The U.S. Debate on Integrated Broadband Networks

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Introduction

Since 1987, integrated broadband networks (IBNs) have been the subject of heated public debate in the USA. Controversy still rages over when, if ever, they will be economically viable and whether, if viable, they will be socially desirable. On one point, however, there is likely to be agreement: de facto public policy on residential IBNs has been to operate in the 'prevent' mode; the main issue now is whether to adopt a national policy of either the 'permit' or the 'promote' variety. Powerful arguments have been made in favor of each of the three positions. Protagonists differ in their assumptions about matters of future fact: for example, on the revenues that can be expected from new services. They differ, too, in their values: for example, on the merits of industrial policy. Key matters of fact are the subject of great uncertainty; not surprisingly, people's positions on them are strongly influenced by their values. No early resolution of the controversy appears likely.

The purpose of this paper is to explain the US policy debate about IBNs and related systems. It draws heavily on a two-year program of policy research conducted at the Columbia Business School's Center for Telecommunications and Information Studies (now the Columbia Institute for Tele-Information). The program started in late 1987, supported by a grant from the Markle Foundation. Its purpose was to undertake research which would make a timely contribution to informed public debate, but the idea of developing a particular policy position was explicitly rejected before the work began. It should, therefore, be emphasized that the observations that follow are the sole responsibility of their single author.

There has been relatively little controversy about IBNs for business

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difficult to avoid the renewal of expiring franchises. Since the Act was passed, there has been an approximate doubling of average cable rates.

The vast majority of local governments have a policy of licensing only one cable company, thus protecting the incumbent from competitive entrants; this, presumably, allows them a share, albeit a small one, in the monopoly rents. Though the industry disputes the fact, most cable systems come close to being unregulated monopolies. In arguing the point, the industry claims it must compete with over-the-air broadcasting, microwave distribution systems (MDS) and videocassettes.

The regulatory model that applies to cable companies derives from newspaper publishing. They are free to decide what to carry and what not to carry (except over a minimal number of 'public access' and government channels which form part of the franchise agreement in some cities). This fits very well with the high level of vertical integration in the industry: most of the premium channel programmers are owned by the same conglomerates which own the local cable systems. Needless to say, there have been allegations in recent years that cable companies have favored their parents' premium channels at the expense of competitors and to the detriment of customers' interests. There have been allegations, too, that the industry has discriminated against MDS companies ('wireless cable') and others in the sale of its programing. A few court cases have been initiated, but they have had no significant impact on the vertical integration.

Nevertheless, the industry has good reason to be concerned about lawmakers and regulators. Sentiment in Washington has swung against the industry as a result of its perceived abuses. Legislation to 'reregulate' the industry is at an advanced stage of discussion and there is increasing talk of opening it to competition.

Another area of vulnerability may be the heavy debt carried by the industry. In the wheeling and dealing on Wall Street of the 1980s, cable systems changed hands at well over $2000 per subscriber, which was justified 'on the strength of operating margins in the 50% range' (Hazlett, 1991).

Technology. By 1988, a state-of-the-art cable system provided more than fifty television channels. But, from a technological perspective, cable systems are decidedly dumb. They are one-way distribution systems with no switching. The only additional functionality of note is provided by addressable converters, whereby, in some systems, the converter boxes in subscribers' homes can be turned on from the head-end to allow pay-per-view programing to be received. Warner's attempt to introduce a limited upstream signaling capability with its 'QUBE' system (first installed at the end of the 1970s in Columbus, Ohio) was not a commercial success.

To say that the technology has been dumb is definitely not to say that management has been dumb about technology. The industry has been

customers. There are no significant barriers to an evolutionary approach which does not proceed too far in advance of demand. This is the direction in which local and interexchange telephone companies, operators of metropolitan area networks (MANs), and corporations which operate their own private networks are heading.

In the USA, the policy problems concern networks which are local and residential. Regulated local telephone companies are pitted against a mature and virtually unregulated cable industry. For both, the stakes are very high and each is correspondingly aggressive in a characteristically American way. Much policy research is advocacy from a predetermined position; some of its practitioners are not above muddying the waters with specious arguments (either that or they have remarkable blind spots); few are assumed to be disinterested.

The strengths of the American process are readily apparent, too, and may be the cause of some envy across the Atlantic. In the best tradition of the First Amendment, the debate is vital and it is open; there are many exceedingly well-informed and vigorous participants outside industry and government; and, in this case, the marketplace of ideas does seem to be working.

The next section provides brief background sketches of the cable industry, the local telephone companies and the technological trends which produced the concept of an IBN. It is followed by a summary of the progress in technology and in thinking which has taken place in the four short years since IBNs first received public attention. After which come sections on the issues of economics and policy design raised by the new technology. There is little discussion of research results for two reasons: there is insufficient space and, in any case, the key research questions are incapable of being answered.

Background

The cable television industry

In the USA, almost 60 percent of homes subscribe to cable television; more than 80 percent are passed by cable systems. In 1989, the industry's revenues were about US$14 billion.[1] The revenues of the largest cable operator, Telecommunications Inc., now exceed those of the three broadcast television networks combined (Hazlett, 1991).[2]

In the National Cable Television Association (NCTA), the industry has had a strikingly successful lobbying organization. Passage of the 1984 Cable Act was a notable coup even by NCTA's standards. The Act removed much of the power of local municipalities to regulate cable companies, it limited franchise fees to 5 percent, and it made it very

successfully pragmatic in adopting new technology so as to provide new products. The use of a communications satellite to launch Home Box Office, and with it a very profitable new era for the industry, is the most obvious example.

In response to the threat posed by the telephone industry's plans for optical fiber and the challenge provided by HDTV, the industry has substantially increased its research and development. At the end of the 1980s, Cable Labs was formed to conduct R&D on behalf of a consortium of the major cable companies.

The local telephone companies

In the controversy about IBNs most of the running is being made by the Bell Operating Companies (BOCs), the Regional Holding Companies (RHCs) which own them, and Bellcore, their jointly owned R&D operation. We will limit our discussion primarily to them and, because their story since the AT&T divestiture is generally well known, it will be sketched only briefly. In passing, however, it must be noted that there are some other significant players among the local telephone companies. GTE, for example, which unlike the RHCs is permitted to own cable systems as well as telephone companies, is conducting the most extensive of the current round of fiber-to-the-home trials.

In terms of revenues, the local telephone industry is about ten times the size of the cable industry. Unlike the latter, it is heavily regulated by state utility commissions, the FCC and, in the case of the BOCs, Judge Greene. In law, telephone companies are common carriers, obliged to carry all traffic offered to them on a non-discriminatory basis. The rates local companies may charge are regulated by the state commissions. Until recently, rates were set to allow what the commissions regarded as a fair return on capital (rate-base rate of return); now there is a strong trend toward price caps and their variants instead.

The competition local telephone companies face from metropolitan area networks and the bypassers who woo their business customers is more of a threat than the competition which their cable television counterparts face from their so-called competitors. But telephone companies do not face any competition yet for residential customers.

While cable systems are broadband and dumb, the public telephone network is narrowband but intelligent. Revenues per subscriber are roughly comparable for cable systems and local telephone companies, but the value of embedded plant is several times higher for the latter. Decades before its divestiture and long before the industry became so profitable, AT&T cast covetous eyes toward cable television. There is all the more reason today for AT&T's offspring to be interested in it. However, they

have been kept at bay by a variety of regulatory barriers at both the federal and state levels, not to mention Judge Greene (until very recently) and the 1984 Cable Act (or so it seemed until an FCC announcement in autumn 1991) (see Pepper, 1991b).

Trends in technology

One of the deep fears of telephone companies has been, and still is, that they will become utilities, providing transmission and switching as commodities: neither a glamorous nor a lucrative future. The picture telephone, launched just over a quarter of a century ago (and too soon forgotten), was one of AT&T's measures to ward off such a threat before telephone penetration reached the level of saturation. The British Post Office (as it then was), planning to launch its version of the picture telephone just a few years later, had barely enough time to learn from its American counterpart's catastrophe and pluck something else from its back burner. And so videotex was born.

While videotex arose as a result of the failure of the picture telephone in the market place, the concept of IBNs sprang from the success of integrated services digital networks (ISDNs) on the drawing board. In the mid-1980s two trends were indisputable, diffusing inexorably outward from the heart of the telephone network like blobs of ink on blotting paper. One was digitalization; the main characteristic of ISDN is that it will, for the first time, provide *end-to-end* digital service over the public switched telephone network (PSTN). The other was optical fiber, following with a small lag, a similar pattern of diffusion. (In the US, optical fiber is already being used in *feeder* systems on the customer side of the central office. In such cases, the local loop has fiber-optic feeder cables, each of which carries the multiplexed signals of a number of subscribers between the central office and a remote serving point, to which subscribers' premises are individually connected by separate *distribution* cables.)

Since the costs of optical fiber and associated opto-electronics continue to decrease at an impressive rate, the two trends could, should and would be brought together in Broadband-ISDN (B-ISDN) extending all the way to the premises of both business and residential customers. In the engineering literature of the mid-1980s, it was taken for granted that there would be ample demand for new services which the 'super-pipe' would provide. And it was taken for granted that an *integrated* solution would be more efficient than separate telephone (plus data) and cable television systems. Both of these assumptions have come under serious challenge during the last three to four years.

As it was formulated by the engineers who had worked together to establish the international standards for ISDN, B-ISDN was an exciting vision,

a fascinating technological challenge and a straightforward case of honest, but naive technological determinism.

When the concept was first discussed outside engineering circles in the US, it was thought that the key problem of public policy was to reconcile the common carrier model which governed the telephone companies with the totally different publishing model which governed cable television; the inevitability of IBNs was taken for granted. This problem has not gone away, but it was soon overtaken by another: assessing whether the new infrastructure would make sense either from a business standpoint or from a broader national perspective.

Emerging realities

Much has changed during the four years in which IBNs have been the subject of public debate. Such changes have affected the way the issues are structured. This section includes a short description of the expanding concept of a residential optical fiber network, perceptions of potential demand and competing technological developments. But, first, a definition.

From ISDN to IBN

The term B-ISDN is unfortunate. It refers to a concept which involves much more than a broadband version of ISDN. (This term is used throughout to apply only to the narrowband version. In the context of IBNs, narrowband has come to mean less than or equal to 1.544 Mbps, i.e. ISDN's *primary rate*.) For example, ISDN employs channels operating at the fixed speeds of 64 and 16 kbps, whereas B-ISDN will offer dynamic allocation of bandwidth. It is unfortunate, too, because the deployment of ISDN has become bogged down. There is no reason to tar IBNs with the same brush.

In this article, the term IBN will generally be used, rather than the term B-ISDN. Either is defined by the following properties:

- It carries all traffic in integrated digital bit streams.
- It extends all the way to subscribers' premises.
- It provides subscribers with connections operating at 150 Mbps or higher.
- It provides switched, two-way broadband service.

Terminology aside, the relationship between ISDN and IBNs is problematic. Some see IBNs as evolving out of ISDN. Some argue for leap-frogging ISDN, since the concept is obsolete and the need to

depreciate investment in ISDN switches will retard the deployment of IBNs. Others argue that, quite possibly, neither concept makes sense.

Evolutionary stepping stones

When BOCs started seriously investigating the construction of IBNs, it became clear that, for the time being (which might be quite a long time), they would be too expensive. The industry looked for lower cost optical fiber systems which it would be cost effective to install in the very near future and which could be upgraded later. Clearly optical fiber could be used for POTS ('plain old telephone service') alone, which would be much cheaper and closer in cost to copper when used in new builds in up-market areas requiring two lines (or more) per household. Alternatively, it could be used for ISDN (although ISDN was optimized for copper). Another possibility was to retain the analog mode for the transmission of television; in the long term, digital transmission will probably be more economical, but not initially.

Two other avenues have proved promising. One is 'fiber almost to the home'. In such a design, the optical fiber terminates (in a handhole or pedestal) at the curb. Here opto-electronic equipment dedicated to between eight and sixteen subscribers converts light signals into electrical signals, and vice versa, for the last leg over copper wire-pairs and coaxial cable.

The other approach involves the topology of the network. Familiar topologies are the star, the double star and the bus. In a star topology, each customer has a dedicated connection to the switch (i.e. central office). In a double star, the switch has a set of satellites; circuits for a number of customers are multiplexed together between the switch and the satellite; dedicated circuits are used between the satellite and the customer. A bus carries signals for a number of subscribers, with all signals running past each subscriber; taps are used to remove or insert a particular subscriber's signals. There are many variations on these themes. Some economize on fiber, others on switching. Some have greater capacity, others less. Some provide switched video, others only distributed video (as in a tree-and-branch cable television system). (For a detailed analysis of the costs of the major varieties, see Reed and Sirbu, 1991.) By economizing on capacity and video switching, some designs save on investment costs.

It is very important to bear in mind the distinction between IBNs and a wide variety of other residential optical fiber systems. We will proceed toward the former via the latter. It is not dishonest, then, for some (1) to describe their vision of their services an IBN would provide, (2) to argue that we should, therefore, lay fiber (almost) to the home as soon as possible, so that (3) it can be upgraded later to an IBN. Unfortunately,

however, (3) is sometimes forgotten: the vision of an IBN becomes associated with the costs of a lesser system, one that may not provide any more functionality than is today obtained from the combination of the public telephone network and a cable television system. This does not make for clear thinking.

New applications

There has been an obvious need for proponents of the new technology to identify attractive services and applications which could be supported by IBNs, but not by lesser infrastructures. On the residential front, there has been an increasingly desperate search. The early favorites were video conferencing and picture telephony. The trouble with these is that they fall comfortably within the compass of (narrowband) ISDN. Digital compression technology has, for some years, supported corporate video conferencing in the range of 128 kbps to 384 kbps. Picture telephony's requirement is 64 kbps. (It says something about our overly specialized society that the engineers propounding IBNs were unaware of the successes already achieved in the market-place by the compression systems developed by fellow engineers.)

HDTV soon took over the running. But then it was pointed out that, with an inexpensive upgrade costing less than US$60 per subscriber, today's cable systems could deliver it. Some would not even need the upgrade.

Video-on-demand stayed in the lead for a little longer. This would allow viewers to retrieve and view any stored television program whenever they wanted to do so. The viability of the service was questioned by some on the grounds that, given the probable premium customers would pay, it was unlikely to cover its costs (Johnson and Reed, 1990). Less has been heard about video-on-demand during the last year, but it has not been completely abandoned.

Telecommuting has been a cyclical favorite of the telecommunications community for the last two decades. Not surprisingly it, too, was pressed into the service of IBNs. Indeed, one analyst estimated that the positive externalities due to IBN-induced telecommuting could be worth a trillion dollars a decade to the USA (Sudit, 1988). The trouble is that while telecommuting is constrained by a variety of factors (managerial attitudes and Internal Revenue Service regulations, among them), there is little indication that they include technology. And even if they did, T1 service (1.5 Mbps), which could be provided over a copper wire-pair and could accommodate several simultaneous video conferences, would appear more than adequate for the needs of the vast majority of would-be telecommuters. Telecommuting has been flagging recently as a purported 'demand driver'.

Enter hypermedia. This has the distinct advantage that cynics are not clear exactly what it is — but neither are those who are backing it, which seems to have prevented their firing the public's imagination. If broadcast quality television turns out to be an important component of it, if access is needed to non-local hypermedia data bases, and if it catches on rapidly with a substantial segment of the population, it may play a positive role. But as a trial balloon it has not risen very far yet.

It has frequently been suggested that IBNs would support some services which could massively improve education and others which would be of considerable importance in improving health care. It requires a tremendous leap of faith to see residential IBNs as having more than a marginal role in either sector (though institutional broadband networks may be a different matter). The leap of faith is even harder if one recalls the extravagant promises made in the past about new technologies' contributions to education, or if one looks into the broadband field trials conducted in the name of telemedicine in the 1970s. Extreme shortages of funds in both sectors could be expected to limit their appeal as significant sources of revenues for IBNs, but some leading politicians do seem to be enthusiastic about the educational possibilities. Of the applications put forward so far, education is probably the strongest runner.

The subject of new applications is discussed further below. The purpose of this section was not to show that there would be no new applications of any significance, it was simply to summarize the results of a search which reminds one of the story of the drunkard looking for his keys under the street light.

Developments in technology

Optical fiber and its associated opto-electronics have, as expected, continued to grow cheaper. Advances in splicing technology have improved the economics of installation. Progress is being made in the development of the high-capacity switches that IBNs will need. Asynchronous transfer mode (ATM) has been recognized as a remarkably powerful and versatile standard for transmission in IBNs. All these developments were correctly anticipated by the engineering experts. More relevant to this article are technological developments which may affect *competing* infrastructures (and, in some case, IBNs as well).

Fiber backbones. Research in the cable industry has shown that cable systems can be upgraded with optical fiber backbones at a cost of no more than US$60 per subscriber. Largely as a result of eliminating many amplifiers, such backbones increase capacity, improve signal quality and reduce maintenance costs; signals continue to be carried in analog form. Such upgrades are already in progress.

Interestingly, one effect is to change the tree-and-branch topology somewhat, so that it becomes better fitted to the provision of switched services.

Bandwidth compression. There has been rapid progress in the development of codecs for the digital compression of broadcast quality television. When the broadcast networks occasionally employ digital transmission for remote feeds, it is generally at 45 Mbps. However, it appears that this can be reduced by a factor of ten or more. There are various ramifications:

- A substantial increase in the number of channels a cable system could deliver, thus allowing for growth in pay-per-view television and a step toward video-on-demand.
- A substantial increase in the capacity of a direct broadcast satellite transponder, thus improving the economics of this potential industry.
- A further decrease in the cost of some of the cheaper evolutionary stepping stones towards IBNs (NERA, 1990).

High-speed digital subscriber loops. Two technologies are at an advanced stage of development which would allow repeaterless transmission at T1 rates over existing copper wire-pairs. High-speed digital subscriber line (HDSL) technology requires two pairs for bidirectional transmission at 1.5 Mbps. Asymmetric digital subscriber line (ADSL) technology requires a single pair for transmission to the subscriber at 1.5 Mbps and in the opposite direction at 144 kbps.

It is unclear what their relevance to IBNs may be. With a little more progress in digital compression, they may permit pay-per-view television over existing copper pairs. In this and/or other ways they may siphon potential demand away from optical fiber networks. They may also create other possible hybrid (fiber–copper) topologies, further reducing the cost to upgrade today's infrastructure in the general direction of IBNs. There has been very little public discussion of such possibilities yet.

Personal communications services (PCS). There has been a scramble to obtain licenses from the FCC to experiment with low-cost variations of cellular telephony. For such services, many very small cells in urban areas would need to be linked together. Cable systems would seem to provide an inexpensive means to this end and cable companies were well to the fore in obtaining licenses.

It is too early to know whether and how soon such systems will live up to the promises of their backers. (If past experience is any guide, the promises are exaggerated.) Nevertheless, at some point, such systems might conceivably compete for the residential subscribers of local telephone companies. And, if they stay the course, cable companies could be among the providers.

Perceptions of cable–telco competition

A few years ago, it seemed that most commentators assumed (usually implicitly) that in head-on competition, the telephone company would have a marked advantage over the cable company. This was unrealistic. There is a growing realization that the cable industry has some significant strengths:

- It is the incumbent in delivering television.
- It knows the business and controls a great deal of the attractive programing.
- Its labor costs are lower.
- Trunks can be upgraded relatively inexpensively with optical fiber; what is expensive is to convert the final legs from narrowband to broadband. So cable can profit from an inexpensive upgrade; the telephone company is faced with a very much more expensive one.

Of course, the cable industry suffers two weaknesses noted earlier: political unpopularity and high leverage. Who should be favored, if competition does develop, will depend on the amount the regulatory playing field is tipped in the telephone company's favor.

Issues of economics

Within a very few years, it will be cost effective for telephone companies to use optical fiber rather than copper in new developments. Subsequently, fiber will be more economical in rehabilitations (i.e. to replace plant which is at the end of its useful life). These processes proceed at 2–3 percent a year. So, eventually, the PSTN will be all fiber (at least, to the curb). This may, however, take close to half a century. Moreover, there remain critical questions of whether and when there will be switched, two-way, digital broadband service in the local loop.

Research by economists and others has illuminated the issues, but, in my opinion, it appears distinctly unlikely that there can be definitive answers to the key questions in the near future. This section briefly discusses the more central formulations and findings.

Costs

Estimates of the investment required to complete a national upgrade of the local telephone loop with optical fiber vary widely, though generally in the range of US$200 billion to $450 billion. As some have pointed out, an investment in the lower portion of the range would not be an unreasonable amount to finance over a period of up to twenty years, especially since what really matters is the excess above what would be spent in any case.

The cost of an upgrade is the cost of going from X to Y. Many different

assumptions about X and Y are reasonable; the correct definitions depend on the problem one is trying to solve. Unfortunately, however, cost estimates have a tendency to take on lives of their own, unencumbered by the definitions and assumptions that originally accompanied them (or should have accompanied them). It is important to avoid directly associating the vision of an IBN with the costs of upgrading to a system which runs fiber to the curb, in a topology which would be relatively expensive to upgrade further and which provides only POTS ('plain old telephone service'). (Selander [1990] accounts for much of the variation by relating it to different topologies and different time scales.)

A particularly thorough and well-documented analysis of costs is provided by Reed and Sirbu (1991). Their time scale is five to ten years into the future and their definitions of X and Y avoid the extreme cases: X is a copper network which already offers ISDN; Y takes various forms ranging up to an integrated digital network, providing broadband to the home, but only narrowband from it. The following are two of their more important conclusions:

> Running fiber to the home, even assuming significant future reductions in component costs, is likely to remain more expensive than copper. . . . To realize the introduction of a fiber IBN, it must be justified on the basis of additional revenue producing services, such as the delivery of entertainment video.
>
> The analysis suggests that a fibre optic network capable of providing voice and video services to the home can be constructed for $1800 to $2500 per home passed. The cost per subscriber is in the range of the combined cost of a CATV and telephone network only if fiber-based services realize near universal penetration (greater than 85%). (Reed and Sirbu, 1991: 127)

However, they also show that for a hybrid network (fiber almost to the home) providing distributed rather than switched video (i.e. similar to a cable television system), the cost could be below US$1250 per home passed. Others have estimated a lower figure (NERA, 1990).

Reed and Sirbu's point about penetration should be taken very seriously. Since fixed costs are high, the cost per subscriber if penetration stalls at around 20 percent will be very different from penetration at 60 percent or more. Since most analysts are concerned with existing communities (where there is generally a cable system) and none includes the cost of buying out a cable incumbent, one must assume that the telephone company *competes* for subscribers. In this case, penetration levels should be regarded as highly uncertain.

Revenues from new services

> Much of the literature on IBNs gives the impression that broadband services [other than cable television] are new. While the concept of an IBN may be

> recent, many of the associated services are not. What are now called video-conferencing and business television go back to at least the 1960s. The National Science Foundation supported ambitious field trials of two-way cable television applications in the mid-1970s, a time when there were also many broadband telemedicine trials. (Elton, 1991b: 54)

Drawing on this experience, Elton concludes that it is beyond the state of the art to forecast the demand for the new services IBNs will make possible. He argues for a public policy based, in part, on our inability to solve the forecasting problem.

Probably the most credible method of assessing the demand for a new service is the field trial. He holds out little hope even for this, pointing out that field trials hardly ever demonstrate significant demand; nor have the rare exceptions been predictive of successful diffusion. Certainly, the thirty or so field trials of residential optical fiber systems currently planned or under way in the US will be of no help in assessing demand. Only one will offer subscribers more functionality than is provided by a combination of today's PSTN and a cable system; this will involve only four households (McGilly et al., 1990).

In the case of IBNs, it is necessary to forecast the demand for a new infrastructure, not just for a single service. One consequence is that providing the service by an alternative narrowband system must be considered; bandwidth compression has already turned video conferencing into a narrowband service. In fairness to the champions of IBNs, it should be noted that IBNs may make it far easier, quicker and cheaper to experiment with, and develop, new applications, even though some may be capable of delivery by narrowband systems subsequently.

A second consequence is that probably the most likely risk of under-estimation arises from overlooking possible services entirely. Relative to IBNs, tone signaling was a modest upgrade of the public network, but it brought forth a wide variety of successful new services — services which were not foreseen at the time of the upgrade from rotary dials.

Some have argued that although there may be no business case for private investment in IBNs, their externalities make them a sound investment for the nation as a whole. If, however, it is correct that the forecasting problem cannot be solved, it also follows that we cannot estimate the value of the positive externalities which might flow from the new services.

Rate-base regulation vs price caps

Of obvious importance is who should shoulder the risks of investment in the new technology — telephone subscribers or investors in telephone companies? If policy is to place the risk on investors, price caps are

preferable. Lehr and Noll (1991), however, argue that 'they only partially ameliorate, and do not solve, the problem of inefficient investment and service provision by regulated firms'.

Egan (1991) has concluded that, under a price cap regime, there is no business case for IBNs, while under the previous rate-base regime, there would have been. The reason lies in the different treatment of capital depreciation. Under rate-base regulation the costs of depreciation are passed on to subscribers and, provided the resulting cash flows are reinvested in new construction, future earnings are not depressed. Under more market-orientated regimes, 'high depreciation and interest on borrowing for construction seriously depress earnings'.

Economies of scope

ISDN and its broadband counterpart are both based on the premise that a single *integrated* network would be more efficient than some set of separate networks, each optimized for some subset of the total traffic (for example, separate networks for voice, data and video). In other words, they rely on the assumption that the economies of scope outweigh the economies of specialization. The centrality of this issue has been noted by Lehr and Noll (1991), Noam (1991) and Hatfield (1990).

In a trenchant report (commissioned by a cable multiple systems operator), Hatfield (1990) concludes that the diseconomies of integration 'may well overshadow any purported economies of scope'. With a focus on the interests of the small user and from a disinterested perspective, Lehr and Noll (1991) reach almost as strong a conclusion: there is sufficient evidence of diseconomies that the onus is on the proponents of integrated solutions to demonstrate that the economies outweigh the diseconomies. The telephone industry has not yet risen to this challenge. As Lehr and Noll point out, however, a final resolution of the matter is likely to require information on patterns of demand, so it may not be possible to have the answer to this until after integrated networks have been built.

The essence of the argument is best illustrated with ISDN. Voice traffic is intolerant of delay, but tolerant of noise; data traffic is the reverse in both respects. Voice traffic is more or less continuous; switched data traffic typically comes in bursts. Catering for these very different characteristics in the same network will add complexity. Both the above-mentioned articles adduce further examples for both narrowband and broadband integrated networks. They demand to be taken seriously.

Policy options

Police choices lie along a continuum from 'prevent' via 'permit' to 'promote'. Under a 'promote' policy, the federal government would

provide incentives to improve the business case for deployment of residential broadband networks. Incentives could take many forms. Direct subsidy is unlikely given the budget deficit; transferring a portion of the costs to telephone subscribers by means of accelerated depreciation is much more likely. Tax incentives may be considered, too. In addition, the avoidance of restrictions intended to safeguard some public interest may improve the business case; an example would be the possible restriction that telephone companies should be allowed to provide television programing only as common carriers.

The positions of the major private sector players require little comment. Local telephone companies favor a 'promote' policy disguised as a 'permit' policy. They would argue that accelerated depreciation is not a cross-subsidy; this is technically correct.[3] Broadcasters and newspaper publishers are the uneasy allies of the cable industry in the 'prevent' camp. Assuming one local monopoly is not traded for another, program producers and distributors stand to profit from the proposed infrastructure by having more outlets and, under a common carrier model, by being able to avoid the cable middleman.

The most interesting questions involve AT&T. It would seem to be a natural partner for cable companies. As Pepper (1991a) notes, there

> is the potential for AT&T to develop strategic alliances with cable operators; building fibre-optic systems, providing subscriber automatic number identification for pay-per-view programming, and providing billing to customers, all in exchange for cable system transport between large business customers and AT&T's interexchange point-of-presence. Some cable systems currently employ AT&T fibre technology to link up facilities in metropolitan areas. Such networks could be provided by the cable operators to provide extended area private line service or even intra-LATA toll service in conjunction with AT&T and other interexchange carriers. While not yet a reality, the potential for such competitive alliances is threatening to some LECs.

In the ruling described in the next section, the FCC recently announced that no restrictions prevented interexchange carriers from entering the cable market. However, by far the most important customers for AT&T's manufacturing arm are the LECs who would be threatened by such a partnership. Is it prepared to antagonize them?

Cities appear to have mixed views. They would like to regain some leverage over local cable companies; competition would probably help in this respect. Telephone companies would very probably not have to pay local franchise fees, however. Sooner or later, cable companies would probably provide less in fees and free services; they would argue that such obligations inhibited their ability to compete.

The issues for state regulators are decidedly complicated (see Pepper, 1991a). Their major concern is to achieve a reasonable balance between keeping rates down and modernizing the telecommunications infra-

structure. In the latter respect, there is a decided element of competition between states, since infrastructure is thought to be important in attracting and retaining businesses — a view that LECs do their best to encourage. What does seem reasonable to predict is that, if and when telephone companies start deploying broadband networks in a few significant states, others will try hard to avoid being left behind.

The remainder of this section deals with two issues. First, what would be a reasonable rationale for adoption of each of the three positions by the federal government? Second, what are the major features of similarity and difference between the 'permit' and 'promote' positions?

Rationales

A 'permit' policy. A 'permit' policy can be based on the following propositions. First, a sound economic case has not been made for deploying residential optical fiber networks and probably cannot be made without substantial field experience. While they may make sense at some point in the future, it is too risky for now to make the major commitment implied by a 'promote' policy. The risks involve both the misallocation of resources and the sacrifice of certain safeguards for the general public.

The second proposition is that an evolutionary policy, with strong public safeguards, minimizes the overall risk. Some RHCs claim that a business case can be made for installing broadband networks almost to the home. Presumably, then, they will at least proceed on a pilot basis if legal and regulatory obstacles are removed. This will produce empirical evidence which will be valuable in decisions about whether, how and at what rate to proceed elsewhere. The third proposition is closely related: it runs counter to American values to deny informed investors the right to take the risks they wish to take.

The final proposition is that the necessary public safeguards can be designed and implemented.

A 'promote' policy. A '*promote*' policy can be based on two propositions. The first is that there is a good enough economic case that can be made for deploying such networks in the near future, provided, probably, that externalities are taken into account. Further, it is reasonable to believe that by reducing uncertainties, a credible 'promote' policy would also reduce costs. The second proposition is that delay would be costly because it would postpone the benefits to be derived from the new infrastructure and because it would put the international competitiveness of the US telecommunications industry at risk. Conceivably, too, the window of opportunity for IBNs may start to close as direct broadcast satellites and much upgraded cable systems cream off potential residential demand.

A 'prevent' policy. A 'prevent' policy can be based on three propositions. The first is that adequate public safeguards cannot be instituted if telephone companies are allowed into the cable market-place. In particular, telephone subscribers would be forced to cross-subsidize the new networks. Also, if it were to succeed in the new market, the local telephone company would have far more power than is safe. The second proposition is that, ultimately, the consumer would be the loser if there were to be a bruising battle between the two industries. The final proposition is that the possible advantages to be derived from a new broadband infrastructure are largely or entirely illusory.

Comparisons. A much greater sense of urgency underlies the 'promote' as opposed to the 'permit' position. The former has the flavor of industrial policy, the latter of laissez-faire. A certain cynicism about BOCs and the ability of regulators to control them underlies the 'prevent', but not the 'permit' position.

Design issues

Both the 'permit' and 'promote' policies would require the removal of federal regulatory and legal barriers barring local telephone companies from providing a cable television service. An important issue with both is whether or not telephone companies should be allowed to buy cable companies in their serving areas or engage in joint ventures with them. Allowing these would reinforce the monopoly provision of both cable service and residential telephone service, which would appear contrary to today's public policy which espouses market solutions rather than regulation. On the other hand, it would allow cable companies a financially satisfactory withdrawal from owning and operating their own facilities. It would also remove the substantial risk that, with competition, the telephone companies' broadband services would take a very long time to become profitable.

A 'promote' policy driven by a vision of rapid deployment of a sophisticated broadband infrastructure might do away with the cross-ownership ban. However, a 'promote' policy could be driven by a vision of a new common carrier broadband infrastructure, as put forward by Geller (1991) (and discussed below), in which case the ban would probably be retained. (This would not be essential since a telephone company buying a cable company could be required to operate in a common carrier mode.) A cautious 'permit' policy would probably retain the ban. But one which placed a high value on obtaining more information might do away with it, since joint ventures would probably provide the least risky basis for early experimental systems.

With both policies, a decision would also be necessary on whether telephone companies should be required to be common carriers of television programing. The case for this appears to be a probable feature of a 'permit' policy. However, it might be sacrificed in the technology-driven 'promote' policy. The reason is that much larger profits could be envisaged by telephone companies who could own some of the programing they delivered; without this possibility, much larger subsidies would be required. If a telephone company were required to be a common carrier of television, this need not necessarily preclude it from having an ownership interest in programing carried on a few channels.

In both cases, it would be necessary to prevent the vertically integrated cable industry from withholding programing from the emerging optical fiber infrastructure. Vigorous legal action over refusals to deal would have to be a credible threat; alternatively, there would need to be legislative action.

State utility commissions could effectively block a 'promote' policy unless the federal government exerted considerably more central control than now. Clearly, it would be preferable to win their support with some combination of persuasion and incentives. While the support of at least some states would be highly desirable if a 'permit' policy were adopted, the immediate need would be much less pressing.

Another issue for the state commissions concerns barriers to cable companies providing switched telephone services. It is argued that it would be inequitable to allow telephone companies into the cable market, while cable companies are not allowed into the telephone market. With very few exceptions, state commissions have not favored the latter; a variety of barriers and disincentives are in place.

Finally, a 'permit' policy leaves telephone companies to bear the entire financial risks of broadband initiatives. Such a policy would make no sense unless their financial rewards, if successful, were commensurate. Provided a telephone company faced a cable competitor, it might, therefore, be reasonable to allow the company to price its broadband services at what the market would bear.

Recent developments

At the federal level, there were, until recently, three barriers to the entry of BOCs into the cable television market-place. One was a provision of the 1984 Cable Act requiring providers of cable television service to obtain a local franchise; as noted above, almost all municipalities have a policy of restricting the number of providers to one. The second was the FCC's regulations against cross-ownership between telephone and cable companies. Third was Judge Greene's ruling in the Modification of Final

Judgment (settling the AT&T divestiture) that BOCs were not to offer information services; in this context, cable television is defined as an information service. All that a BOC could do was to provide *channel service*: i.e. build the facility and lease it exclusively to the local franchisee. Few have done so.

Now all three barriers seem to be crumbling. In addition, an intellectually powerful 'promote' policy has, at last, been proposed.

Information services

In the summer of 1991, Judge Greene removed his remaining restrictions on information services. Accepting the inevitability of an appeal, he also issued an immediate stay of the order. The stay, however, was quickly overturned by the Appeals Court. The BOCs can now offer information services, but this could be overturned on appeal.

Video dialtone

A few months later, the FCC issued a ruling that no local cable television franchise be required either by the local exchange carrier (LEC) providing video dialtone or by a video programmer using the service. Video dialtone is described by the FCC as a common carrier service analogous to ordinary telephone dialtone, which would provide customers with access to video programing, videotex, videophone and other advanced services which may develop. It would be enriched with non-programing services provided by the LEC (presumably, for example, menus).

Given the analogy with channel service, the ruling offers a sensible reinterpretation of the 1984 Cable Act. The timing of the ruling was somewhat unexpected, but not its substance. As head of the National Telecommunications and Information Agency, the now chairman of the FCC was regarded as a strong believer in video dialtone.

In the same action, the FCC indicated that it 'tentatively concluded that there should be a regulatory policy with respect to video dialtone which will encourage a competitive video marketplace and permit telephone companies to develop broadband communications services. It has proposed, and asked for comments on, regulations to implement this policy.' In particular, it sought comments on 'whether LECs should be permitted to participate in video programming in the video dialtone environment . . . [and] whether incentives are desirable in order to foster investment for video dialtone' (FCC, 1991).

The FCC notice was accompanied by individual statements from commissioners. Some were decidely cautious. Two were determined that

the FCC should not endorse residential fiber-optic networks; this would be 'industrial policy', hence anathema.

If the FCC's position stands up to the onslaught which will undoubtedly be mounted, it could allow LECs into the cable television market-place without further action by Congress. What will happen? It is unclear what, if anything, Congress will do. It is unclear what will happen on appeal to Judge Greene's ruling. It is not yet clear on what terms the FCC would allow the local telephone companies to provide video dialtone. Nevertheless, the next question is clear: would the removal of barriers at the federal level be enough to bring about change or are there more skins on the onion? It turns out that there are — state policy and commercial considerations.

From a commercial perspective, the major problems are as follows:

- Will telephone companies be able to offer enough attractive programing to achieve sufficient sales per subscriber? Given the powerful hold on programing that the cable industry now enjoys and given the telephone companies' lack of experience in the television business, it seems likely that this will pose serious difficulties, at least in the short term.
- Will telephone companies be able to convert enough potential customers into actual subscribers? As the analysis by Reed and Sirbu (1991) demonstrates, the economic viability of a residential optical fiber network is almost certainly very sensitive to the rate of uptake. The well-known chicken-and-egg problem seems likely: until there is enough programing, there will be few customers; until there are enough customers, little programing will be offered to the networks.
- Will installation costs be low enough? In up-market new builds, assuming two telephone lines per subscriber, optical fiber may cost about the same as copper wire, but in an existing community served by plant that is far from the end of its useful life (and not yet fully depreciated), rewiring with optical fiber will be expensive. Moreover, the less costly topologies may well be more expensive to upgrade later.

Accelerated depreciation would considerably improve the business case for the necessary investment. If telephone companies were allowed to accelerate depreciation, they would be able to write off existing plant more quickly, thus raising rates to all telephone subscribers and thereby providing additional funds for the investment in new plant. (A cross-subsidy by any other name would smell as sweet!) This would require the approval of state public utility commissioners, which cannot be taken for granted.

In a variety of ways, state utility commissioners could obstruct telephone companies wishing to upgrade their networks with optical fiber so as to provide television. Grudging acceptance of the idea will probably not remove enough of the obstacles already in place; full-blooded approval is likely to be necessary. Another grey area can, therefore, be seen in the

relationship between the FCC and states. Possibly the FCC could decide to pre-empt state regulation in this area, but such a policy would probably sour an increasingly delicate relationship and lead to legal action.

The commercial picture would be somewhat better if telephone companies were allowed an interest in some of the programing provided via video dialtone systems. This need not be inconsistent with common carrier status as long as no would-be providers are turned away because there is insufficient capacity. However, the incentive to operate the system in such a way as to discriminate in favor of programing in which they had an interest would pose difficult problems.

Joint ventures with cable companies could provide a way forward with less risk for local telephone companies. Conceivably cable companies might agree to them where the most likely alternative would be head-on competition, but otherwise it is difficult to see why they would make it easier for telephone companies to deploy broadband networks. The key public policy issue here is that joint ventures would substantially retard future competition in both the telephone and cable markets; there would be a strong case for banning them.

It is far from clear what the overall effect of the FCC's proposed policy would be.

The Geller proposal

The FCC has gone further than might have been expected in showing leadership on broadband networks, but the major advance in recent thinking came from a different source. With a characteristic tour de force published in November 1991, Henry Geller entered the debate (Geller, 1991).

The starting point for Geller's analysis is the First Amendment's objective of diversity in the sources of information available to the American people. He points out that the regulatory models for broadcasting and for cable television have failed in terms of the First Amendment. Moreover, although they can be patched up to achieve short-term gains, they are fundamentally flawed and incapable of providing long-term solutions. His major example in the field of cable television is NBC's failure in recent years to establish a twenty-four-hour news channel. NBC was unable to break through the vertical integration of the cable industry.

The regulatory model that has best served the objective of the First Amendment is the combination of print with common carrier delivery, he points out. And technology has now advanced to the point at which this model can be fitted to television. Geller's proposal is that local telephone companies should employ optical fiber networks to deliver television on a common carrier basis. While acknowledging that demand for the new

services which IBNs would provide cannot be predicted (although he appears to lean somewhat toward the optimistic view put forward by the telephone industry), he concludes that local broadband systems should be planned now so that they can be easily upgraded to a switched status.

To overcome initial problems of economics and to speed the deployment of a common carrier broadband infrastructure, Geller advocates accelerated depreciation of existing telephone plant. In essence, this means that the general public, qua telephone subscribers, would pay for the new technology. This, he argues, legitimizes restricting telephone companies to the role of common carrier and preventing them from acquiring existing cable systems or entering the market as overbuilders. (An overbuilder is a cable company which builds a new system to compete with an incumbent cable company.) To forestall challenges by telephone companies that their rights under the First Amendment have been denied and to permit some 'pump priming', telephone companies would themselves be allowed to program between two and five of the channels through a separate subsidiary.

Geller strengthens his proposal with recommendations on a variety of associated issues: for example, the FCC's ability to move ahead without waiting for Congress; gaining the cooperation of state public utility commissions; and the cable industry's entry into the telephony marketplace.

By broadening the focus explicitly to include First Amendment issues, Geller has identified a positive externality sufficient, in his judgment, to settle the dispute about the economic case for IBNs. What is more, the primary benefits result from the provision of a service for which there is known demand — television as we experience it today — and not from speculative new services.

The proposal can be expected to encounter strong opposition from vested interests. The cable industry would be the biggest loser. If the worst came to the worst, it had hoped to sell its properties to the telephone companies; Geller's proposal would even preclude this. Newspapers are very worried about the newly permitted provision by telephone companies of information services which would compete for their advertising dollars; they can be expected to oppose this strengthening of the telephone industry. It is unclear where the interests of the television networks lie. Even though it seems curious to find them allied with the cable industry, albeit uneasily, as they have been regarding telephone companies' proposed broadband networks, this position probably makes sense. The new technology clearly threatens further to hasten the fragmentation of the television audience.

Which of the vested interests would support the proposal? Probably the optical fiber manufacturers would: their market has been dwindling now that the long distance telephone companies have substantially completed

their fiber networks. Quite possibly that part of the film and television production industry which is not the captive of the cable industry would also support the proposal. But what of the local telephone companies? They would be denied the cable industry's advantage of vertical integration which would be a disappointment. Nevertheless, they would be offered the opportunity to socialize the costs of proceeding toward IBNs, while privatizing the profits that common carriage would provide. And this would avoid the nightmare of the cable industry's fiber network reaching the home ahead of theirs.

A broader perspective suggests that Geller's proposal will encounter other problems which sectional interests will be quick to exploit. First, by espousing a particular technological solution, it will be perceived as industrial policy. As a result it will encounter reflex-action opposition from influential parts of the political establishment, not least from among the FCC commissioners.

Second, even with the cash flows from accelerated depreciation, it is far from clear how the telephone companies will fare in head-to-head competition with the cable industry. A long and bloody battle could worsen the economics for the telephone industry; politicians and regulators, already heavily committed to fiber networks would, presumably, increase the public's forced investment in the new technology. As a result of wheeling and dealing during the 1980s, many cable enterprises are heavily leveraged and could be vulnerable to fierce price competition. But even if they were forced out of business — an outcome that a federal government would certainly wish to avoid — their plant would remain, to be bought and operated by others. The cable industry can be expected to yell foul. Telephone companies would compete against them without having the obligations imposed by local franchises (e.g. in some cases, public access channels). Worse, they will enjoy a rich public subsidy to drive cable companies out of business. This, it will be argued, comes close to confiscation of capital, against which there is constitutional protection.

Thirdly, issues of distributional equity remain to be addressed. The telephone industry and its supporters will strengthen the campaign for a redefinition of *universal service*, in this context to encompass residential optical fiber networks, so as to avoid a continuing disparity between rural and urban areas. This will push costs up.

Fired by a passionate concern for the First Amendment, Geller has put forward a distinctly American solution to a distinctly American problem. Even though his reasoning does not apply to Japan or to Europe, it would not be surprising if its adoption were not to spur Japan to acclerate its plans for IBN. In this case, Europe could be expected to follow suit. But will such a proposal be adopted? Should US citizens be optimistic about the triumph of the public interest over the profits of powerful sectional

interests? Anyway, do they care enough about the First Amendment to pay for common carrier television through higher telephone rates?

Conclusions

Under a 'prevent' policy, the PSTN would continue to be upgraded, as would cable television systems, and direct broadcast satellites would be launched. Under a 'promote' policy, for at least one, most probably two, decades, few subscribers would enjoy any more functionality than under the 'prevent' approach. If the policy which is adopted has any substantial impact on consumers during the next fifteen years or so, it will be as a result of competition, or lack of it, in the supply of cable television and as a result of associated changes in industrial structure, not because of new services which IBNs may come to offer.

In conclusion, we offer a summary of the main uncertainties and issues, as seen from a standpoint intermediate between the 'prevent' and 'promote' extremes.

Technology

The main short- to medium-term uncertainties surrounding technology are as follows:

- *ISDN*. Will it be deployed fairly rapidly? If so, will it demonstrate economies of scope?
- *Bandwidth compression*. What new possibilities, competitive and complementary to IBNs, will be opened by the combination of continuing bandwidth compression and emerging technologies for very rapid digital transmission in the copper loop?
- *IBN switches*. What will be the costs of the high-capacity switches which will be needed for IBNs, as opposed to their immediate predecessors?
- *Digital television*. At what pace will the future transition from analog to digital *receivers* proceed? The latter will substantially improve the economics of digital transmission.

Although the possibility of surprises should not be ruled out, some trends seem safe to predict. The future technological course of cable systems appears fairly clear: optical fiber trunking; improved pay-per-view technology; increased number of channels (by means of optical fiber and bandwidth compression). As far as use of optical fiber in the residential loop is concerned, estimates of the costs of topologically different designs should become more precise; optical fiber will continue to diffuse into

feeder systems; and the increasing deployment of 'fiber-ready' technology can be anticipated.

Economics

The main uncertainties concerning the economics of IBNs are as follows:

- What would the revenues be?
- What would the externalities be worth?
- Would the economies of scope outweigh the economies of specialization?

The first two uncertainties will remain high because we cannot foretell with any confidence what the uptake of new applications will be. Even more important to the first item is the unanswerable question of how competition between the telephone and cable industries would play out. The third uncertainty involves issues related to demand, so it, too, may remain high.

Policy

Obviously, the primary policy issue is whether local telephone companies should be allowed to deliver television. With the assumption that they will be, the key national issues concern the terms of their entry into this market, in particular:

- Should LECs be allowed to buy, or engage in joint ventures with, cable companies in their serving areas?
- Should LECs be required to be common carriers of video programing? If so, should they be able to carry programing in which they have an ownership interest?
- Should LECs be allowed to accelerate depreciation?
- What, if anything, should be done to remove barriers in the way of programing controlled by the cable industry being delivered by competing technologies?

The fate of IBNs may also be affected by shifts in more fundamental policies — three in particular. The first is competition policy. The concept of an IBN was created by monopoly providers of telecommunications services; competition provides a harsher environment for the emergence of the proposed infrastructure. The present trend is toward greater reliance on market approaches, i.e. competition, in the provision of telecommunications services. This does not augur well for IBNs.

Secondly, there is industrial policy. As noted earlier, two FCC commissioners have warned against its endorsing a particular infrastructure technology on the grounds that this would be industrial policy. However, a

softening in the US position on industrial policy would not be unthinkable if the American economy continues to be very weak. Such a shift could be favorable for IBNs.

The third policy concerns the radio spectrum. With rapid growth in demand for mobile services and with planning for high-definition television, demand for access to the spectrum is outstripping supply. The current allocation favors bandwidth-hungry television at the expense of mobile services. A case can be made for shifting broadcast television to transmission by cable — whether coaxial or fiber-optic. This case will very probably grow stronger. A consequent shift in policy would be most helpful to IBNs.

The US controversy described in this article is an expression of more than the conflict between two industries and their respective technologies. It may not be settled for a long time.

Notes

1. American usage is adopted: a billion is a thousand million; a trillion is a million million.
2. The whole of this section draws heavily on Hazlett's analysis.
3. Whatever rate is used, the allowance for depreciation permits telephone companies to recover only 100 percent of their capital costs. However, raising the rate that applies to telephone plant increases the price of telephone service and provides funds for investment in a broadband infrastructure.

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