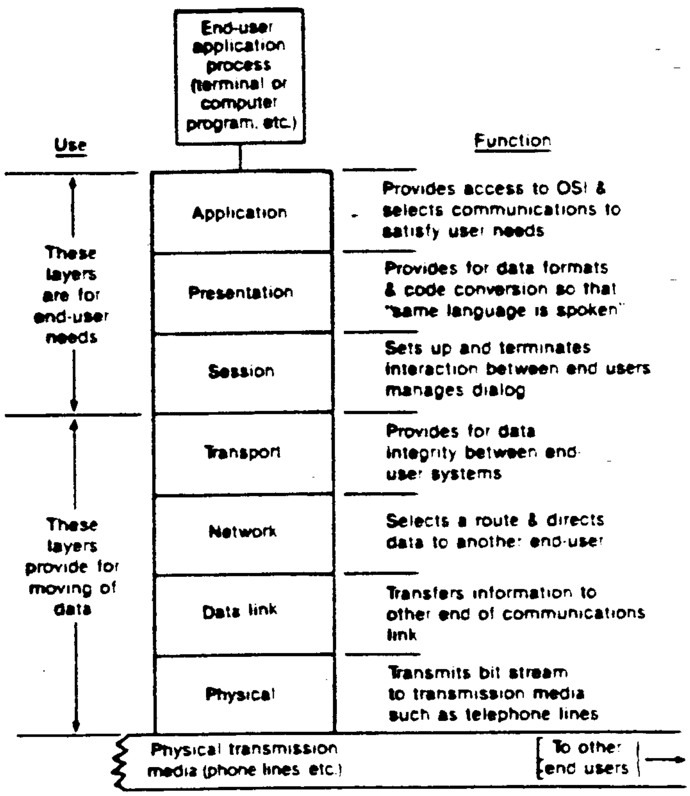
Users, however, pressured for some form of compatible interconnection of computer communications. In response, IBM modified SNA to increase its attractiveness, and it also offered a "network-interface adaptor" which permitted access to public data networks such as the French Transpac. But the rest of the computer industry was not mollified. Thus, the Open Systems Interconnection (OSI) concept arose, introduced at the 1977 Sydney meeting of the ISO (International Standards Organization) and adopted in 1978 as a means to establish open communications and intercompatibility of equipment. OSI established a "reference model" in order to establish a system of subdivided "layers" for telecommunications services, from layer #1 (the physical transmission of information), over layers to control such procedures as the beginning and termination of a call, to the highest layer, #7, the application layer. (See Figure 3.) Both ANSI (American National Standards Institute) and ECMA (European Computer Manufacturers Association). the computer industry technical groups, supported OSI.

In response, IBM began to be more conciliatory. Although it still took a leadership role in standard setting, it did so within the computer industry, rather than on its own, and it joined the standardization process. It also modified its SNA to make it compatible with the OSI specifications.

B. Computer Industry vs. Telecommunications Providers

As IBM became more integrated into the computer industry's

Figure 3. OSI Reference Model Layers

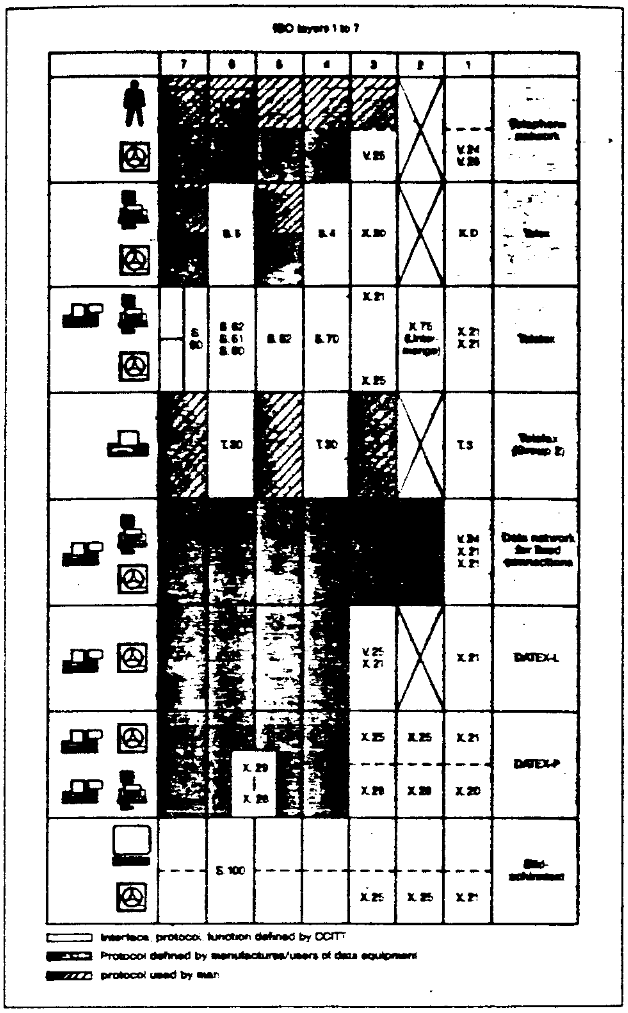


Source: U.S. Department of Commerce, NTIS, "Primer on Integrated Service Digital Network (ISDN): Implications for Future Global Communications," U.S. Department of Commerce, 1983, p. 78.

standard setting, the lines of conflict shifted from those within the industry to those between the computer industry and the governmental telecommunications service providers, the PTTs. (Post, Telephone, and Telegraph administrations.) ^R Simply put, it was either the computer equipment manufacturers who would set standards for the networks and the traditional telecommunications equipment manufacturers, or the networks providers who would set standards for the computer equipment manufacturers. For the PTTs, the threat was that the computer industry would establish standards that would be incompatible with the existing public or specialized networks and would accelerate instead the creation of private networks. Computer standards were the purview of the ISO, while telecommunications standards were those of the CCITT, the Consultative Committee on International Telephone and Telegraph, a body thoroughly dominated by the PTTs and its affiliated manufacturers. In 1980, the CCITT decided to study ISDN and to issue recommendations, i.e., standards. Though some coordination between ISO and CCITT exists, there is also a built-in rivalry. The dividing line between standards set by network authorities and those of computer manufacturers is a meandering one. Figure 4 shows how standards control varies, depending on the type of service (telephones, telex, teletex, electronic mail, etc.) and depending on the layer in the OSI reference model. The shaded boxes are those whose protocols are set by the data equipment makers and their standards organizations, while the white fields

Figure 4.

List of standardised protocols



The above figure is a matrix containing
- the present telecommunication services and
- the 7 layers of the ISO layer model

The figure indicates for each interface whether any, and if so what, protocols have been specified. Furthermore, the origin of the protocols applied in using the various telecommunication services and networks is shown:
- The interfaces, protocols and functions defined by the CCITT are yellow
- The protocols used by man are green.
- The protocols defined by manufacturers or users of terminal equipment are grey

It should be noted that the degree of standardisation is relatively low in the field of data communication (fixed connections, DATEX-L and DATEX-P)

Source: Federal Minister of Posts and Telecommunications, ISDN--The Deutsche Bundespost's response to the telecommunications requirements of tomorrow, Federal Minister of Posts and Telecommunications, Bonn, 1984.

are those of the CCITT. As the Figure explains, the CCITT standardization is less pronounced in various fields of data communications (Datex-P and -L) and fixed connections (private lines).

In 1980 the CCITT established Study Group XVIII, which has proceeded very actively to issue recommendations with the aim of concluding the standard setting by the 1988 World Administrative Telephone and Telegraph Conference (WATTC). (For a detailed chronology of these proceedings see Rutkowski, 1985) [Rutowski, Integrated Service Digital Networks, Dedham, Mass.: Artech House, Inc., 1985.]

The ISDN concept is therefore, in part, a response by the telephone authorities to reassert control over the network as a defensive move. It is also an offensive move in the sense that it expands standard setting and approval power upstream into an equipment field that has previously been the domain of the computer industry.

A similar implicit assertiveness to expand the range of the PTTs' activities also lies in the potential of future broadband ISDN, or IBN. It reflects the PTT's claim to provide in the future television signals for residential use as part of regular public network services. At present, the primary countries with substantial cable television distribution -- the United States, Canada, Holland, and Belgium -- have established cable television as a second network of communications wires, wholly separate from the telephone network. The concept of full integration is thus a challenge to separate cable networks, and to their potential as alternative communications systems of a more general nature, (Noam, 1982). [Noam, Eli. "Towards an Integrated Communications Market," Federal Communications Law Journal, Vol. 34, No. 2 (Spring 1982), pp. 209-57.]

The conflict of telecommunications providers with the computer industry is in particular with the American computer giant IBM. Europeans, in particular, have endowed IBM with near-mythical abilities, which justify drastic government actions. The preoccupation with IBM leads to recommendations to use telecommunications, which governments control, as a lever over the computer industry, now that the two sectors are merging. This strategy was spelled out in the famous 1978 Nora-Minc report to the French President, which became a best-seller, and, with its combination of brilliance, gloom, and nationalism, deeply influenced French and European policy makers and intellectuals. Because of its relevance to the underlying causes for the disputes over ISDN, the report will be quoted at length:

> Paradoxically, IBM's success and the field of its new development provide governments with the opportunity to take their place as the company's intermediaries in an area where they are not so defenseless. Manufacturing and selling machines, IBM had customers and a few rivals. As a controller of networks, the company would take on a dimension extending beyond the strictly industrial sphere: it would participate, whether it wanted to or not, in the government of the planet. In effect, it has everything it needs to become one of the great world regulatory systems. (p. 71-72) ...

> (National governments need to) strengthen their bargaining position with a solid mastry of their communications media.... But the internationalization of the stakes means that today no economic Gallicanism is sufficient to keep Rome out of Armonk. Independence would be vain and as easy to outflank as a useless Maginot Line if it were not supported by an international alliance having the same objecives. (p. 72-73)...
>
> Controlling the network system is thus an essential objective. This requires that its framework be designed to serve the public. But it is also necessary for the state to define access standards; otherwise the manufacturers will, utilizing hte available routes but subjecting them to their own protocols. (p. 74)...
>
> The level of standardization will thus shift the boundary between the manufacturers and the telecommunications organizations; it will be a bitter struggle, since it will develop out of a reciprocal play for influence. But the objective of public control indicates the strategy to follow: increase the pressure in favor of standardization. (p. 75)...
>
> Certain specialized instances (CEPT at the European level, CCITT on a world-wide scale) form the traditional framework within which this telecommunications "international" finds expression. (p. 79)
>
> [Nora, S., and Minc, A. The Computerization of Society, Report to the President of the French Republic (Cambridge: MIT Press, 1980.)

C. United States vs. the PTTs

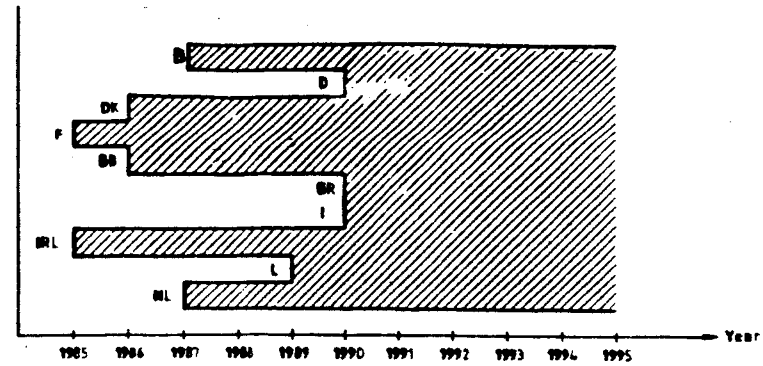
Given this perception, it is not surprising that there are conflicts between the U.S. and the major PTT countries. The concept of ISDN, by itself, does not require monopoly. Strictly speaking, all it means is that the same communication link is able to provide a range of digital telecommunications services. It could be provided by multiple and competing ISDNs or by private customized ISDNs. However, the usage has, at least within the PTTs, implied a de facto exclusivity; the abolition of duplicative network is stressed as a main goal of integration. Economies of scale and scope are the arguments. With such justification, the idea of permitting rival networks seems self-defeating, and deeply at odds with the motivations for ISDN. In the United States, on the other hand, an ISDN cannot be one of exclusivity, neither geographically nor functionally, but must involve the interconnectivity of multiple networks, several of which could be ISDN-types.

Within the European community, on the other hand, the stress has been on a common aliby that goes beyond technical standards into the types of communication services offered and the tariff structures charged. The EEC Commission's Information Task Force recommended in late 1985 in its report on ISDN a common European plan to reduce duplication and fragmentation in the range of equipment, and towards an agreement on common communications tariffs. Figure 5 provides the timetable for European ISDN projects, as compiled by the European Commission. (Ungerer, 1985) [Ungerer, Dr. H., Commission of the European Communities, "Focus on ISDN -- a Review of European Telecommunications Policies," in G. Rusell Pipe, ed., The ISDN Workshop: INTUG Proceedings, October 1985, Cologne, pp. 6-25.] Europeans have been relatively effective in standard setting proceedings; they have tended to coordinate ("harmonize") their positions through

Figure 5.

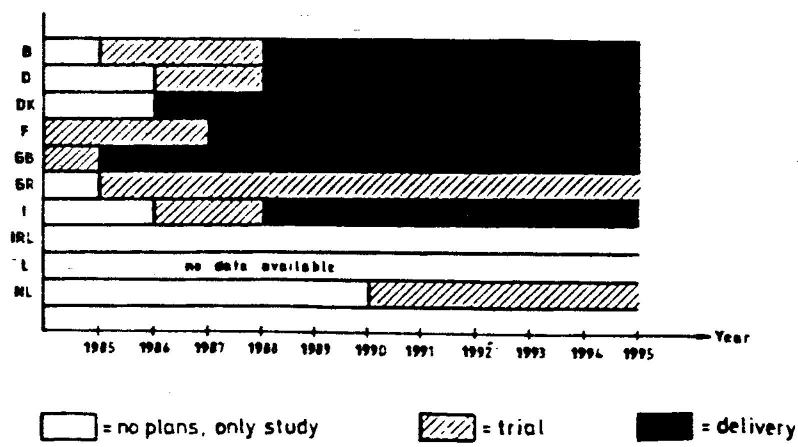
PLANS IN EC COUNTRIES

DIGITAL BACKBONE:



Years in which a Digital Backbone Network will be available for the Administrations in the Community

ISDN NARROWBAND



Years in which the Administration in the Community will start Trials and Provision of ISDN Connections

Source: Ungerer, H., "Focus ISDN--A Review of European Telecommunications Policies," in G. Russel Pipe, ed., The ISDN Workshop: INTUG Proceedings, The International Telecommunications User Group, 29 October 1984, Cologne, p. 21

their regional organizations CEPT, CEN, and CENELEC [check], to leverage their influence in standards organizations such at the CCITT, IEC, and ISO with their one-country, one-vote decision making system.

For United States policy makers, the ISDN creates several problems. The impetus for it has been primarily from Europe under the control of PTTs. Within the United States, much of early ISDN discussion was technical in nature, and not necessarily in tune with the broader policy concerns of U.S. telecommunications policy, (Marks, 1984). [Herbert E. Marks, "ISDN in the United States," Paper delivered at the Twelfth Annual Telecommunications Policy Research Conference, Airlie, Virginia, April 1984]. It was advanced by the American analog of a PTT, the undivested AT&T system, for similar reasons than the PTTs do.

Because ISDN calls for standardization, integration, and international coordination, centralized telecommunications systems such as the European ones had an easier time in formulating their ISDN goals than the United States, where such central decision-making does not exist in telecommunications. Particularly after the AT&T divestiture, American industry is fragmented, and coordination is difficult. The Bell operating companies have formed a central technical organization, Bellcore, to provide some of the services that the old AT&T had provided; but by the nature of decentralization, it can move only slowly. Furthermore, independent telephone companies, including such major firms as GTE, are outside of Bellcore, as are the computer and component industries. A measure of AT&T's diminished ability to set standards de facto even in the United States has been within the American committee (Tl/Dl) that deals with digital standard recommendations, where AT&T has been unable to dominate as in the past. It has been a matter of concern to American electronic industry, as well as to regulators and telephone companies that they would in effect have standards imposed on them from abroad by entites whose operative philosophy was very different from the American one. Comments of the American Telephone and Telegraph Company, para. 18 (FCC Notice of Inquiry, Gen. Doc. No. 83-841, FCC 83-375, Integrated Services Digital Network Inquiry.)

It is is not only the issue of technological preeminance that is at issue. Also in dispute are issues that seem technical but in reality mirror the underlying difference of regulatory philosophy.

The CCITT's Study Group XVIII drafted a long set of so-called I-series recommendations, (Dept. of Commerce, 1983). [Source: Department of Commerce, NTIA, A Primer on Integrated Services Digital Network (ISDN): Implications for Future Global Communications, NTIA Report 1983-138, September 1983.] The FCC has largely excused itself from the details of ISDN standard setting involvement, and has left the technical and system issues to the United States Committee on the CCITT (US-CCITT); but it has kept a close watch on policy issues.

After soliciting comments, the FCC issued on April 2, 1984 its first report in Docket 83-841 concerning ISDN, in which it went further into technical standards in a matter before the CCITT than ever before. It is unusual for the FCC to get involved into regulatory standards issues, given its deregulatory philosophy. On the other hand, the emerging CCITT standards could have anti-competitive consequences, some intended and some only perceived later. As the chief of the FCC's Technical Analysis Division writes:

> Traditionally, the FCC has had almost no role in the technical side of CCITT, as opposed to the tariff side. The reason for the increased FCC role is a shift in the role of CCITT. In the past, CCITT had focused on developing technical standards and operational procedures to facilitate the interconnection of national communications networks. (p. 32)
>
> [Now] the national telecommunications administrations (PTTs) of the world have a legitimate desire to avoid duplication of effort. [p. 32].... However, since only two other countries out of 159 members of the International Telecommunication Union (ITU) have any aspect of competition in their carrier industry, technical decisions made in this forum have a tendency to be biased toward monopoly. This is not to imply that other ocuntries seek to impose their industry structure on the United States intentionally; rather they are focusing on their own situations and honestly do not understand the implications of the US industry structure." [p. 33] [Source: Michael J. Marcus, "The Regulatory Point of View: ISDN in the United States" in Telephony, March 11, 1985, pp. 32-34]

To deal with the ISDN issues, the FCC issued in August 1983 a Notice of Inquiry (Docket 83-841). Its goals were both to generate comments on the FCC's role in ISDN and to stimulate interest in the policy discussion on ISDN itself. The first report, issued in April 1984, restates the FCC's intention for a limited role. It sets, however, several policy principles for ISDN design: a flexible numbering plan that permits user choice of carriers, domestically and internationally (this is possible for international telex today, but not for international telephony under the existing numbering plan); and no limitations of satellite hops in international connections.

Secondly, the FCC declared that customer provision of the network termination device (NT1) should be a national option and asked for comments on the definition of the so-called "U" interface point between customer premises equipment and the network. Thirdly, the FCC described as fundamental that CCITT recommendations must be flexible enough for national options, and that the American distinction between basic and enhanced services be maintained.

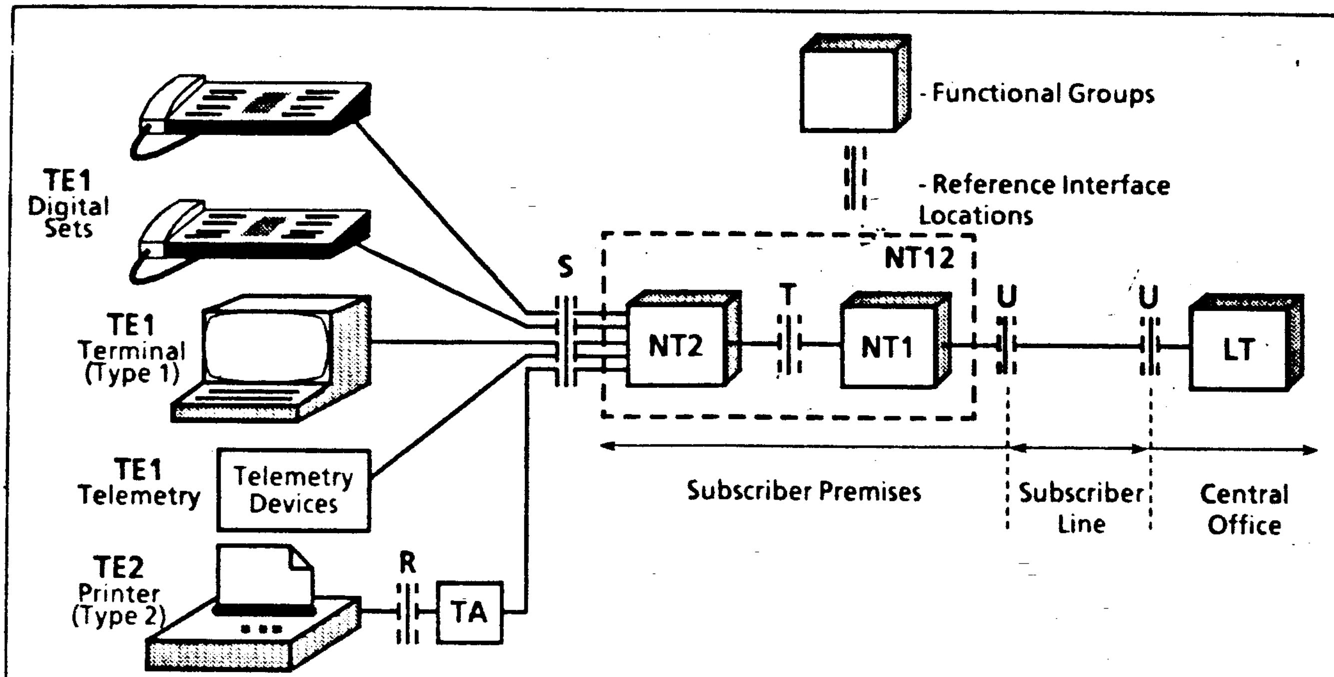
On the numbering issue, the 1984 Brasilia meeting of the CCITT adopted a numbering plan which permits a multi-vendor system not only in the United States, but also accomodates in PTT countries alternative providers of data bases and local area networks, (Schiller, 1984). [Dan Schiller, "The Emerging Global Grid: Planning for What?" paper presented to the Final Plenary Session of the 14th IAMCR Conference and General Assembly, Aug. 27 to Sept. 1, 1984, Prague, Czechoslovakia.]

Much more complicated to work out turned out to be the proper demarcation point, or interface, between the domain of the network and that of the users. Essentially, three inter points are possible, known respectively as the S, T and U points in CCITT terminology. (See Figure 5.) The S point is closest to the end user, and hence carries the network controlled portion far upstream. Between the transmission line and the user, two sets of networks termination equipment exist, known as NT1 and NT2. NT1 provides the maintenance functions such as test loops, power feedings, and timing. The network termination point T is located between NT1 and NT2. NT2 is equipment of a more sophisticated kind and provides functions of switching, muiltiplexing, and protocol handling by equipment such as PBXs, local area neworks, and terminal controllers. The PTTs want to have point S as the interface between user and network, because they would then control equipment standards up to that point. Users and independent equipment manufacturers, on the other hand, do not want to see PTT's control to reach that far.

The attached Figure 6 illustrates the divergence in views between the United States and other industrialized countries, (Reaume, 1985). [Lloyd Reaume, "An ISDN subscriber loop interface," in Telephony, June 17, 1985, pp. 30-39.]

The original American position had been to go with T as the demarcation point; this point had to be defined by the CCITT Study Group, which had thought in terms of an integrated rather than separated NT1 and NT2. (PTTs can integrate them if they wish

Figure 6.



U Interface - Two wire transmission carrying the 2B + D channel format implemented by the MT8972 DNIC.

T Interface, S Interface - Four wire interfaces intended to be physically identical for Star or Passive bus configurations.

R Interface - Existing standard interface such as RS-232-C or X.21.

Network Termination 1 - Transmission line terminating equipment at subscriber side of network.

NT2 - Network Termination 2 - Intelligent device to convert the single T interface to multiple S interfaces.

Terminal Adaptor - Conversion between the ISDN interface (S) and existing interfaces (R) such as RS-232-c or X.21.

Terminal Equipment (Type 1) - Intelligent digital devices that can interface directly to the ISDN specified S or R interfaces.

Terminal Equipment (Type 2) - Existing terminal equipment used with existing interface standards such as RS-232-C or X.21.

Source: Telephony, June 17, 1985, p. 31.

to do so; and the German Bundespost's elaborate graphic representation of ISDN architecture carefully omit even a depiction of point T's existence.) By 1983 the FCC went one step further and pushed its demarcation point inward and to the U point, when it deregulated channel terminating equipment (NCTE) and treated it similarly to previously deregulated customer premises equipment (CPE). [Digital NCTE decision, FCC Docket 81-216.] This had been resisted by American telephone companies, who share some of the sentiments and motivations of the PTTs. Some American equipment manufacturers have also been concerned whether NCTE deregulation would lead to different terminal standards which would make their equipment less competitive in the world markets. Most equipment manufacturers, however, prefer the flexibility which U as a termination point entails, even though it creates coordination problems in agreeing to a U point.

Another problem for Americans is the fit of the CCITT recommendations with the regulatory separation rules of the Second Computer Inquiry, which distinguishes between "basic" and "enhanced" communication services. This separation does not correspond to the CCITT's ISDN recommendations. The CCITT distinction, not strictly congruent in concept to that of the FCC, is between "bearer" and "telecommunications services." Enhanced services are defined as procedures which "act on format, content, code, protocol, or similar aspects of the subscriber's transmitter information," and such services were deregulated and opened for competition. Other services are "basic."

Bearer services, on the other hand, provide basic telecommunications, but also some protocol conversion, which the FCC includes under enhanced services. Teleservices are [ADD]... Thus, the two CCITT service categories overlap some of both of the FCC's classifications; though, in the FCC's view, the CCITT definitions "accomodate" the rules of Computer Inquiry II. Of course, there is nothing sacred about these FCC rules, which are already being modified in light of changing technology and business realities.

VII. The Postal Industrial Complex

ISDN has always meant different things to different people, from a simple and partial upgrading of digitization to more ambitious undertakings encompassing everything up to video transmission. However, recent international standardization efforts have narrowed the term for the present. But these different definitions revolve around technology. A different classification of ISDN is based on its purpose, and distinguishes "hegemonial" from "upgrade" ISDN. The latter is a step in the technical evolution of telecommunications. The former, on the other hand, is part of a general attempt of maintaining control over networks.

In many ways, a classical telecommunications network is a metaphor for authoritarianism. It is hierarchical, centralized, orderly, functional, planned, and monopolistic. Its staff is often uniformed; its policies are set by "experts" rather than "politicians;" their goals are technical efficiency, standardization, and order; its budget tends to be outside the normal course of parliamentary appropriation. PTT organizations are remarkably similar, whether in a democracy or a dictatorship. To be sure, it is a benevolent authoritarianism, since it serves as a mechanism of redistribution. A network is a social concept, since it derives its existance, in a real economic and technical sense, from the sharing of resources, which creates value. Networks bundle the communications needs of individuals, and thereby make communications affordable. They derive benefits from the universality of the network in the community, and partly for that reason, the tradition of subsidizing some classes of users to join the network is long-standing in every country. The rules of the sharing and redistribution are largely set by the technical experts who control the network.

Networks also serve the exercise of speech, and the free movement of information that are essential functions of a free society. The information flows requires increasingly sophisticated apparatus. This tension of authoritarian organization and democratic function worked tolerably well when technology moved slowly. In the recent two decades, however, major changes in technology, the importance of information as an input in the production process, and the general trend towards a services-based economy have vastly enlarged the significance and variety of telecommunications, leading to difficulties for one organization, as effective as it may be, to be solely entrusted with this key task in the economy.

The status quo, however, has its defenders. Over the years, the state telephone authorities (PTTs) have established close alliances with other important segments of society in a broad coalition which can be termed the "postal-industrial complex."

The key elements in this coalition are the PTTs. With their vast procurement budgets and huge labor forces, PTTs are frequently the largest investors and employers in their countries. They are usually staffed by very able and experienced public servants who are effective advocates of their positions and seasoned practitioners of institutional self-preservation.

Nominally, the PTTs are controlled by a minister who is responsible to Parlaiment, and sometimes by a supervisory board. However, the actual ability of these bodies--which are substantially co-opted in any event--to exercise control is limited, in particular where policy decisions have been transformed into issues of technical development and of operations. (For a detailed study of the German Bundespost's _de facto_ bypassing of its supervisory board, including on ISDN, see Scherer, 1985.) [Scherer, Joachim. _Telekommunikationsrecht und Telekommunikationspolitik_, Nomos, Baden-Baden, 1985.]

Apart from their own positions of direct influence, much of the PTTs' power arises from allowing other groups of society to share in the benefits of their monopoly. One such group are the equipment manufacturers, typically huge private companies with strong political connections. In most European countries the market share of the largest four manufacturers in total telecommunications equipment is above 90%. These companies are among the most potent European firms and tend to set the tone for the private sector's telecommunications policy preferences within general industry associations. In the equipment markets, PTTs fill the role of a monopsonist, or primary buyer. The maximum of joint profit for both monoposonist (who is a monopolist supplier of the final product) and a group of oligopolists usually lies in some form of cooperative behavior. The PTTs therefore are instrumental in coordinating the industry, an arrangement that can be advantageous to suppliers, who as a result need not compete vigorously against one another.

A variety of barriers are set to protect this cooperation; these include an unwillingness to procure foreign equipment, coordinated development of new technology, and PTT-organized setting of equipment standards.

One consequence of this protective system is that European prices are said to be 60 to 100% higher for switching equipment and 40% higher for transmission equipment than prices in North America, even before divestiture generated competitive supply for the equipment of the Bell companies, (OECD, 1983.) [Organization for Economic Cooperation and Development, Telecommunications: Pressures and Policies for Change, Paris: OECD, 1983.]

The labor unions hold a similarly supportive position because PTTs are among the largest national employers, and because employees benefit from salary levels and job security that may not be sustainable under a competitive regime. Furthermore, for unions as well as for the political left, the existing PTT system merits support not only for material but often also for ideological reasons, as a nationalized key industry. The frequently ideological class divisions in Europe lead to a strong feeling that a critical part of the infrastructure, particularly one with such future importance in the information society, cannot be entrusted to private interests dedicated to the profit motive.

Other members of the postal-industrial coalition are the poor, the elderly, the farmers, and the small towns, all of whom support the PTT system because they fear that a liberalized regime would threaten the subsidy of their service.

One would expect that large end-users would be outside this coalition; however, the largest such users tend to be financial institutions, who, in their capacity as lenders and investors, have in most European countries the closest of ties with the equipment industry.

The office equipment manufacturers, new computer companies, and data processors have been somewhat outside the postal-industrial complex, at least in the past. In recent years, however, the PTTs have been able to draw them into their orbit, often assuming a key role in domestic industrial policy.

This role makes the PTT an important financial backer, valued customer, domestic protector, and international promoter in high-technology markets. They can channel development contracts to domestic industries and undertake tests of such technology. They can also coordinate R&D among manufacturers and provide nontariff protection and export advantages. The PTTs assume some of the costs of the early part of the learning curve, and in effect subsidize the development of products that are then offered in the world market. ISDN is an excellent means for this strategy. Europeans, of course, assert that defense and space spending in the United States has filled many of these same functions in the past for American industry and that the encouragement of a high-technology industry is an important governmental function.

The key element of the coalition between bureaucracy and establishment equipment manufacturers is strongly evident in the discussions on ISDN. And for good reason. In most European countries, the decades following World War II have been a very active period in the expansion of telecommunications. The combination of war damage repair and the expansion of telephone penetration from the business and upper classes to universal use has kept telephone authorities busy and manufacturers profitable. But this expansion arrived at its natural plateau when most households were served. Whereas in 1960, only some twenty percent [check precise figures] of the German households had telephones, by 1982, it was over 80%. [check] In France, the bitter saying in the early 1970s was that one-half of the country was waiting for a telephone installation, while the other half was waiting for a dial tone. After a major development push, penetration by 1984 was over 80%. The implications for equipment manufacturers were clear; the domestic market was close to saturation in terms of standard equipment and would decline; this would leave them only with the export market, of which, according to an OECD study, only 15% was free from protectionism. [OECD 1983.] Furthermore, the absence of a strong domestic market is also likely to make exports more costly, since they would not benefit from economies of scale in production. (On the advantages of protectionism to exports, see Paul Krugman, 198x.) [FULL CITATION.] One way to activate the sagging domestic market is therefore to launch an ambitious program of upgrading, and ISDN is just such a project. Figure 7 illustrates, for Germany, the role of ISDN digital upgrade for both transmission and switching.

The investment in a major upgrading of the network has the effect of raising barriers to entry in the following ways: First, it increases the required initial investment which a potential rival needs to match the upgraded technical capabilities of the existing network. Second, where there is a trade-off between fixed costs and marginal costs, as there often is, the latter are lowered by the investment, making it more difficult for a rival to enter and match marginal cost pricing. Third, by raising the initial investment, one can stretch the

Figure 7.

A. Annual Investments for Transmission Technology (Germany)

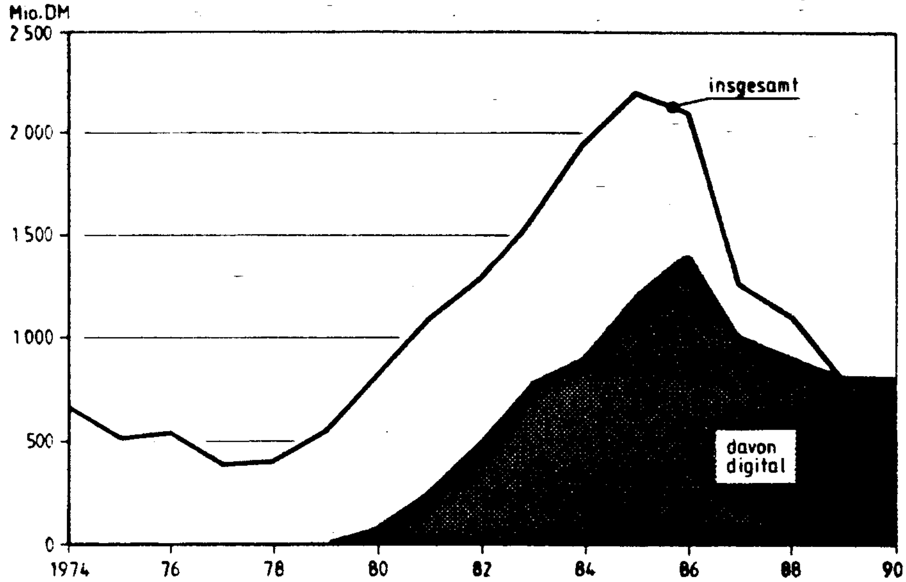


Bild 2: Jährliche Investitionen in der Übertragungstechnik

B. Annual Investments in Switching Technology (Germany)

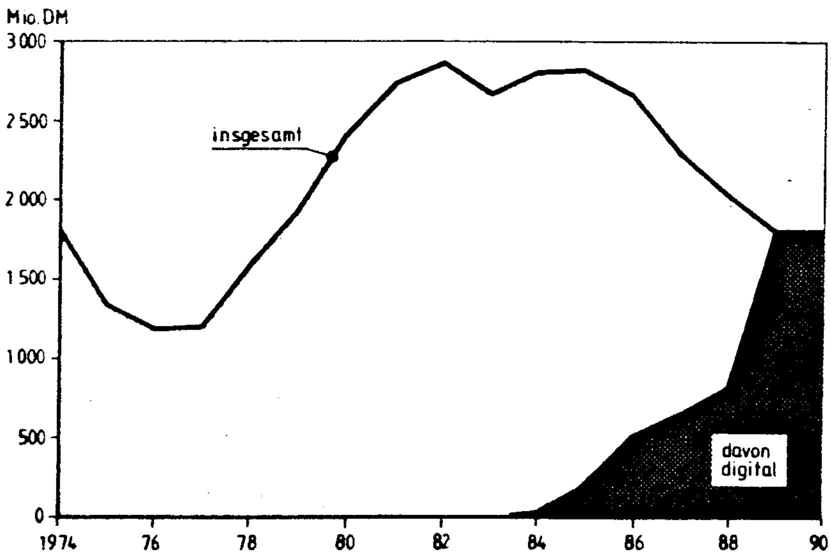


Bild 3: Jährliche Investitionen in der Vermittlungstechnik

Source: Helmut Schön, "Das ISDN im Investitions-, Industrie- Und Fernmeldepolitischen Kontext," in W. Kaiser, ed., Integrierte Telekommunikation, Münchner Kreis, no. 11, Springer-Verlag, Berlin, 1985.

range of economies of scale, (declining average cost), and thus of "natural monopoly." The trough of a U-shaped cost curve is shifted to a higher level of production by an increase in fixed costs. This can be shown analytically. Table 3 provides simple numerical examples for three cases.

Table 3

Schematic Costs of Two Systems

(a) Fixed Costs = 50

No. of Users	0	1	2	3	4	5	6	7
Marginal Cost:	50	5	10	15	20	25	30	35
Total Cost:	50	55	65	80	100	125	155	190
Average Cost:		55	37.5	26.67	25	25	25.83	27.14

(b) Fixed Costs = 100

Marginal Cost increments = 5

No. of Users	0	1	2	3	4	5	6	7
Marginal Cost:	100	5	10	15	20	25	30	35
Total Cost:	100	105	110	125	145	170	200	235
Average Cost:		105	55	41.66	36.25	34	33.33	33.57

(c) Fixed Costs = 100

Marginal Cost Increments = 3

No. of Users	0	1	2	3	4	5	6	7	8	9
Marginal Cost:	100	3	6	9	12	15	18	21	24	26
Total Cost:	100	103	109	118	130	145	163	184	208	234
Average Cost:		103	34.5	39.33	32.5	29	27.16	26.28	26	26

In the first case, fixed costs are 50. Minimum average cost is reached between 4 and 5 users; after that, average cost increases. In the second situation, fixed costs are now 100, while marginal costs remain as they were before. Now, average costs decrease up to user number 6, and thus start to go up later than before. This effect is still enhanced if, as in part (c) of the table, marginal cost is smaller than before, as a trade-off to the higher fixed cost. Now, average cost bottoms out at 8-9, at a cost of 26 that is similar to the one of the original model (25) and justifiable in light of the greater network capabilities. But while at the original number of users, (5 in example (a)), total cost was 125, it is now 145.

Where marginal costs are not increasing but are constant or falling, the incremental economies of scale would be more pronounced with the larger fixed cost, along the same principle.

The PTTs seeking support for their domestic position have been courting their traditional allies by dangling ISDN before them. A good example is provides by a high official of the German Bundespost.

Helmut Schoen, now head of Telecommunications at the German Federal Ministry of Post and Telecommunications, argues that ISDN is important for export success of German industry; and that it requires the ability of the Bundespost to play a role in the equipment supply field, a role which has been under attack by the

German Monopoly Commission and the German Ministry of Economics.

Schoen tempts equipment manufacturers with this argument:

> One secret of the German telecom industry's success on the world market is that it has led the way in the field of standardization. Teletex (electronic mail) also came from Germany as a fully standardized service, which gives us a certain international lead over other countries at the moment. (p. 22)
>
> But teletex was practically the last great achievement in terms of standardizing a complete service with all the telematic protocols. This was only possible because all-round operating experience with telex equipment exclusively serviced by the DBP could serve as a basis. <u>An organization can standardize services only if it has experience with both network and terminals because their protocols and operating systems relate to each other.</u>" (p. 22, (emphasis in original.) (Schoen, 1984.) [Schoen, Helmud, "The Deutsche Bundespost On Its Way towards the ISDN." Zeitschirift fuer das Post-und Fernmeldewesen, Heft 6, 27. June 1984, pp 13-24; Joseph Keller Gimblt & Co. (English language version.)

Thus, Schoen tells the German equipment makers that their success on world market in the rich area of ISDN depends on letting the Bundespost play a role in the equipment field:

> In order to standardize state-of-the-art ISDN services and press ahead with these at the international level <u>the network operator must also be in a position to gather experience with new teletex, videotex, and facsimile terminals himself.</u> (p. 22, emphasis in original.)

But lest this could cause alarm to equipment manufacturers or the Ministry of Economics:

> Just a small market share of 10-15%, as is the case with Telefax (11%), and PABX's (16%), suffices for this purpose. Even if the PTT does not earn anything directly through the terminal business because it must generally bear the worst risks

> (i.e. small customers and hinterland subscribers), the gain for the network operator is indirect in his enhanced potential when it comes to service standardization. And ultimately this benefits the network. (p. 22).

Schoen then appeals for industry support of the Bundespost in international standard-setting:

> If in anticipating CCITT work in this way we come close to the mark with regard to international standards, redevelopment costs will be low. If our aim is bad, though, and the next CCITT study period brings clearly differing results for standardization, the outlay will have gone down the drain. <u>But the international race for the ISDN, in which we Germans have out noses out in front, demands its price in business risks.</u> (Emphasis in original.) [page]

Schoen is frank in claiming the special role of standard setting for export success:

> The PTT that takes on the leading role internationally when a new service is standardized gives the communications industry in their country a big headstart in this service. (German industry is currently enjoying such a headstart with the new teletex service.) The German communications industry in particular, with its small domestic market, is dependent on larger markets being created through international standardization. The Deutsche Bundespost has so far played a prominent part in this context (telex, teletex, telefax). Not least of all for this reason is the Federal Republic of Germany, the largest exporter of communicatins products in the world, with a export quota of 30%. <u>Anyone who blocks this influence in his own country damages the innovative force of a future technology and ultimately the entire economy.</u> (Emphasis in original) (p. 22)

Schoen also uses ISDN as an argument against liberal interconnection. Equipment that is connected would require permission: even control over some usage features is claimed:

Provisions for testing the access lines have been

> incorporated in the networks termination, and the network users must not interfere with these by manipulating the terminals in an inadmissible manner (e.g. by unplugging them.) (p. 21)

Going still one step further, the German telecommunications equipment industry, consciously promoting a demand for public high technology assistance around the ISDN project, commissioned another former head of the governmental telecommunications department, Franz Arnold, to report on the ISDN. His study is, if anything, critical of the Bundespost's ISDN and cable television plans as too timid. He argues that it is necessary to develop fully integrated video and voice communications. Arnold calls for a "national effort" (nationale Anstregung), which would include private and public funds, in which ISDN provides a first step in the right direction. This would provide German export industry with future potential, which it does not have in the present traditional copper wire oriented technology. For such support, public funds have to be available to reduce private risk. (Source: Mueller-Sachse, Karl H., "Noch fehlt die nationale Anstrengung." Medium, 2/84, p. 6-7.

In pursuit of goals, the Bundespost took an administrative leadership role in the CCITT Study Group XVIII which was chaired by a German official, Theodor Irmer, who subsequently became the head of the CCITT itself. It was also the first PTT administration to announce a tariff structure for ISDN.

VII. Network Fragmentation and the Open Network Concept

In America, the idea of all telecommunications under one organization was never palatable. Even in AT&T's heyday, it shared the field geographically with almost 2000 other independent telephone companies (covering more than half the country and 20% of subscribers), and functionally with the domestic and international record carriers, and with the international record carriers. Deregulation and divestiture accelerated the fragmentation of networks. The term "fragmentation" is not a negative characterization. What is meant are alternative or specialized networks, usually controlled and operated by several entities, and usually interconnecting with each other. First to emerge were private and then public alternative long-distance carriers, of which MCI, Sprint, and SBS were the largest. Their story is well known. Subsequently, rival <u>local</u> transmission began to take place too, known as "by-pass" service. This was accelerated by the emergence of "shared tenant services," which provide resale of local bypass service and also provide competition in local switching. These developments led to yet another and still more radical approach that is just beginning to emerge, known as "open network architecture," (ONA), similarly known as "comparably efficient interconnection," (CEI). (The former term is broader and more descriptive.) This approach is not incompatible with ISDN in terms of technology; there could easily be an ISDN-ONA, and in the United States this is likely to happen. But in terms of underlying philosophy, ONA derives from a diametrically different concept of the future environment of the telecommunications networks, and of the role of the major carriers in it than those held by ISDN's major international supporters.

Open network architecture expands the concepts of service alternatives and network fragmentation into the very core of the networks, and lowers barriers to entry for rival and varied communications services. ISDN, in contrast, is part of an effort to raise entry barriers and assure monopoly by providing a highly integrated network. ONA unbundles, where ISDN consolidates.

The "open network architecture" concept must be distinguished from the similarly named "open systems interconnection" (OSI) of the International Standards Organization which provides a definitional framework of seven broad layers of the entire network process, as could be seen in Figure 3. ONA takes this further by not only going into more detailed sub-functions of several of these layers, but also proposing their functional separation together with a business and regulatory policy concept.

Ameritech, one of the seven regional holding companies, proposed in February 1985 to the FCC a first-generation model of the new concept, named somewhat inelegantly "feature node/service interface" (FN/SI). A similar concept, though less detailed, was presented in November 1985 to the FCC by US West, another of the Bell regional holding companies, under the name of "open network architecture." A variant of ONA is also known as "comparably efficient interconnection" or CEI, the term which the FCC uses in its Computer III Notice of Inquiry when it requested comments on the concept. An operational framework for a CEI was reached in March, 1986, by three major firms with diverse interests: Pacific Bell (carrier), IBM (equipment supplier), and Tymnet (value added provider).

ONA is a framework of disaggregating network components in such a way that permits open access; it operates on the concept that all central office functions consist of components known as "primitives", or fundamental building blocks, and that these components can be unbundled. Different communications services use different building blocks, or different configurations of them, sequenced in various ways by a routing central point (RCP). The open network architecture permits the use by outside parties (users or third-party service providers) of the building blocks of their choice. Where any of the blocks could be provided cheaper or better from another supplier, it could be substituted and combined with blocks of the local exchange company. In other words, competition would exist for the various functions of the exchange switch by unbundling its multiple functions. To make such a system work, service providers could in some instances co-locate their own "third party feature nodes" on the physical premises of the local exchange company. The third party service providers are partly a form of value added networks, competing physical networks on the local level, and partly simple resellers. In all of these functions they would compete head-on with the local exchange companies who act both as retailers and as wholesalers of these services.

Through ONA/CEI, the local exchange company would permit the resale of separate parts of its services, down to separate functions of the local exchange. This is a radical reversal of past practice, where the monopolistic telephone companies tried to prevent resale. Now, the local exchange companies are recognizing that their network is their greatest asset, and that they should sell its capabilities as much as possible, to the point of encouraging the use by outsiders. In this fashion, the network would be more highly utilized, and the telephone company could profit.

Rather then fight competing local bypass service, the local exchange companies aim to benefit from also using it to become more <u>unregulated</u>. Indeed, the desire to become deregulated in local exchange functions is the motivating force in these proposals, and raises problems for the regulators.

Most immediately, the companies are striving to be freed from the restrictions of the Computer II Inquiry rules. The BOCs desire to offer enhanced services. Under Computer II, however, this was possible only through the cumbersome device of fully separated subsidiaries for these services, in order to prevent cross-subsidies from the monopolistic and regulated basic services to the competitive services. The ONA/CEI concept substitutes a functional technical separation for the organizational-legal one. Once the building blocks are separated from each other, a pricing mechanism can be put into place that can establish transparent and non-discriminatory pricing for all, whether they are re-sellers or the local exchange company itself. For those building blocks where a true competition exists, deregulation could be instituted. Elsewhere, tariffed rates would be set.

Clearly, a wide array of complex regulatory questions need to be resolved in the process of introducing ONE/CEI. (A similar unbundling concept, though less differentiated, had been imposed by the FCC in its earlier proceedings on asynchronous/X.25 protocol conversion. [CITE]

Another reason for the open network architecture concept for the companies is to move to a more flexible environment in their own equipment and software procurement. At present, central office switches are highly integrated equipment, and their operation depends on extraordinarily complicated software. Thus, the local exchange companies are largely dependent on their switch suppliers, mostly AT&T and increasingly Northern Telecom, to modifty the software for new functions. A modular approach of separated functions has operational as well as economic advantages. New services could be introduced more flexibly by adjusting equipment and software modules, or by substituting them through shopping around in a competitive market.

In technical terms, the ONA/CEI approach is not contradictory to ISDN since an ISDN operator could similarly provide for the subdivision of its functions, selling them separately and permitting various reconfigurations and resale to third parties. This is likely to happen in the U.S. in the future. But, attitudinally, the ISDN concept as presently held by its champions abroad is widely different. While the open network architecture is another step in the fragmentation of American networks, the PTTs purpose for ISDN is another step in its centralization.

The ONA concept, for example, makes it clear that third party access and use will be provided to the common channel signaling. This is important, because many of the sophisticated communications functions and operations are greatly facilitated by that channel, and the exclusive control of the dominant common carriers over it as an internal housekeeping channel constrains their rivals. In the ISDN context, ONA would thus provide access to the D- channel. In the European ISDN context, the signalling D- channel is not being offered for user access in the same way that the B- channels are. [check]

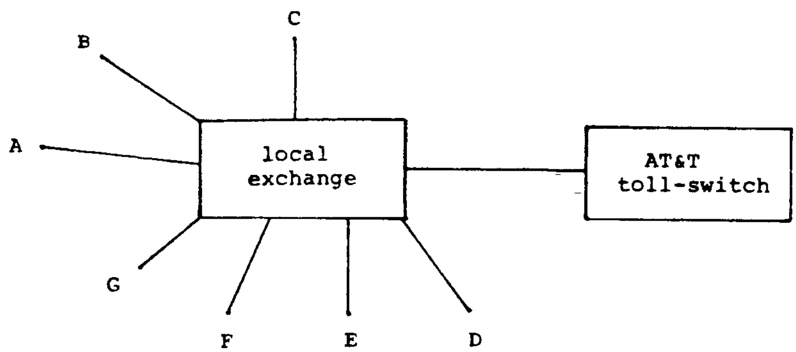
ONA/CEI are not the only move of fragmentation in central office switching. Already mentioned were shared tenant services, by which multiple users share a common (non-partitioned) PBX. This concept, by its economic logic of aggregation, does not stop at the building line, but has already begun to move into the clustering of office buildings, (Noam, 1986). [Noam, Eli, "The `New' Local Communications: Office Networks and Private Cable," Computer Law Journal, Vol. VI, 1986.]

Another manifestation of this fragmentation and specialization is the emergence of inter-organizational networks (IONs) which can be understood as interconnecting value-added networks, i.e., with access at the higher level of the OSI reference model. [add]

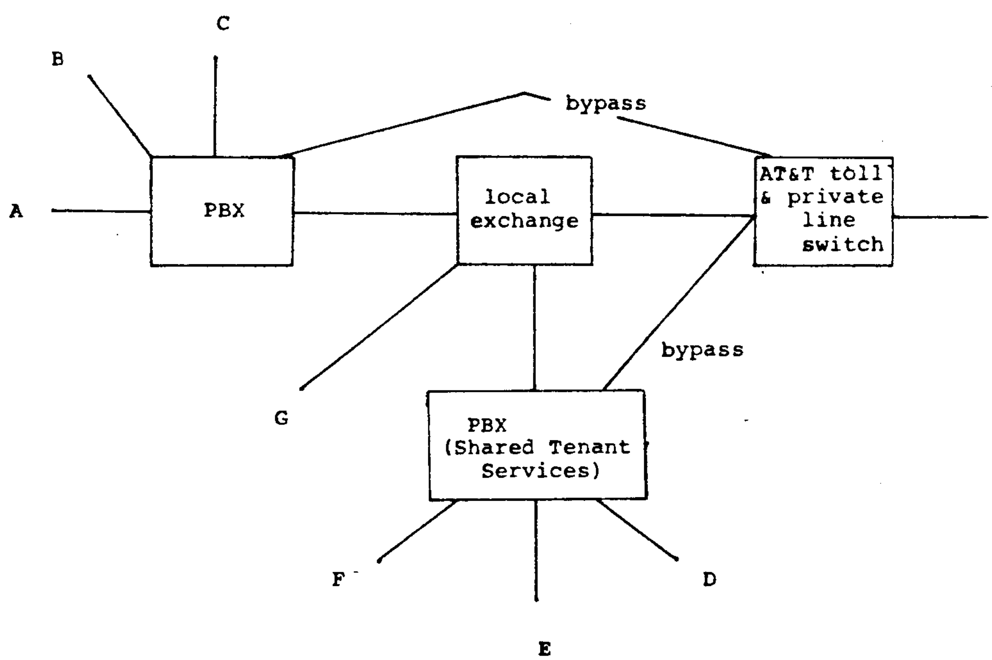
Another step in the direction of competition in local transmission and switching comes from AT&T, technically precluded from local service by the Divestiture decree. AT&T is moving back, nevertheless, in two ways. First, it establishes local bypass in transmission by setting up of leased facilities to give end-users direct access to AT&T's long-distance switches. In New York, this is done over the fiber optic lines of an independent carrier, Teleport Communications. More interesting is AT&T's move into local switching under its Software Defined Network (SDN). Under this system, AT&T links customers in a tie-line network and permits them to switch their calls in the AT&T toll switch. For example, the internal network of a company's site A, concentrated by a PBX, is linked by bypass service to AT&T's toll switch, from where it is moved to the company's sites B and C in other locations. PBXs at B and C route traffic to their destination according to a programmed dial plan. What this means is that in this network, any terminal can reach any other terminal without ever using the local exchange companies or their public switched network. It is clear that technically this system can be taken one simple step further--in technical terms--with the AT&T toll switch connecting also between <u>different</u> users who have tie-lines to the AT&T switches, and also <u>within</u> the local exchange area itself, omitting the trunk transmission portion. This would make AT&T's toll switch, together with customer PBXs, into an alternative system of local switching. This can be illustrated in Figure 8. In Section (a) terminals A-G are interconnected through the local exchange in the conventional way. In Section (b), terminals A-C and D-F are interconnected to each other by PBXs. This is frequent for internal networks, but shared tenant services (STS) move it also into the interconnection of unrelated parties, and potentially entire clusters of buildings. The PBXs, in turn, can be interconnected in two ways: first, to the regular local exchange, partly in order to access a user of type G. But in addition, they also can link to the AT&T toll switch, which can switch them with or without toll transmission (at least in technical terms; regulation may be a roadblock). Thus the local exchange has now competition from the two directions. For user clusters A-C and D-F, it has internal and STS- PBXs as rivals to

Figure 8.

a) Traditional centralized local switching



b) Competitive local switching



its service. And for connections between those clusters, it has AT&T/s "toll" switch as a competitor. A switched call could thus be made from user A to user F entirely outside the local exchange.

VIII. Effects on End-Users

One advantage of an ISDN system is that it allows an increase in the bit rate of data transmission, typically from 2.4 kilobits/sec to 64 kilobits/sec. This means that a regular sized letter sent by telefax, which now takes several seconds, would take less than one second. Similar advantages exist for the transmission of electronic mail. Those two applications are likely to benefit most from digitization. Slow scan pictures can also be transmitted, and videotex service will be quicker and of better quality.

Perhaps even more important is that the existance of two basic channels makes possible a doubling of the line capacity. Instead of having to add a second line to a household with substantial telephone usage, a single digital line suffices. With data compression, even more than a doubling could be accomplished.

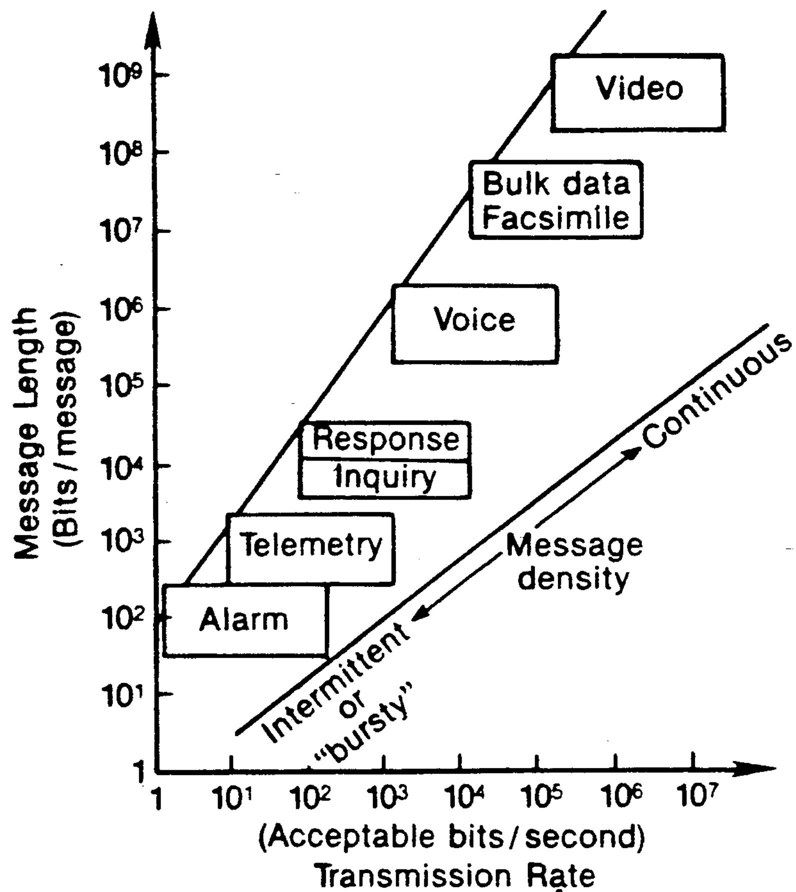
On the other hand, there are problems, which explains its less than enthusiastic reception.

A. Technical Capability

ISDN operates primarily on two channels of 64 kbps which is an intermediate speed. As can be seen in Figure 9. [U.S. Department of Commerce, NTIS, Primer on Integrated Service Digital Network)ISDN): Implications for Future Global Communications, 1983, p. 40.], customer data needs vary widely. Some services need only a very slow bit rate. For example, telemetry such as meter reading, security, alarm services and energy management require 300 bits/sec or less. Inquiry response applications such as airline flight reservations, electronic banking, or elecronic shopping require rates of less than 4.8 kbps. A 64 kbps rate supports transmission of quality facimile as well as simple fixed graphic images. Voice transmission in the United States has in the past been generally encoded at 64 kbit/sec, but 32 kbps is emerging as a frequently used rate of sufficient quality. Thus, one need not expect the 64 kbps requirement for digitized voice to endure. This is a fairly high standard for digital encoding, and it had been chosen in the context of an analog network with frequent modulations and demodulations. In a digital network, 32 kbps is adequate, which would again double the voice channels available. It is already used in some transmission. By various forces of compression, voice transmission of regular quality has been accomplished with as little as 9.6 kbps.

On the other hand, the transfer of bulk data such as large data files, or communications among mainframe computers, uses

Figure 9. Range of message lengths, density, and transmission rates for ISDN planning (after Skrzypczak et al., 1981).



Source: U.S. Department of Commerce, NTIS, "Primer on Integrated Service Digital Network (ISDN): Implications for Future Global Communications," 1983, p. 40.

much higher rates. In the United States, they are typically in the T1 rate range of 1.544 megabits/sec, i.e, more than 20 times faster than rates of the ISDN, and in Europe at 2.048 megabits/sec.

Full motion broadcast-quality video requires an analog signal of about 4.5 mhZ, or about 100 megabits/sec as a digital signal. Using signal compression techniques, the signal can be compressed down to 1.5 megabits/sec., i.e., the T1 rate. For slow scan video or video conferencing where high quality may not be required, a slower rate is possible. (Felts et al 1982) [Wayne J. Felts, Warren S. Gifford, and Frank J. Grāpzer, "Bell's Concept of the ISDN," in Telephony, Oct. 25, 1982, p. 43-51.]

ISDN thus results in a compromise rate: faster than necessary for some users, but too slow for others. Avoidance of duplication is thus offset by loss of the advantage of specialization. What is to some a "streamlining" of services is to others a loss of technical options.

B. The Scope of Integration: Towards the Integrated Broadband Network

Its name notwithstanding, ISDN does not fully integrate all communications services. The transmission of broadband services -- most importantly of cable television programs -- cannot be accomodated. The bandwidth of ISDN network is too low for it; 4-wire transmission of one video signal can be accomplished with some technical effort. In comparison, standard coaxial cable television links in the U.S. can carry up to 70 video channels. Furthermore, at present no digital switches are operationally available to permit the large scale switching of broadband services. However, the technology is rapidly moving ahead, and even the notion of hierarchically switching is giving way. Several PTTs are experimenting with pilot projects that would permit full-scale integration; examples are the German Bundespost's BIGFON (Breitband Integriertes Glasfaser Optisches Netz) and the French DGT's Biarriz projects.

Another important communications use that is outside the "integrated services" are local area networks (LANs). LANs are communications links that permit computers and other electronic equipment located in the vidinity of each other interconnect. They are best described as facilities-based data networks that do not use a common carrier transmission facility. They carry in some instances nearly 60% of an organization's communications flows. Recent developments make possible the interconnection of LANs with PBXs, and thereby with other networks, including the public ones. They can also be interconnected with each other and expand geographically into "wide area networks" or WANs.

Also outside the "integrated services" of the public ISDN network are the internal networks that lie beyond a user's PBX. It is possible, however, for users with a digital PBX to extend the public ISDN service on their internal network, or to establish their private ISDN.

Furthermore, even packet switched data networks are not efficiently integrated into an ISDN switch; although integration is technically feasible, either on a B-channel or by using most of the capacity of the D-signalling channel, there is some sacrifice in performance.

The next technological step after integration and digitalization is integrated broadband service -- IBN. Such a broadband service could be more fully integrated, carrying also video programming and mass media entertainment as well as high-speed data streams.

By moving in that direction, PTTs would enlarge their scope of activities into a major part of the residential wire-line telecommunications needs. They would also pre-empt or squeeze the emergence of a second set of communications links reaching many homes, namely that of cable television operators which are independent from the PTT, and who can over time become alternate service providers. (Noam, 1983.)

A discussion of moves towards IBN is provided in (Kaiser 1985) [W. Kaiser, ed., Integrierte Telecommunikation, Munchener Kreis, Telecommunications #11, Springer Verlag, Berlin 1985.] The spreading of digitization from the core of the network to the periphery is not the only such trend. A similar development is taking place in the spreading of fiber optic communications with their large transmission capabilities. Experimentally, transmission rates of 20 gigabits/sec over a single fiber strand have been achieved. At present, fiber is largely used to high-capacity trunk usage. Its cost (supporting equipment, installation, etc.) is still too high for regular subscriber loops, though some large end-users have already been reached. But it is likely that fiber will be used in the future for small users, too. In the meantime, development work is taking place for optical switches which can process fiber's photon flow without requiring its transformation into electrons for the electronic switches of today, and which will have the capability to switch high-capacity data streams, which at present are limited in electronic switches. It will take some time for these developments but their eventual arrival is likely. Therefore, one may ask whether it makes sense to move to the narrowband, electronic, and copper-based (for subscriber loops) ISDN, if it is merely a transitional technology. Should one postpone the next generation of communications technology in order to wait for the one after it? This depends on the speed of innovation and the cost of replacement, questions which call for analysis along technical and economical lines. (For some theoretical consideration, see Wilson (1984), Rohlfs (1974) and Dybvig & Spatt (1983). [Wilson, C. "Games of Timing with Incomplete Information," Mimeo, New York University, 1984; Rohlfs, J. "A Theory of Interdependent Demand for a Communications Service," Bell Journal of Economics and Management Science, Vol. 5 (1974), pp. 16-37; Dybvig, F.H. and Spatt, C., "Adoption of QWERTY, or "Is History Necessary?", Mimeo, Stanford University, 1984.]

It should be noted that it does not appear that fiber will rapidly replace already embedded copper loops. And where separate coaxial cable television lines exist, the most demanded broadband services are already provided to subscribers. Thus, the time-window (or narrow-band digitization seems to have some duration.

C. Large Users

Technologists often overlook user demand as a consideration. A special ISDN issue of the journal of the main electrical engineering association, [IEEE Communications, (January 1984, Vol. 22, No. 1)] ("What an ISDN Means to Both Users and Common Carriers," as the preface notes) is devoid of more than a nod to cost aspects. One noted author writes: "The typical user sees communication in terms of terminals, modular connectors, and local wiring, with little appreciation of network intricacies." (p. 7) Even that is an overstatement. For users the tecnology behind their telephones is of little relevance. They are not interested in ISDN per se, but in telecommunications services at the right price, whatever the technology. According to the American NTIA liason officer on ISDN to the CCITT, "it does not pay to build a netwrok to the highest requirement which for 80-90% of the time will be used for the lowest requirement," [Data Communications, Sept. 1982, p. 39]

For the lowest requirements, digitization is not necessarily required. For example, the analog network can be ugraded for use with the "derived channel transport" technique by which a second simultaneous channel can be created, mostly for telemetry data such as meter reading and monitoring of pay-per-view cable television usage. Similarly, there has been technical progress in the use of analog lines for data transmission. Commercial modems have reached snychronous 19.2 kbps transmission on the same bandwidth as previously needed for 2.4 kbps.

Thus, there is a distinct element of supply drive to ISDN. To some users, ISDN has come to stand for "Innovations Subscribers Don't Need." [Newstead 1986, p. 2]

Large users fear that the financing of the cost of the new network enhancement of the ISDN will be laid mostly at their doorstep. One way in which this will happen is that the flat rate charges for leased lines will be phased out in favor of volume sensitive pricing, and that different types of communication services will be priced differently on the ISDN, even though they do not impose different costs. Furthermore, users without need for digital data transmission fear that they will have to pay higher rates for a higher performance which they do not require.

Furthermore, since the user equipment will not be fully digital at once but will remain for some time a hybrid of digital and analog, there will be adjustment costs to users, such as to acquire modems or codecs. Much of the existing analog equipment is still operating satisfactorily and is not fully depreciated, and its accelerated replacement adds to cost.

Similarly, large users may have invested in complicated private networks comprising equipment and leased lines which may become obsolete, not for technical but for regulatory and economic reasons. For example, some users have invested in highly sophisticated multiplexing equipment to cram as much information on their T1 lines and to use the wide channel flexibly according to each moment's needs.

When it comes to rates, the first telephone administration established a rate structure for ISDN was the German Bundespost which announced rate systems in March 1985, well ahead of introduction of schedule in 1987. The charges are for installation fees and monthly charges are exactly twice the monthly telephone rates for analog telephones in Germany. Message unit costs are the same. It would be cost saving to telex and teletex service because of the higher transmission rates. (Hibbs, 1986) [Mark Hibbs, "Two Times Telephone Charge Equals ISDN Fees on the First Rate Structure," in Data Communications, March 1986, p. 72.]

But it is not cost comparison to public switched analog service that bothers large users. They are most worried about the continued availability of leased lines at reasonable tariffs if ISDN is pushed by the PTTs. They fear for their alternatives. For Ernst Weiss, head of the international big user umbrella organization INTUG, "The concern is that TC-agencies are able to make this judgement a self-fulfilling prophecy, if they so choose, by limiting the user's choice. The indications are at least that some TC-agencies may choose this direction and it is the concern of restricted choice, which is at the heart of the matter." (Weiss 1983) [Ernst O. Weiss, "ISDN-User and Social Aspects," paper presented to the World Telecommunications Forum, 1983. Oct. 27, 1983, Geneva, Switzerland.]

Users of IBM equipment are particularly concerned about the move towards usage sensitive pricing, since IBM's SNA concept is built on private lines; it could be modified for a switching model, but at a loss of efficiency.

Users are also nervous about ISDN tendency to provide a "virtual" leased circuit as opposed to a dedicated private line. The difference is that the virtual circuit provides a switched transmission path that terminates at the end of the transmission, is less transparent to users, and requires adjustments of user protocols to network protocols. (Tanase 1985) [Masanao Tanase, "Integrated Services Digital Network (ISDN): Concepts and Issues in the U.S. and in Japan," Program on Information Research Policy, Harvard University, 1985]

Virtual leased circuits are also more susceptible to usage-sensitive pricing, since they, in effect, create differentiated resource capacity demand on the network, in contrast to dedicated private lines. On the other hand, the use of virtual circuits can be more efficient for the network as a whole.

The PTTs are similarly not planning to open user access to the signalling D-channel, which would facilitate the use of more sophisticated end-equipment under the control of users. [check] One other application of the D-channel would be for packet switched data communications; it appears that this use will be reserved to the PTTs rather than end-users as value-added service providers. (check).

C. Residential Users

Many of the benefits of ISDN for residential subscribers are speculative, which is not to say that they are not likely to occur. The Bundespost lists ISDN uses by private households to include videotex; connection of home computers for educational or housekeeping purposes, filling in of tax returns; access to electronic libraries; private data bases; and video games. (Schoen 1984) [Helmut Schoen, "The Deutsche Bundespost On its Way to the ISDN," Zeitschrift fur das Post--und Fermeldewesen: No. 6, June 27, 1984, Joseph Keller GmbH & Co., Verlags-KG. Starnberg (English Language Reprint). In fairness, it seems likely that an ISDN will develop useful applications beyond those anticipated today. In particular, the use of electronic mail and of telefax services will probably increase dramatically, and substitute for physical delivery.

Videotex, so far, has not shown to have found much consumer response as consumer information service, despite heavy promotion and subsidization. (The French "minitel" terminals which have received media attention merely prove that if one gives away equipment for free, some people will use it; the economically self-sustaining non-trivial applications have so far been few.)

Much more significant as an advantage of ISDN (or rather of digitization), as mentioned is its ability to provide a second connection to residential users without having to lay a new line, if a spare one is not available. This would primarily benefit the use of traditional voice telephony by making it possible for a household to lead two simultaneous telephone calls or be connected to a computer while conducting a voice call. ISDN can affect residential users telephone rates, too, if they are called upon to pay for the ISDN capability, whether they use it or not.

COST OF ISDN

The incidental observation is noteworthy, however, that among all the benefits to users which the telecommunications authroities lists, the one the author could not detect was reference to itemized billing of telephone charges. It takes no ISDN to do so, but a digital exchange makes it easier to provide such billing service which American users enjoyed for a long time. The absense in the past of such information from the PTT -- the notorious aggregated bill -reflected the reality of power between subscribers and the PTTs. It seems that itemized billing information is still not a priority, even though there now should be not technical difficulty in providing it.

[This requires checking with experts]

As mentioned, there seems to be no publicly available cost studies of ISDN. Some figures will be given in the following. But it would go beyond the scope of this chapter to provide a full analysis.

There are several components to the cost associated with moving to an ISDN.

(a) Digitization of trunk lines. This cost is one of upgrading, and not specifically attributable to ISDN. Similarly, channel signalling has already been introduced for some time, independent of ISDN.

(b) Long distance and local digital switches. Digital switching equipment would have been introduced without ISDN, though possible at a slower rate. (Alternatively, there would be excess capacity -- or stranding -- of analog equipment base.) For line termination cost, see (e)

(c) Conversion to ISDN software. The development of software for exchanges is very expensive. Recent reports on ITT's efforts to connect its System-12 digital switch to U.S. specifications were 145 million (Broady 1986; Keller 1986) [Michael Broady, "ITT's Wrong Number in the U.S.", Fortune, March 17, 1986, pp. 40-42. John J. Keller, "Why ITT Pulled System 12 out of U.S.", Communications Week, March 17, 1986, pp. 1, 38-39.] $100 million provides a rough estimate for ISDN software development and cost.

(d) Digital subscriber loop. Unloaded (i.e. non-amplified) loops rarely require upgrading, although each line may need testing. Where new lines have to be substituted, average line cost is estimated as $800, outside of rural areas. About 20% of lines have loading coils (though the percentage is less for business users.) These lines require re-engineering, which is estimated at $320 each. [This figure, as well as several others, are from M. Sirbu, by communication. Requires sources] It is possible to reduce the numbers of loaded circuits that need such retrofitting by moving the exchange itself closer to the users, thus making amplification unnecessary. But this imposes cost for such new exchanges. It also raises the policy question who should pay for these exchanges: all subscribers, whether or not they have ISDN service, or only those who choose the digital service? This is an issue which state public utility commission will have to face soon. Source: M. Sirbu, communication)

(e) Line termination equipment. This is the NT1 terminal. It includes signalling between subscribers and exchanges. Its cost per line is estimated at $80 <u>at each end</u> (i.e. including the exchange) [does this include installation?]

(f) Digital telephones. At present, such telephones (though with many features) cost $600-900. They are likely to come down to $150-200, and for residential phones to $75. Alternatively, analog equipment can be kept operating with an adaptor.

(g) PBX's and other subscriber office equipment. The digitization of such equipment is likely to have happenend for larger users without ISDN, though possibly at a slower rate.

(h) There are also substantial R&D costs (beyond the software development) in equipment, including the development of appropriate very large scale integration (VLSI) electronic components. It is assumed that most of this cost is already captured in equipment prices and should not be double-counted.

(This excludes the government cost of R&D subsidies and the revenue cost of tax-deductible R&D.)

These very rough estimates can lead to a still rougher back-of-the-envelope estimate of ISDN cost. There are about 130 million telephones in the United States. Of these, about 30 million are business lines. Assume that 75% of them would use ISDN, and that in turn 10% of these lines need retrofitting. Assume further that each business line uses, on the average, 3 terminals (check). Assume 100 million residential lines, with 1.5 extensions per line and that (check) 30% would use ISDN, of which in turn 15% need retrofitting. This would impose a direct equipment cost of $12 billion for business users (not including PBXs). [How much PBX cost attributable?] For residential users, direct equipment costs would be about $6 billion. Line retrofitting would require $.8 billion to provide service for business users, and $1.5 billion for residents. Line termination costs at the exchange is $4.5 billion. Software costs, assuming developments by 5 firms, is $.6 billion of which we assume that 2/3 would be borne by American companies and carriers. This adds to about $25 billion as the cost of ISDN in the U.S. This figure did not include the cost of digitizing trunks and switches, which are assumed to take place in any event; nor does it include the cost to the government of R&D subsidies and lost tax revenues. [Estimate] Nor does it include indirect costs and transaction expenses. If comparable costs occur in the other industrialized (OECD) countries), total ISDN costs are in the range of $100 billion. This is a significant amount of public and private investment to be decided about mostly outside the political sphere.

ISDN in the United States

In the U.S., equipment manufacturers share a similar interest in the sales potential of ISDN as their European counterparts, although they are generally less dependent on telephone organizations' procurement. Similarly, the major carriers (AT&T, the Bell Operating Companies, and the largest independent telcos) see ISDN as a strategic move to enhance their competitive position. However, the reality of ISDN operations in the United States is complicated by the presence of multiple carriers, all with different timetables for the introduction of ISDN; this is likely to lead to the development of ISDN "islands," and to varying service features. Technical coordination takes place in the Exchange Carriers Standards Association (ECSA) and its T1/D1 subcommittee, which makes non-binding recommendations. One item of contention is the treatment of the different long distance carriers under ISDN. AT&T with its common channel signalling has an advantage in inter exchange ISDN, which creates problems for equal access to local exchanges. (Sapronov 1985) [Walt Sapronov, "Technical and regulatory issues are challenging ISDN's progress," Data Communications, Nov. 1985, pp. 265-272.]

The development in the United States towards ISDN began in the early 1960s, when AT&T introduced the T1 carrier system and the 1-ESS electronic switching system. T1 carriers operate on a 1.544 megabit/sec., with 24 channels of 64 kbit/sec. (This, incidentally, creates another coordination problem with European countries, whose standard is 2,048 kilobits/sec., and 30 channels.)

Of the 64 kbit/sec. channels, some capacity must be used for signalling purposes. For data transmision, in order to keep error rate low, only 56 kbit/sec is left for user applications. The CCITT recommended rate is 64 12 bps, and the US may upgrade from 56 kbps to it. [check]

As the major digital switches, the AT&T 5-ESS and the Northern Telecom's DSM-100 have been introduced by the Bell Operating Companies. (Wienski 1984) [Source: R.M. Wienski, "Evolution to ISDN Within the Bell Operating Company," in IEEE Communications, Jan. 1984, vol. 22, no. 1.]

The Bell system's move towards ISDN, however, is not the only such activity. Fully digital communications were made available for a number of years by Satellite Business Systems (SBS), partly owned by IBM and later sold to MCI after years of financial losses. Another digital "ISDN" system is that of Argo, a small communications company owned by Centel, Alltel, and France Cable et Radio. (The latter participation is interesting, because it introduces a foreign telecommunications participation in entity the American long-distance market.) Argo has created a network with operating nodes in several cities, from which it provides national and international service. The company has called itself the first ISDN in the world, which is somewhat of an exaggeration, since it is not an ISDN along the definitions of the CCITT. Argo has only a single 56 kilobits/sec. channel (instead of the two 64 kilobits/sec. plus 16 kilobits/sec signaling channel of CCITT ISDN) and its signaling operates through regular telephone line access.

Similarly, ITT Telecom has introduced a concept called USDN--for United States digital network for digital traffic processing through existing central offices.

There have also been private ISDN networks. A sophisticated example for such a private network is that of Boeing. Both production and engineering of the 767 plane were decentralized internationally to Japan and Italy. Communications required voice, telefax, access to maintenance and parts programs, data base use, as well as CAD-CAM engineering design and manufacturing programs, and teletype facilities. Boeing was able to structure an international network, spanning three continents, that integrated these communication needs in a 2.4 kbit/sec. system, using dedicated circuits which were also aggregated for higher transmission rates. It took 14 months to obtain the necessary PTT permits.

The system was inaugurated in 1979 and expanded in 1980 to Germany and the Netherlands for the construction of the AWACS aircraft. (Fisher 1984) [Dale E. Fisher, "Integrated Digital Communications Networking," in IEEE Communications Magazine, Vol. 22, no. 1, January 1984 pp. 42-48.]

Returning to public ISDN: The AT&T divestiture accelerated the introduction of digital switches, since it mandates equal access by 1987, which is easier to accomplish for the BOCs with digital switches. Furthermore, central office equipment cost fell rapidly for the BOCs as they ceased being the captive customer of AT&T and were free to solicit competitive bids from other manufacturers. Among the Bell companies the most advanced ISDN project is in Chicago, where Illinois Bell, Belcore, and AT&T are conducting in 1986 the first American full-scale ISDN field trial, with regular service anticipated for mid-1987.

Illinois Bell has already deployed a large number of digital switches in the area, and virtually all of the system offices are connected by digital facilities. AT&T's contribution is primarily software for the switches that operate ISDN. CPE terminals are provided by several vendors to selected customers. If the system proves successful, it could expand rapidly, since the sytem software and hardware are easily transferrable, and since the 5-ESS switches have been proliferating in the past year.

Millions of American businesses and homes are already virtually served by digital two-wire local loops. These loops tend to terminate within hundreds of feet from the users and residents at an A-D converter, which transforms it into a standard analog telephone signal receiver at the customer terminator box. ISDN means, to a large measure, moving the digitization a few hundred feet further upstream to the user premises. This process is slowed, in the United States, by the fact that user equipment, mostly analog, as well as the terminator box, are customer-owned. Many customers would be unwilling to buy new equipment which they do not really need. Hence, telephone companies would have to continue to offer analog service. Hence, the transition in the U.S. is more complicated than in other countries.

Alternatively, users with analog equipment will have to be provided with, or acquire, an interface that transforms the analog signals into ISDN compatible digital signals similar to the way that a modem at present converts digital into analog signals and vice versa.

With the proper electronics, existing wire connections can be used for 56 kilobit/sec transmission of full duplex data. However, transmission distance is limited to 5 km, and some customers require more specialized electronics (pair gain systems).

In areas where an exchange does not have ISDN capabilities, but where some ISDN users may be located, service could be provided by an RX remote exchanger arrangement (RX) in which a user's transmission is forwarded to a remote exchange with ISDN capabilities, similar to the existing foreign exchange (FX) service for analog transmission.

American semiconductor manufactorers, have begun to design the appropriate hardware. No great admiration is expressed for the CCITT standards within the manufacturing industry. A typical comment by the ISDN product manager (at Motorola) is that "95% of the people can design something better. There's a certain limitation to any committee decision...it's a standard for the sake of a standard." But it is agreed that a standard is necessary. [Source: "Semicon Makers Gear Up for ISDN Standards," Electronic News, Mar. 25, 1985, p. 1, 50-55.0 (p.55)

American equipment makers have been designing circuit interfaces for ISDN which can link the incoming two-wire network circuit with the four-wire circuits of the customer premises equipment. Such equipment is of the NT2 or NT1 variety. It turned out to be difficult in the United States to agree on standards for the "U" interface. The key element here is a microchip subscriber digital network interface circuit (DNIC). Basically two techniques can be used, one known as "ping-pong" (or transition code modulation, TCM), employing alternative burst transmission in opposite directions. A second method is the echo cancelling (EC) approach in which data is transmitted simultaneously from both directions, but the system can separate and distinguish them from each other. For a full duplex transmisison, to separate the signals from each other, it is necessary to supress the echo from the dominant signal (Reaume 1985) [Lloyd Reaume, "An ISDN Subscriber Loop Interface," in Telephony, June 17, 1985, pp. 30-39.]

Efforts which began in June 1984 in a US subcommittee decided to prefer the echo cancellation (EC) technology, rather than the time compression multiplexing (TCM), after one year of study. But several firms were intent to go ahead anyway with TCM development. (Ameritech 1985) [Comments of the Ameritech Operating Companies to the Federal Communications Commission in the Matters of Third Computer Inquiry, Nov. 13, 1985, CC Docket no. 85-229). In most other countries, the choice of the technology turned out to be simpler. Germany, Italy, and Great Britain all chose the echo-cacelling route; Japan, on the other hand, chose TCM. In the United States, it turned out to be an additional problem to agree on the type of EC standards, with rival systems presented by two coalitions of AT&T & Northern Telecom, and Siemens & ITT. [check] It is necessary to be in agreement on standards since the exchange company must install equipment on its end that matches the one on the subscriber end. While theoretically each local company could choose its own standards, and even each user could coordinate their equipment with the exchange company, this would reduce portability of user equipment and increase cost. [check]

<u>Outlook</u>

It has been asserted throughout this chapter that ISDN and the general issue of integration stand for much more fundamental questions of control over the telecommunications network, the nervous system of an increasingly information-based society and economy.

This conflict extends into control of machine intelligence itself.

The ISDN standards issues can be seen as a dispute between computer industry and networks over standards and protocols. In a wider sense, this can also be viewed as part of a contest over where the intelligence in the network resides, and who controls it. The advent of "smart" PBXs and other equipment has moved intelligence to the periphery, as has the advent of value-added networks which add computer enhancement of data storage and processing to information flows.

Should the intelligence be located in the network switches, or in the customer's equipment? Should user equipment be the cutting edge of development, leaving the networks in the humdrum business of commodity transporter of information, the keepers of the roadbed and the sidewalks of the information age, which in turn are used by innovative equipment for exciting uses? Today, for example, the new application of "voicemail" (voice storage) is largely located in customer equipment, because the Computer II rules make it too cumbersome to mvoe it into the network. Similarly, such functions as least-cost routing or call screening are in the CPE rather than the switch.

The traditional carriers have attempted to reassess their role in intelligence by increasing its role in the center. In the American context, they have begun to offer central-office LANs (local area networks that interconnect computers and other equipment) as a form of super-centrex service that makes them play a role in these computer communications.

Similarly, they have argued for a change in the restrictions of the Computer II Inquiry, which imposes on them the burden of having to provide enhanced services through fully separated subsidiaries. They have, belatedly, come up with proposals for "open network architecture" which would segment the switching intelligence into several building blocks which could be customized to user needs, and lead, they hope, to a greater concentration of intelligence in the center.

ISDN's role in the question of where intelligence resides is ambiguous. On the one hand, it is used by the networks as a way to move intelligence into the center of the public network. With its powerful capabilities, it raises barriers to entry for potential alternative carriers, in particular of specialized data carriers. It makes it easier to install value added capability at the center, since more users for such services can be reached by the public networks, which reduces unit cost. Telephone authorities could thus become "computer utilities" for value added and data processing functions. On the other hand, the full digitalization of the network also has the opposite effect, since it facilitates the move of information processing to the periphery. With digital signals reaching the user's premises, it becomes easier for them to install intelligent equipment under their control.

Generally speaking, in the United States the policies of divestiture, deregulation, and Computer II specifically sacrificed economies of scale and scope in favor of the benefits of competition. ISDN does not, per se, require a monopoly; competing ISDNs could lower the cost curve, too. This is indeed possible; but it depends on the underlying cost and demand characteristics. A competition of two separated services that are partly overlapping may be more efficient than a competition of two fully integrated networks. For example, it may be better to have a national railroad system compete against a nation-wide trucking system, instead of two integrated rail-truck operations.

In the former case, one preserves economies of scale; in the latter case, one gains economies of scope. The optimal policy hence depends on their relative magnitude, and on the impact of partial competition on shifting the cost curve.

Whether "fragmentation" or "integration" are optimal solutions for networks is a matter that cannot be determined a priori. It is a classic trade-off of four economic principles in two combinations: the efficiency of specialized production and of a competitive environment, versus the productivity contributions of economies of scale and scope and the reduction of uncertainty. One cannot generalize on what works better. For telecommunications networks, however, an empirical answer should be available in the near future.

Few of the economic question marks raised in this charpter are asked by the proponents of ISDN, because these answers do not really matter. The PTTs have been effective in transforming, in the public mind, telecommunications policy issues into those of social policy, and then of industrial policy. These questions would be relevant if we were dealing with an "upgrade ISDN," another step in the improvement of the communications infrastructure. However, much of the impetus behind the scheme is that of "hegemonial ISDN," which combines the institutional self-interest of the PTT with the economic interests of its affiliated "postal-industrial complex," in particular of traditional equipment manufacturers whose domestic demand is plateauing while its international competitiveness is slipping.

Thus, the United States and many of the PTT countries are embarked on fundamentally different paths, exemplified by ISDN and UNA.

Where will the road lead? It is hard to imagine that tight control and the super-pipe will be the governing principles of communications in the future.

The notion that in the age of information all communications flows -- in societies operating largely on the market principle -- will pass through one (or at most a few) "streamlined" communications links of a single organization seems hard to entertain on technical, economic or political grounds, except by reference to institutional conservatism and the present balance of political powers. But these conditions may not prevail in the long run; like a Greek tragedy, the unified system of hegemonial ISDN will unravel, because it reflects the needs of a bygone era.