TECHNICAL STANDARDS AND THEIR POLICY IMPLICATIONS

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1. Introduction*

Communications networks are extremely complex systems. One of the major accomplishments of modern technology has been the evolution of systems engineering concepts that allow the design of nationwide and worldwide systems that interconnect and intercommunicate successfully even though parts may be owned and operated by different organizations. Early networks were developed on a national basis in most countries and standardization efforts can be traced to the beginnings of the International Telecommunications Union (ITU) in 1865.

In the U.S. early telephone technology was fragmented with many competing local firms. But the consolidation of the industry under AT&T early in this century resulted in a dominant player that could easily set technical standards for the whole industry and in most cases had the general support of the independents. The cable television (CATV) industry, in contrast, has been more diversified in ownership and, owing in part to the nature of its service, divergent in approaches to the technical design of its networks.

The body of the ITU which deals with telephone standards issues is the CCITT (the French initials of the International Telegraph and Telephone Consultative Committee). Until roughly twenty years ago, the efforts of the CCITT did not have much impact on the design of national networks; they focused primarily on the interconnectivity of such networks, not their internal design. This has been changing and there is now much effort placed on the design of new networks and services before they are actually implemented. CCITT efforts in X.25, Teletext, and ISDN show a new direction for the

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organization (FCC 1984a). In these cases whole new services and networks were designed within the context of an international standards body before they were implemented. American interest in CCITT has also increased significantly in the past decade. In part this is due to the standards vacuum resulting from the end of AT&T's leadership. It is also due to greater interest by American firms in export markets where CCITT standards are key in procurement specifications. There is some concern that such international formulation of standards may not be sensitive enough to policy issues within specific countries. International standards making is a very esoteric area involving many technical experts whose goal is reaching timely, workable technical standards.

The policy making community can easily become distracted from this task, which is marked by frequent meeting and discussion of very detailed drafts on large numbers of apparently obscure sub-problems. Yet technical decisions about network design can have a large impact on policy. The author finally received "equal access" telephone service at his residence in November, 1988. During the many years of ENFIA (Exchange Network Facilities for Interstate Access) negotiations prior to the AT&T Divestiture, a wide variety of technical problems were raised by AT&T as barriers to equal access. These issues were all real (although some feel that many were exaggerated) and in great part had their origin in system engineering decisions which were made in the late 1940s leading to the introduction of Direct Distance Dialing and the five-level toll hierarchy in 1953. It is likely that those who made these early technical decisions did not focus on their implications with respect to (the then nonexistent) Other Common Carriers (OCCs), nor were the policy makers of that era cognizant of the long-term implications of certain aspects of the design. Nevertheless, those early decisions created many difficulties for the policy community in the years prior to Divestiture.

While the implementation of broadband networks will involve a great many design decisions, many of them will have no policy implications. Unfortunately, it is not always easy to identify which decisions fall into this category. The policy community must be careful not to get into a Vietnam War by trying to monitor the design of new networks and services too closely. The major challenge is to try to flag, as early as possible, those issues which truly do have policy significance and to stimulate a constructive dialog between the policy community and the technical development community on strategies that can be used to avoid policy dilemmas.

It is common when discussing new telecommunications systems to focus on the development of standards for such systems. One of the most controversial decisions of the FCC during the past decade was its decision not to adopt explicit technical standards for AM stereophonic broadcasting (FCC 1982). However, standards can be a mixed blessing, especially in areas where the technology is changing rapidly and in which there is market uncertainty as to what services are actually needed. This paper will take a more neutral view with respect to the benefits of standards in an area such as broadband networks.

This paper has three major topics: first, the basic issues involved in setting a technical

standard and the forums in which these standards evolve; second, a review of current broadband standards in CCITT; and finally, the likely policy-related standards issues dealing with broadband networks.

2. Standards: Pros, Cons, and Forums

Technical standards in telecommunications serve two principal functions: ensuring compatibility for end-to-end communications, and minimizing variety of design to enable economies of scale in production and more effective marketplace competition between suppliers in order to benefit consumers (Krauss 1982; Sirbu 1985).

In the absence of standards, interconnection of systems becomes either impossible or economically burdened by the need for converters (technology can build almost any kind of conversion device). While it may appear that compatibility and variety reduction are closely related goals, they are not the same. A great many different types of communications systems use a small number of fiber optic cable types. Indeed, such cable is often reused for different systems over its installed lifetime. The absence of standards for fiber optics communications systems has not prevented a number of firms from mass-producing relatively interchangeable cable.

In many applications the importance of standards is related to the practicality and economics of conversion devices which can be used for interconnectivity. In the early years of digitally encoded voice, the divergence of the American Mu-law companding scheme and the European A-law scheme was a major impediment since the only way to convert from one to the other was by using analog conversion which degraded sound quality and increased cost. This issue is less important with today's technology where the cost and quality impact of conversion is much less. Similarly, the incompatibility between American and European color television standards prevented realtime exchange of programming once satellites became available. Conversion devices are now available which are well within the budgets of television broadcasting organizations. The long-term effects of M/A and NTSC/PAL/SECAM divergences for the U.S. and Europe have been: tolerable operational inconveniences for systems operators; some residual quality degradation from conversion; and a requirement that manufacturers build different models for different nations.

Even in the absence of standards there are marketplace forces which, in the long term, encourage movement towards de facto standards. As Krauss has written:

> Communications equipment manufacturers who make incompatible products may have an incentive to voluntarily reach compatible standards as a compromise, or else to buy enough market share through specialization, advertising, or other marketing practice to be assured of an adequate demand for their product. This amounts to establishing a de facto standard, outside of the traditional standard-setting process (Krauss 1982, 28).

The role of standards is generally viewed as a positive one, perhaps on the level of motherhood and apple pie. In reviewing literature on the matter it is hard to find sources that discuss the negative aspects of standards or comment on when they may not be appropriate. Indeed, a special issue of *IEEE Communications Magazine* (January, 1985) on telecommunications standards contains not a single negative word about the topic! By contrast, the FCC's AM stereo decision which did not pick a standard, has been universally derided. Nevertheless, it is appropriate to review the pros and cons of standards in order to help the coming policy decisions in the broadband network area.

While standards generally are perceived to speed the introduction of new services this is not always the case. The standardization process itself is very time consuming despite continuing efforts to speed it up. The X.25 packet switching standard took only four years to be adopted — a record-setting pace (Sirbu 1985), yet it is far simpler than the package of standards needed for broadband networks. CCITT efforts in ISDN date from 1971 (Habara 1988) and have not yet reached a stable point. In seeking standards there is the real danger a decision may be reached too quickly. A classic example is color television standards. The FCC's 1950 decision in favor of the field sequential/CBS color television system can be viewed as choosing the best system at the time, yet one whose long-term practicality was questionable (Sterling 1982). As technology advanced, the FCC fortunately had the opportunity to change its mind and pick the dot sequential/RCA system now known as NTSC.

In international standards deliberations it is possible for nationalistic issues to play a major role in determining the end result (Crane 1978; Sirbu 1985). Problems involved include national prestige and old-fashioned non-tariff trade barriers.

The adoption of technical standards can also have the impact of delaying technical innovation by freezing a technology for implementation. The question of when to freeze a design confronts all manufacturers, but in areas where design standards are not important, it is easier to handle new developments which occur after the initial design has been frozen for production. The difference between American and European standards for color television and PCM digital voice is due in part to the later adoption date of standards in Europe, with the resulting opportunity to take advantage of technical developments after the Americans had committed themselves.

There are a wide variety of forums where telecommunications standards evolve (Schutz 1974; Rutkowski 1986). While the details are not important for the purposes of this paper, the key point to remember is that there are a great number of forums, many of them interconnected in complicated ways. A list compiled in 1984 by a former colleague of mine, Anthony Rutkowski, showed all scheduled ISDN standard meetings for the ensuing year. There were continuous meetings throughout the world on various aspects of ISDN and, at times, there were two or three meetings going on simultaneously on different continents!

The CCITT is the body of the ITU which handles broadband standards. The ITU and its components are treaty organizations under the United Nations umbrella. (The ITU actually predates all other such specialized organizations.) Only national governments

are full voting members of the ITU, thus only representatives of the U.S. government may be formal delegates to CCITT meetings. This formality is not as significant in practice as it sounds, since ways have been found for representatives from private firms to function as effective national representatives at the working level meetings where most issues are resolved. Prior to Divestiture, AT&T and the U.S. international record carriers almost completely dominated U.S. representation at technical CCITT meetings as a result of lack of interest from other organizations, including the FCC. Prior to Divestiture, the National Communication System was active in CCITT, representing Executive Branch agencies in their role as large users of communications services.

U.S. representation to the CCITT is vested in the Department of State, which relies on the U.S. National Committee, an advisory group from industry and other government agencies, to formulate U.S. positions (Cerni 1985).

Prior to 1984 the U.S. National Committee and its five subcommittees were involved in de novo discussions of possible U.S. positions in CCITT. Divestiture made it unclear who would set the national level standards that were previously set by AT&T. The ANSI/T-1 Committee was sponsored by the Exchange Carriers Standards Association to fill this vacuum. The committee is a broadly based group of carriers, manufacturers, users, and government agencies (Lifchus 1988). In practice, most of the discussion of U.S. positions now takes place within the ANSI/T-1 Committee so that the National Committee now has a less direct role in approving standards.

The FCC raised the question in the ISDN Inquiry (FCC 1984a) as to what its role should be in this process. While some of the details of this inquiry were specific to the state of ISDN in 1984, many points expressed seem applicable to ongoing broadband standards issues.

The ISDN Inquiry confirmed that "telecommunications policy issues may be implicated by ISDN plans" indicating that some FCC role must be considered in such CCITT standards development. However, the Commission expressed no interest in setting technical quality standards, stating that "[i]t has been the position of the FCC that performance standards may be desirable, but they should be nongovernmental voluntary ones adopted under the auspices of organizations such as those accredited by the American National Standards Institute (ANSI)." The inquiry also reaffirmed that "it is not the function of this Commission to plan or to design carriers' and others' ISDNs." The Commission chose to avoid formal rulemakings in parallel with standards development because "subjecting the design process to an often adversarial formal rulemaking procedure would paralyze the design process."

The Inquiry decided that the most appropriate role for the FCC was to have its staff participate informally in various national and international standards groups to "sensitize" others to its policy and to rely, in general, on the consensus mechanism in these groups to resolve issues. However, as a last resort, it reminded the standards community of the FCC's special role in international communications policy, as stated in Executive Order 12046 (as amended by Executive Order 12148), that "the Secretary of State shall coordinate with other agencies as appropriate, and in particular, shall give full

consideration to the Federal Communication Commission's regulatory and policy responsibility in this area." The Inquiry goes on to conclude that "this responsibility of the Department of State, and the possibility that the FCC may advise the department directly (bypassing the National Committee), which is always present, ensures that the policy concerns of the FCC will be weighed in the deliberations of the various ISDN planning bodies."

The sibling of the CCITT within the ITU is the International Radio Consultative Committee (CCIR), which as the name implies, deals with spectrum-related issues. CCIR is involved with broadband standards through their work with high-definition television (HDTV) standards in a joint effort with CCITT called the Joint CCIR/CCITT Study Group on Transmission of Sound and Television Systems Over Long Distances. As with CCITT, U.S. representation at CCIR is handled by the Department of State with a U.S. National Committee which usually makes the final decisions. Because of the more direct impact of technical issues on radio policy, the FCC and NTIA traditionally have taken a more active role in CCIR matters than in CCITT matters.

The FCC plays a major role in setting many technical standards in the U.S. Its power to set a wide variety of radio-related standards is clearly described in 47 USC 303 (1982) and, historically it has set prescriptive technical standards for radio frequency emissions. However, for over a decade the FCC has been more open-minded about when such detailed technical standards are needed (Marcus 1986). The Fixed Satellite Service (domsats) has never had technical standards which deal with interoperability and has been successful both technically and financially (Sterling 1982). The FCC authorized direct broadcast satellites with a new set of rules, 47 CFR 100 (1989), which included only two pages for both technical and non-technical issues.

While the FCC has historically prescribed technical standards for radio frequency systems, technical standards for "wire" systems are much newer and are of different origin. In the CATV area there have been quality standards for signals in order to protect broadcasters. However, these have been repealed and all that remains is an optional quality guideline for local governments to use in regulating CATV (47 CFR 76.605 [1985]). CATV interoperability was never regulated.

In June, 1972, the FCC initiated Docket 19528 to consider how to allow the connection of customer-owned equipment to MTS and WATS services. Prior to that proceeding, telephone companies had a monopoly on the provision of such equipment. After a long drawn out proceeding, including appeals to the Supreme Court, the FCC implemented its registration program for telephone equipment, 47 CFR 68 on October 17, 1977. The registration program allows connection of any equipment to the network that does not cause "harm to the network". (By contrast, a recent program in Canada prevents harm to the network and ensures that equipment functions well.)

The Part 68 program had no explicit statutory authorization, such as the radio standards adopted under 47 USC 302,303 (1982), as the FCC cannot ban the sale and use of unauthorized equipment. The logical thrust of Part 68 was that telephone companies must allow customers to use any registered equipment; indeed, they were

free to allow unregistered equipment if it was mutually agreeable. The scope of the Part 68 Rules has grown to include PBX connections, key telephone systems, network channel terminating equipment (NCTE) for leased digital circuits, and in-house wiring for residential premises. In effect, the FCC has become the standards setting body for customer premises equipment. This approach was taken at a time when the telephone companies were dominated by a vertically integrated AT&T which forcefully opposed most changes in its CPE monopoly. More recently, the FCC has become more flexible in its approach. It declined to adopt Part 68 standards for the NCTE-like equipment that terminates analog groups and supergroups at users' premises. In this case it relied on carrier tariffs to set the standards — subject to review should there be an accusation of unreasonable action.

There is no statutory requirement or precedent that would extend Part 68 standards to broadband networks. To date, the FCC has made no clear statement about whether it intends to consider Part 68 rulemaking action for such networks or will rely on tariffed standards. It is unclear what the benefits of such rulemaking would be since the ANSI/T-1 committee already functions as a broadly based forum for the discussion of such standards, presumably free of the anticompetitive potential of the pre-1977 situation where AT&T set standards of this kind. Formal FCC action in this area would add additional time delays to the already lengthy standards process. Once embedded in Part 68, such standards would be more resistant to evolutionary improvements as technology advanced. While the initial goal of Part 68 — to introduce effective competition into the CPE market — has been a great success, it is not clear that formal rulemaking is the only means to this end given current industry structure. The electrical industry and natural gas industry have non-governmental technical standards that govern their CPE and this might prove to be a better approach for broadband networks.

The FCC is also active in developing HDTV technical standards, an issue which has an impact on broadband networks. The FCC clearly has the authority to adopt technical standards for broadcast television. Its authority to set CATV-like standards for broadband networks is less clear and such action would be without precedent. To date, the FCC has not asserted any interest in, nor claimed any jurisdiction over technical standards for HDTV, except when broadcast in the VHF/UHF range.

It is interesting to note the FCC's recent action in GEN Docket 87-390 dealing with another new technology, cellular telephones. The present system has detailed interoperability standards given in 47 CFR 22. The FCC has adopted a flexible scheme arguing that "currently these standards stymie innovation with no corresponding benefits." As one observer commented:

> In short, the FCC has apparently decided that, however painful it may be, it is going to force the industry to modernize its transmission technology to achieve genuine spectrum efficiency. It is also not going to allow the introduction of new technology to be delayed by what would almost certainly be a protracted, and possibly futile, search for a single technical standard (Calhoun 1988, 41).

3. Status of Current Technical Standards for Broadband Networks

At the IXth CCITT Plenary Assembly in Melbourne in November, 1988, two key documents were approved relating to broadband standards. Recommendation I.121, Broadband Aspects of ISDN (CCITT 1988a), summarizes the efforts of the 1985-1988 study period and serves as a guideline for the 1989-1992 study period. The second document is a list of specific questions for Study Group XVIII for the 1989-1992 study period. It is interesting to note that both I.121 and Bellcore's Preliminary Special Report on Broadband ISDN Access (Bellcore 1987) contain no mention of possible broadband networks with analog distribution of video.

The present CCITT thinking on the principles of broadband networks are clearly stated as follows in I.121:

- The main features of the ISDN concept is the support of a wide range of audio, video, and data applications in the same network. A key element of service integration for ISDN is the provision of a range of services using a limited set of connection types and multipurpose user-network interfaces.

- In the context of this Recommendation, the term B-ISDN is used for convenience in order to refer to and emphasize the broadband aspects of ISDN. The intent, however, is that there is one comprehensive notion of an ISDN which provides broadband and other ISDN services.

- B-ISDNs support both switched and non-switched connections. Connections in B-ISDN support both circuit-mode and packet-mode services.

- B-ISDN will contain intelligence for the purpose of providing service features, maintenance, and network management functions. This intelligence may not be sufficient for some new services and may have to be supplemented by either additional intelligence within the network, or compatible intelligence in the user terminals.

- A layered structure should be used for the specification of the access protocol to a B-ISDN.

- It is recognized that ISDNs may be implemented in a variety of configurations according to specific national situations.

The last sentence is a key point in all CCITT deliberations, as it recognizes the existence of distinct telecommunications policy environments in different nations. Thus a network in a country with a pure PTT monopoly would differ in many aspects

from one provided in the context of the highly competitive U.S. industry structure. U.S. entities must recognize that almost all CCITT member nations are either monopoly situations or are only recently evolving from a monopoly and have little experience with a competitive environment. Developing network concepts that are competition-neutral is a very difficult task. While CCITT has recognized the need for such options, the onus is on the U.S. entities to work within the CCITT process to ensure that competitive networks can smoothly function with the CCITT recommendations with a minimum need for a "variety of configurations".

I.121 goes on to specify that asynchronous transfer mode (ATM) is "the target transfer mode solution for implementing a B-ISDN." ATM is a packet switching method that facilitates the combining of various services in the same transport system. These services can be switched or nonswitched and can have widely differing data rates. The decision to use ATM ensures that broadband planning will be very flexible. I.121 recognizes that present systems do no use ATM and that in "certain countries" some interim combination of ATM and Synchronous Transfer Mode may be needed "to facilitate early penetration of digital service capabilities."

I.121 envisions five classes of broadband services:

1. Conversational services such as video telephony, video conferencing, and high-speed data transmission.

2. Messaging services such as electronic mail and mail services for motion pictures.

3. Retrieval services such as retrieval of high resolution images and audio information from "information centers".

4. Distribution services without user individual presentation control, such as non-interactive CATV.

5. Distribution services with user individual presentation control, such as pay-per-view CATV.

It is interesting to note that I.121 defines messaging services as offering: "user-to-user communication between individual users via *storage units* with store-and-forward, mailbox, and/or message handling (e.g., *information editing, processing, and conversion* functions)" [emphasis added]. This is another indication of how much the CCITT standards environment differs from the U.S. policy environment. CCITT partners of the U.S. intended to offer integrated networks that offer a wide range of services, not all of which are considered telecommunications in the U.S. Users in the U.S. will rightfully be disappointed if they see that other countries have access to more services than they do. A solution would be either to seek a limitation on the scope of

services defined by CCITT for broadband networks, or to change U.S. policy to allow direct and simple implementation of the integrated services that will come from CCITT. A more modest alternative would be to have the U.S. entities seek to give users the same functionality and ease of use that will be available in other countries by carefully defining the interfaces needed between various transport and enhanced service providers and between the individual user. Such definitions would need to be specified early in the standards development process.

Finally, I.121 defines goals for two user interfaces and three new user channel rates. The user interfaces are at 150 Mbps and at 600 Mbps. The lower rate would be adequate for residential use of HDTV and for lower-speed POTS and data, while the higher speed could serve business users and residential customers wanting simultaneous video capability.

The CCITT Plenary defined twenty-two questions for the 1989-1992 period dealing with ISDN and broadband issues (CCITT 1988b). Two of these questions (J/XVIII and V/XVIII) deal with digital coding techniques for HDTV and other new services over broadband networks. Five of the questions (E, F, G, H, and I/XVIII) deal with performance objectives for such networks. Four of the questions (C,D,L and S/XVIII) deal with technical issues involving the interconnection of different transmission media and networks. From the policy viewpoint, it appears that the following questions are probably the most significant ones.

Question N/XVIII
ISDN network capabilities for the support of additional and/or new services. This includes an examination of intelligent networks, value added networks, and universal personal telecommunications.

Question P/XVIII
ISDN architecture and functional principles, characterization methods, and reference configurations, including user network interfaces and interfaces with private networks. It includes an attempt to develop service descriptions and architectural reference models.

4. Policy-related Standards Issues for Broadband Networks

There are a great many technical issues which must be decided in the process of implementing broadband networks. Many of these decisions are important but have no policy significance. For example, in the present network it is important to standardize the plugs and signal levels used at the subscriber's interface to the network. The details of such standards have no policy impact as long as they are within reasonable parameters. In this section we will discuss the standards issues that appear to be vital from the viewpoint of public policy.

Need for and Scope of National Standards

A basic issue in broadband networks is whether national standards — voluntary or governmental — are needed at all, and if so, what scope is needed. CATV systems exist with no national standards except signal leakage. It may assist in the timely implementation of broadband networks if there are trials of a number of different designs in order to explore different technologies and to investigate the possible economic advantages to be gained from different environments. In this case, the issue of national standards for video programming distribution may not be very important since it does not involve interexchange connectivity as it is understood in telephony. Both Bellcore and CCITT standards planning documents (Bellcore 1987; CCITT 1988a) anticipate diverse implementations of broadband networks before long-term standards are reached.

Questions about the need for a complete long-term standard remain. What would happen if some areas had analog distribution of video signals while others had digital distribution? Such a situation may be acceptable in the long term if the cost savings associated with customizing an installation to a given neighborhood would outweigh the costs incurred by forfeiting economies of scale in production of equipment. It may be desirable to standardize some aspects of broadband networks and not others.

Voluntary versus Regulatory Standards

What role should the FCC have in the adoption of broadband network technical standards? Precedent exist in POTS and NCTE for a Part 68 rulemaking to define the technical standards for the termination at the residence. However, the precedent for groups and supergroups would call for the interface to be defined in a carrier's tariff, and the view recently adopted in the cellular radio telephone context is that lack of standards may stimulate technological innovation. Given that standards are normally developed in an open forum such as the ANSI/T-1 Committee, how much is to be gained by subjecting a standard to the formal steps of FCC rulemaking? What will be the impact of the rigidity that is inevitable once a technical standard is adopted in the Code of Federal Regulations?

Scope of Services Provided

While fiber installation may soon be competitive with traditional technology in new construction, major penetration will require replacing existing local loops. At target costs of $1500 per subscriber, such rebuilds could have a total cost of one trillion dollars (Pepper 1988, citing 1988 figures). Clearly such a massive investment will need careful scrutiny. The functionality of new systems must be carefully defined and it must be impressive enough to convince regulators to approve such massive additions to the rate base. It will be easier to convince regulators if the network standards include provisions for large numbers of new services which cannot be provided in any other way.

Network Topology

CATV systems have a tree and branch topology while local telephone systems have a

star topology. CATV systems deliver the same 30 to 100 channels of video to all their subscribers but there is a limit to their channel capacity. Most discussions in the literature assume that broadband networks will use a star or double star topology with a neighborhood node connected to the central office. These topologies would allow for incremental growth in the number of video channels available and may finally give us a video distribution system where channel capacity is not an issue. By contrast, loop topologies will have the same limitations on channel capacity as present CATV technology. Regulators may want to give close attention to topology and its resulting impact on video channel capacity.

HDTV Standards for Broadband Networks

It is generally thought that HDTV will be available over broadband networks and satellites before it will be available via traditional VHF/UHF broadcasting (*Broadcasting* 1988). As stated above, the FCC has shown no interest in mandating an HDTV format for non-broadcast applications. There are fifteen proposed systems for HDTV being discussed in the U.S. (USSG 1988b), some of which include variants that trade bandwidth for picture quality reduction and receiver complexity. (This is done to facilitate broadcasting of the signals.) Some of the options are closely related so that it would be easy to build a modular receiver that could accept both a wideband signal from a broadband network and a compressed signal from a broadcaster. If it happens that the broadcast standard requires a complex receiver with limited picture quality and the broadband standard requires a less expensive receiver with better quality, there could be a major impact on the traditional role of broadcasters. Should bandwidth compression technology for HDTV receivers remain expensive, broadband networks would gain a real advantage in the distribution of HDTV signals. Broadcasters would have to cope with the limited bandwidth of the VHF/UHF spectrum.

Network Interface Ownership and Location

There will have to be some sort of optical network interface (ONI) between the broadband network and the CPE. Initially, the CPE will be analog telephone and television and the ONI will have to convert to these formats. Ultimately, a fiber distribution system may replace the standard copper wiring within residences and small businesses. Large businesses, driven by the need for data distribution on premises, will probably see the evolution from conventional PBXs to digital PBX/LAN systems at a much earlier date.

The FCC has defined the telephone network as ending at a customers premises where minimum functionality is required; a lightning protection device and a standard jack. For the business oriented digital services that terminate with more complex NCTE, the FCC allows either telephone company or customer ownership. Broadband network termination presents a new scenario. Functionality will be more complex and it will probably have to be modified as broadband network technology evolves. Permitting telephone company ownership of an ONI will facilitate the introduction of broadband networks but may set a long-term precedent which is not desirable.

Power Supply

While we are considering the most advanced communications system we must return to one of the issues which confronted the early designers of telephone systems: who supplies power to subscribers? (Early telephones included dry cells for powering the audio circuit and magnetos to provide ringing current at the called end.) It is not practical to use fiber optics to power the necessary electronics at a user's site even for simple telephones. It would be possible to provide power via copper pairs to each subscriber but this would have a real impact on installed cost. Alternatively, users could provide power from their regular electric system with some sort of battery backup. Battery backup is currently limited to a replacement life of about five years, although twenty year batteries may be possible.

We have grown accustomed to having reliable telephone service. If we want this to continue we will have to resolve the power supply problem. If this is left to the subscriber, should we allow marketplace forces to determine how long a reserve supply the subscriber provides? Many subscribers will forget to replace the battery. Should telephone companies have an automatic reminder service to remind subscribers to change the battery? Should the network interface be designed to test the battery to determine if it needs to be replaced or is missing?

Analog Video versus Digital Video

All of the CCITT and most of the Bellcore standards work has focused on broadband networks within the context of Broadband ISDN. The assumption has been that video distribution would be digital; after all, this is an Integrated Services *Digital* Network. However, there is no fundamental reason why it has to be digital. This appears to be an engineering tradeoff issue. The original Elie-St. Eustache, Manitoba Field Trial used a hybrid analog/digital system. More recently, the GTE Cerritos, California experiment and the Bell Atlantic western Pennsylvania experiments used analog video. The name "Broadband Integrated Services Hybrid Network" (B-ISHN) has recently been proposed for this concept (Mesiya 1988). Such a system works as follows: the capacity of a fiber can be divided up into different wavelengths and each wavelength region can then use a different modulation scheme.

In residential applications, the projected bit rate requirements for video, 20 to 45 Mbps for NTSC and 92 to 200 Mbps for HDTV, dominate the overall rate needed. Analog video distribution would permit the use of less expensive, slower, digital optical equipment for telephony and data. Mesiya gives near term costs of $2570 per subscriber for an all-digital broadband network versus costs of $709 to $1360 for various alternatives of a B-ISHN (Mesiya 1988). Of course, the pure digital options have more long-term flexibility than the B-ISHN alternatives, but it remains to be seen whether such flexibility is cost effective at initial installation. Most of the cost is in the fiber installation (Sirbu 1988]) and a B-ISHN could be retrofitted to an all-digital system at a later date.

Many proponents of broadband networks see the digital versus analog question as a fundamental policy question. Some feel that broadband must use digital video. It is

difficult to state specific policy implications for either option. Each approach could have cost advantages in different applications, depending on the relative cost of different technologies at the time of implementation. An area with mixed residential and business use may benefit from an all-digital system since the users would be interested in wide bandwidth digital service per se. A densely populated residential area with only modest digital traffic might benefit from a hybrid system, assuming a lower cost for analog components than digital ones.

The basic policy point is to make sure that the implementers of broadband networks keep an open mind and that they can justify their design choice before large costs are added to the rate base. The present CCITT deliberations are somewhat troubling in this respect, although they do recognize that national networks may diverge from international standards.

Service Gateway/Kiosks

Assuming that a broadband network provides a wide variety of services, there has to be a mechanism which gives a subscriber access to these services in a simple way. In many countries this issue has no effect on policy since the networks and the services are controlled by the same entity. This is not the case in the U.S. As the CCITT standards evolve they will have to deal with this gateway/kiosk issue.

In the U.S. we have nearly completed the conversion to equal access, replacing a system which made it very difficult to access certain services. For example, using OCCs required dialing twenty or more digits; the new 10XXX codes handle the same function more efficiently. Similarly, in broadband networks, non-discriminatory ways must be found to access the large number of expected services.

Most CCITT members come from countries with little or no competition in telecommunications. It is likely that CCITT deliberations will not focus on competition-related policy matters unless U.S. policy makers keep the issue on the agenda and provide feedback to the U.S. standards community. The goal is to have an access mechanism which is both fair to all parties and user friendly.

Recently, several BOCs have made efforts to provide such gateways in the context of videotex-like services (*Communications Daily* 1988). Such gateways provide uniform access to a number of services as well as handling billing details. These concepts will have to be extended to deal with the much wider variety of services expected in broadband networks.

Trunking Standards

These standards deal with formats used within broadband networks to multiplex information streams for inter-location trunks. Bellcore has proposed its SONET standard to CCITT and it has been well received. This area is full of fascinating technical problems but it appears unlikely that the details of the techniques used will have much impact on public policy.

5. Conclusions

The broadband network area is marked by a plethora of standards issues, enough to keep technical standards experts hopping continually from one meeting to another. There is a need for the policy community to provide input on certain standards questions at an early point in order to preserve policy options that are consistent with overall U.S. policy goals. This paper has tried to present a list of the key areas where technical decisions will interrelate with broader public policy issues, in order to stimulate interdisciplinary dialog. It is also important to note that excessive policy discussion of the numerous pending standards issues may have the effect of slowing down an already slow process. A better approach would be to develop a strategy for focusing on a limited number of key issues. The technical standards community can then fill in the technical details around these issues.

References

Armbruster, Heinrich and Arndt, Gerhard, Nov. 1987. "Broadband Communications and Its Realization with Broadband ISDN." *IEEE Communications Magazine*, Vol. 25, No. 11:8.

Barrett, Anthony C., 1988. "Why Fiber to the Home? A Regulator's View", *Proc. Nat. Comm. Forum*, 340.

Bell Communications Research, Dec., 1987. "Preliminary Special Report on Broadband ISDN Access," SR-TSY-000857.

Broadcasting, Nov. 21, 1988. "Fiber, home satellite to deliver HDTV before broadcasting, says panel," 63.

CCITT, 1988a. "Final Report to IXth CCITT Plenary Assembly (Part III — Recommendations of the I.100-Series), Study Group XVIII Report R 58, IXth Plenary Assembly Document 143.

CCITT, 1988b. "List of Questions for Study During the 1989-1992 Study Period," Study Group XVIII Report R 64, IXth Plenary Assembly Document 149.

Calhoun,George, 1988. "The Next Generation of Cellular Radio,"*Telecommunications*, Vol. 22, No. 6:41.

Cerni, Dorothy M., 1985. "The United States Organization for the CCITT," *IEEE Communications Magazine*, Vol. 23, No.1: 38.

Communications Daily, Dec. 12, 1988. "First Independent 'Test Drive' held for Competing Gateways," Vol. 8, No. 250:3.

Crane, Rhonda J., Dec., 1988. "Communications Standards and the Politics of Protectionism", *Telecommunications Policy*, 267.

Federal Communications Commission, March 4, 1982. "Report and Order in Docket 21313."

Federal Communications Commission, April 2, 1984a. "Report and Order in Gen Docket 83-841," 98 FCC 2d 249.

Federal Communications Commission, Nov. 26, 1984b. "Second Report and Order in CC Docket 81-216," FCC 84-522.

Federal Communications Commission, Jan. 9, 1986. "Third Report and Order in CC Docket 81-216 and CC Docket 84-490," 51 *Fed. Reg.* 929.

Federal Communications Commission, Oct. 10, 1987. "Notice of Proposed Rulemaking in GEN Docket 87-390."

Habara, Kohei, Nov., 1988. "ISDN: A Look at the Future Through the Past," *IEEE Communications Magazine*, Vol. 26, No. 11:25.

Kraus, C. Raymond, Sept., 1982. "A Reader's Commentary: The Case Against Deregulation," *IEEE Communications Magazine*, Vol. 20, No. 9:26.

Krauss, Jeffrey, Sept., 1982. "Implications of FCC Regulation of Telecommunications Technical Standards," *IEEE Communications Magazine*, Vol. 20, No. 9:28.

Lifchus, Ian M., Jan., 1988. "Standards Committee T-1 -Telecommunications," *IEEE Communications Magazine*, Vol. 23, No.1:34.

Marcus, Michael J., Jan., 1987. "Deregulation: A Trend in U.S. Telecommunications Policy," *IEEE Communications Magazine*, Vol.25, No. 1:66.

Mesiya, M. Farooque, Jan., 1988. "Implementation of a Broadband Integrated Services Hybrid Network," *IEEE Communications Magazine*, Vol. 26, No.1:34.

Pepper, Robert M., Nov., 1988. "Through the Looking Glass: Integrated Broadband Networks, Regulatory Policies, and Institutional Change," OPP Working Paper No. 24, Federal Communications Commission.

Rosner, Roy. D., April, 1988. "Can Packet Switching Survive ISDN and Fiber," *Telecommunications*, Vol. 22, No. 4:83.

Rutkowski, A. M., Nov., 1986. "An Overview of the Forums for Standards and Regulations for Digital Networks," *Telecommunications*, Vol. 20, No. 10:84.

Schutz, Gerald C. and Clark, George E., Feb., 1974. "Data Communications Standards," *IEEE Computer*, Vol. 7, No. 2:32.

Sirbu, Marvin A. and Zwimpfer, Laurence E., March, 1985. "Standards Setting for Computer Communications: The Case of X. 25," *IEEE Communications Magazine*, Vol. 23, No. 3:35.

Sirbu, Marvin, Ferrante, Frank, and Reed, David, June, 1988. "An Engineering and Policy Analysis of Introducing Fiber into the Residential Subscriber Loop," in this volume.

Sterling, Christopher H., Aug., 1982. "The FCC and Changing Technological Standards," *Journal of Communication*, Vol. 32:137.

USSG, (CCIR) Study Group, Dec. 23, 1988a. "Architecture of, and Interfaces Among, HDTV Broadcasting and Distribution Media," USSGJIWP10-11/3-3.

USSG (CCIR) Study Group, 1988b. "HDTV Emission Formats Under Development in the United States and Satellite Transmission Applications," US JIWP10-11/3-1.