Technical Standards for Broadband Networks and Their Policy Implications

Marcus, Michael J.

Columbia Institute for Tele-Information
Graduate School of Business
809 Uris Hall
Columbia University
New York, New York 10027
(212) 854-4222

Presented at Integrated Broadband Networks 2 Conference, Columbia University, February 3,1989

Technical Standards for Broadband Networks and Their Policy Implications

Michael J. Marcus*

Abstract

In the implementation of broadband networks a great many technical design decisions must be made. While many of these decisions are transparent to the end user of the service, many directly affect the nature of the service which is offered and in some cases can have a major policy impact. In communications networks, such design decisions are often made in national and international standards bodies. This paper reviews the types of decisions that must be made, the fora in which they will be considered, and the pros and cons of resolving these issues via the traditional standards procedures.

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 Telecommunication Union (ITU) in 1865.

In the U.S. early telephony technology was fragmented with many, often 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 in the technical area. The cable TV (CATV) industry, in contrast has been much more diversified in ownership and, due in part to the nature of its service, divergent in approaches to the technical design of its networks in various localities.

* Assistant Bureau Chief for Technology, Field Operations Bureau, Federal Communications Commission, Washington, DC 20554 & Research Affiliate, Center for Technology, Policy, & Industrial Development, Massachusetts Institute of Technology. The views expressed here are solely those of the author and are not necessarily those of the FCC.

The body of the ITU which deals with telephony standards issues is the CCITT (the French initials of the International Telegraph and Telephone Consultative Committee). Until roughly 20 years ago the efforts of the CCITT did not have much impact on the design of national networks as they focused primarily on the interconnectivity of such networks, not their internal design. For a variety of reasons this has been changing and there is now much effort on the design of new networks and services from the bottom up before they are implemented anywhere. The CCITT efforts in X.25, Teletex, and ISDN show the new direction for the organization (FCC-84a). 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 in part to greater interest by American firms in export markets where CCITT standards are key in procurement specifications. However there is some concern that such international formulation of standards may not be sensitive enough to the policy arena 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 decoupled from this arena which is marked by frequent meeting and discussion of very detailed drafts on large numbers of apparently obscure subproblems. Yet technical decision in network design can have a large impact on policy that can take a long time to fade away. The author final 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 have their origins in system engineering decisions which were made in the late 1940's 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 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 fall into this category. The policy community must be careful not to get into a "Vietnam War" by trying to monitor too closely the design of new networks and services. 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 popular in the discussion of new telecommunications systems to focus on the development of standards for such systems. Indeed, one of the most controversial decisions of the FCC of the past decade was its decision not to adopt explicit technical standards for AM sterophonic broadcasting (FCC-82). 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.

The structure of the paper consists of three major areas. First, what are the basic issues involved in whether to make a technical standard and in what fora do these standards evolve. Second, a review of current broadband standards in CCITT. And finally, what are likely to be the policy-related standards issues dealing in broadband networks.

Standards: Pros, Cons, and Fora

Technical standards in telecommunications serve two principal functions: ensuring compatibility for end-to-end communications capability and minimizing variety of design to enable both economies of scale in production and more effective marketplace competition between suppliers in order to benefit consumers (Krauss-82, Sirbu-85).

In the absence of compatibility-related standards, interconnection of systems becomes either impossible or, more likely with more modern technology which can build almost any type of communications conversion device, economically burdened by the need for converters. While it may appear that compatibility and variety reduction are closely related goals they are not the same. For example, a great many different types of communications systems use a much smaller variety of types of fiber optic cable. 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 the mass production by multiple sources of relatively interchangeable cable.

In many applications the importance of standards is very much related to the practicality and economics of conversion devices which could be used for interconnectivity. Thus in the early the years of digitally encoded voice for telephony the divergence of the American "μ-law" companding scheme and the European "A-law" scheme was a major impediment since the only way to convert from one to another was to use an analog conversion which introduced quality degradation and cost. This issue is less important with contemporary technology where the cost and quality impact of conversion is much less. Similarly the incompatibility between American and European color television standards initially prevented real time exchange of programming (once satellites became available). However, conversion devices are now available well within the budgets of television broadcasting organizations. The long term implications of the μ/A and NTSC/PAL/SECAM divergences for the US and Europe has become 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-82)

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

While standards are generally 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 set many record by being adopted in only 4 years (Sirbu-85), yet it is far simpler than the package of standards needed for broadband networks. The CCITT efforts in ISDN date from 1971 (Habara-88) and have not reached a stable point yet. In seeking standards there is a real danger that one may actually decide too quickly. A classic example is in the area of color television standards. The FCC's 1950 decision 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-82). As technology advanced the FCC fortunately had the opportunity to flip flop and pick the dot sequential/RCA system now known as NTSC. (The impact of this flip flop was minimized by the intervening Korean War which prevented the implementation of *any* system due to national security allocation of electronic parts.)

In the standards deliberations at the international level it is possible for nationalistic issues to have a major role in determining the end result (Crane-78,Sirbu-85). The issues involved could involve national prestige or they could be old fashioned nontarfiff trade barriers.

The adoption of technical standards can have the impact of delaying technical innovation in that they say that the technology should be frozen at some point for implementation. Of course the question of when to freeze a design is a problem that confronts all manufacturers. But in area where design standards are not important it is easier to consider a new technology that comes after the design was frozen for production. The different between American and European standards in color television and PCM digital voice is due *in part* to the later adoption date of standards in both areas in Europe and the resulting opportunity to take advantage of technical developments after the Americans had committed themselves.

There are a wide variety of fora where telecommunications standards evolve (Schutz-74,Rutkowski-86). Figure 1 shows the key fora, and while the all the details are not important for the purposes of this paper, the key point to remember is that there are a great many fora, many of which are interconnected in complicated ways. The author remembers a consolidated list of all scheduled ISDN standards meeting that was compiled by his former colleague Anthony Rutkowski in 1984 and showed that for the next 12 months there were continuous meetings throughout the world on various aspects of ISDN standards and that at times there were two or three meetings going on simultaneously on different continents!

As mentioned previously, the CCITT is the body of the ITU which relates to broadband standards. The ITU, and hence its components, are treaty organizations and are specialized organizations within 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, although this formality is not as significant in practice as it sounds as pragmatic ways have been found for representatives of 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 due to lack of interest from other organizations including the FCC. (Even 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 in almost all matters on the U. S. National Committee, an advisory committee from industry and other agencies, to formulate U.S. positions (Cerni-85).

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. The Divestiture left a power vacuum for the position of who would set the national level standards that were previously set by AT&T. The ANSI T1 Committee was sponsored by the Exchange Carriers Standards Association to fill this vacuum and is a broadly based group of carriers, manufacturers, users, and government agencies (Lifchus-85). In current practice most of the discussion of U.S. positions now takes place within the T1 organization so that the National Committee organization now has a less direct approval role.

The FCC raised the question in the ISDN Inquiry (FCC-84a) 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 issues in 1984, many points expressed in it seem applicable to the ongoing broadband standards issues.

The ISDN Inquiry confirmed that "telecommunications policy issues may be implicated by ISDN plans" and thus that some FCC role must be considered in such CCITT standards development. However, the Commission immediately expressed no interest in setting technical quality standards, stating that " It 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 concensus 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 (i.e. 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 CCIR or International Radio Consultative Committee, which as the name implies deals with spectrum-related issues. The interrelationship with broadband standards comes from the issue of high definition television (HDTV) standards which are being discussed within the CCIR and its joint effort with CCITT, CMTT - Joint CCIR/CCITT Study Group on Transmission of Sound and Television Systems Over Long Distances. As with CCITT, US representation at CCIR is handled by the Department of State with a U.S. National Committee which usually makes the final decisions. Due to the more direct impact of radio technical issues on policy, FCC and NTIA traditionally have taken a much more active role in CCIR matters than CCITT matters.

The FCC is a major player in many technical standards in technical standards in the U.S. Its power to set a wide variety of radio-related technical standards is clearly set out in 47 USC 303 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-86). The Fixed Satellite Service (domsats) has never had technical standards which deal with interoperability and has been tremendously successful both technically and financially (Sterling-82). The FCC authorized direct broadcast satellites with a new set of rules, 47 CFR 100, which covered only two pages for both technical and nontechnical issues.

While the FCC has historically had 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 technical quality standards for signals in order to protect broadcasters from the perceived monopoly power of CATV suppliers. 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). 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 focus of the registration program has been to allow connection of any equipment to the network that does not cause "harm to the network". (By contrast the more recent corresponding program in Canada deals with both preventing network harm and ensuring equipment functions well.)

The Part 68 program had no explicit statutory authorization such as the radio standards adopted under 47 USC 302,303 as the FCC can not ban the sale and use of unauthorized equipment. The logical thrust of Part 68 was that telcos *must* allow customers to use any registered equipment, indeed they were free to allow nonregistered 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 inhouse wiring for residential premises. In effect, the FCC has become the apparent standards body for customer premises equipment. This basic approach was taken in an era in which the telcos were dominated by a vertically integrated AT&T which forcefully opposed most changes in its CPE monopoly. More recently, the FCC has been more flexible in its approach in that it declined to adopt Part 68 standards for the NCTE-like equipment that terminates analog groups and supergroups at users and in this case relies on carriers' tariffs to set the standards - subject to review should there be an accusation of unreasonable action.

Thus despite the apparent extension from Part 68 standards for conventional telephony to ISDN and broadband networks, there is no statutory requirement or even clear precendential requirement that it do so. 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/T1 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 the vertically integrated AT&T set such standards. Formal FCC action in this area would also add additional time delays to the already lengthy standards process. Once embedded in Part 68 such standards would also 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 in the current industry structure. The electrical industry and natural gas industry have nongovernmental technical standards that govern their "CPE" and such nongovernmental standards may be superior to Part 68-like action for broadband networks.

The FCC is also active in the HDTV technical standards question which impacts 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 much less clear and such action would be without precedent. To date the FCC has not asserted any interest or jurisdiction in setting technical standards for HDTV other than for VHF/UHF TV broadcasting.

It is interesting to note the FCC's recent action in GEN Docket 87-390 dealing with future technology cellular radiotelephone. The present generation 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-88)

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-88a), summarizes the efforts of the 1985-1988 study period and serves as a guideline for the 1989-1992 study period. The second key document is the 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-87) 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.
>
> A B-ISDN will contain intelligence for the purpose of providing service features, maintenance, and network management functions. This intelligence nay not be sufficient for some new services and may have to be supplemented by either additional intelligence within the network, or possibly 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 the highly competitive U.S. industry structure. Yet, U.S. entities must recognize that almost all CCITT members/nations are either monopoly situations or are only recently evolving from a monopoly and have little experience with a U.S.-like environment. Developing network concepts that are competition-neutral is a very difficult task. While CCITT has recognized the need for such options, realistically 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 the minimum need for a "variety of configurations".

I.121 goes on to specify that asychronous transfer mode (ATM) is "the target transfer mode solution for implementing a B-ISDN". ATM is a packet switching method that facilitiates the combining of various services in the same transport system. These services can be switched or nonswitched and can have widely differring data rates. This decision to use ATM ensures that broadband planning will be very flexible. I.121, however, recognizes that present system 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 for broadband networks:

1. *Conversational services* such as videotelephony, video conference, and high speed data transmission.

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

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

4. *Distribution services without user individual presentation control* such as noninteractive CATV.

5. *Distribution services with user individual presentation control* such pay per view CATV.

It is interesting to note that in the discussion of messaging services, I.121 defines them 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. The U.S.'s partners in CCITT intended to offer within their countries 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 users in other countries have significantly more convenient access to a broad group of service than they do. Simplistic solutions to this point would be either to seek a limitation of the scope of services defined by CCITT for broadband networks or to change U.S. policy to allow direct and simple implementation of the broad integrated services that will come from CCITT. While there may be advocates of such approaches, a more modest alternative would be to have the U.S. entities seek to give the 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 early in standards developments.

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

The CCITT Plenary define twenty two questions for the 1989-1992 period dealing with ISDN and broadband issues (CCITT-88b). Two of these questions (J/XVIII and V/XVIII) deal with with what digital coding techniques should be used 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 questions of how to interconnect 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 funtional principles, characterization methods, and reference configurations (including user-network interfaces). (This includes issues of interfacing with private networks and goes into more detail on broadband issues and seeks to develop service descriptions and architectural reference models.)

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 public policy viewpoint.

1. Need for/Scope of National Standards. A basic issue in broadband networks standards is whether national standards, whether voluntary or governmental, are needed at all, and if so what scope is needed. CATV systems exist with no national standards (except for signal leakage). It may be beneficial for the timely implementation of broadband networks to have a wide diversity of physical implementations in order both to explore different technologies and to taken advantage of possible different economics in different environments. In this case, the need for national standards for video programming distribution may not be very important since it does not involve interexchange connectivity in the telephony sense. Both Bellcore and CCITT standards planning documents (Bellcore-87, CCITT-88a) anticipate a diversity of initial implementations of broadband networks before a long term standard is reached.

However, there is some question about the need for a complete long term standard. What would happen if some areas had analog distribution of video signals while others had digital distribution, provided that the switched aspects of the networks were compatible? Such a situation may be acceptable in the long term if the cost savings associated with customizing an installation to the needs and environment of a neighborhood would outweigh the costs incurred by forfeiting economies of scale in production of equipment. Thus it may be desirable to standardize some aspects of broadband networks and not others.

2. Voluntary vs. Regulatory Standards. The basic question here is what should be the role of the FCC in the adoption of broadband network technical standards. The precedent in POTS and NCTE would be for a Part 68 rulemaking to define the technical standards for the termination at the residence. However, the precedent for groups/supergroups would call for the interface to be defined in a carrier's tariff and the view recently adopted in the cellular radiotelephone context is that lack of standards may stimulate technological innovation in a dynamic area. Given that any standard is developed in a wide open forum such as the ANSI/T1 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 CFR?

3. Scope of Services Provided. A basic regulatory decision that will have to be made early in the implementation of broadband networks is to allow the cost of construction of the local loops needed. 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/subscriber, such rebuilds could have a total cost of 10^{10} $-1988 (Pepper-88). Clearly such a massive investment will get careful scrutiny. The functionality of such new systems must be carefully defined and it must be impressive enough to convince regulators to approve such massive additions to the rate base. This selling job will be much easier if the network standards include provisions for large numbers of new services which can not be provided for in any other way.

4. Network Topology. This point is closely related to the service issue. Today's CATV systems have a tree and branch topology while local telephone systems have a star topology. Thus CATV systems deliver the same 30-100 channels of video to all their subscribers and have an upper bound on their channel capacity. Most discussions in the literature assume that broadband networks will have a star or double star technology (using 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 scarcity is not an issue. By contrast, loop topologies give the same type of limitations on channel capacity as present CATV technology. Thus regulators may want to give close attention to topology and its resulting impact on video channel capacity.

5. 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 broadcasters (Broadcasting-88). As was stated above, the FCC has not indicated to date an interest in mandating an HDTV format for nonbroadcast applications. There are 15 basic systems being discussed in the US for HDTV (USSG-88b). Some of these options have variants that trade bandwidth for picture quality reduction and receiver complexity in order to facilitate broadcasting of such signals. Some of the options are closely related so that it would be easy to build a modular receiver that could receive both a wideband signal from a broadband network and a compressed signal from a broadcaster. In the extreme case where the broadcast standard required a complex receiver with limited picture quality and the broadband standard required a less expensive receiver with better quality, one can see that there could be a major impact on the traditional role of broadcasters. Should bandwidth compression technology for HDTV receivers remain expensive broadband networks, would have a real advantage in the distribution of HDTV signals and broadcast standards will have to cope with limited bandwidth of the VHF/UHF spectrum.

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

For traditional telephony, the FCC has defined the network as ending at a customers premise with a minimum of on premises functionality - a lightning protection device and a standard socket. For the business oriented digital services that terminate with the more complex NCTE, the FCC allows either telco or customer ownership. A broadband network termination poses a new scenario. Its functionality will be more complex than the previous examples and, during its initial years, it will probably have to be modified several times as broadband network technology evolves. Permitting telco ownership of an ONI that produced a user interface with conventional telephone and video signals would facilitate the introduction of broadband networks yet may set a long term precedent which is not all desirable.

7. Power supply. It is ironic that while we are considering the most advanced communications system we must go back to consider 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 provide enough power optically to power the necessary electronics at a users site even for simple telephones. It would be possible to provide copper pairs to each subscriber for the sole purpose of providing reliable power but this would have a real impact on installed cost. Alternatively, the user could provide power from his regular electric system and some sort of battery backup. Even this battery backup is limited by present technology to a replacement life of about 5 years, although 20 year life batteries may be possible.

We have grown accustomed to having telephone service as our most reliable utility and as one which is almost always available in time of emergency. If we want this to continue we will have to decide responsibility for power. If this is left to the subscriber, should we allow marketplace forces to determine how long a reserve supply the subscriber provides? Assuming that batteries have a lifetime of a few years, many subscribers will have marginal backup that long after installation since they will forget to replace the batteries. Should telcos have an automatic "nag" service to remind subscribers to change the battery? Should the network interface be designed to test the battery and signal either the subscriber or the telco when it needs to be replaced or is missing?

8. Analog 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" and has naturally assumed 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, rather it 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 are using analog video. The name "Broadband Integrated Services Hybrid Network" (B-ISHN) has recently been proposed for this concept (Mesiya-88). Basically, 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 (20-45 Mbits/s for NTSC, 92-200 Mbits/s for HDTV) dominates the overall rate needed. Thus using 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/subscriber for an all digital broadband network versus costs of $709-1360 for various alternatives of a B-ISHN (Mesiya-88). 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 intial installation. Most of the cost of any broadband network is in the fiber installation (Sirbu-88) and a B-ISHN could be retrofitted to an all digital system at a later date.

Many proponents of broadband networks either see the digital vs. analog question as a fundamental policy question or see it as obvious that they must use digital video. From the policy viewpoint it is difficult to see specific implications of either option. Depending on the relative cost of different technologies at the time of implementation, each approach could have cost advantages in different applications. Thus, an area which has mixed residential and business use may benefit from an all digital system since it would have users who would be interested in wide bandwidth digital service *per se* . While a dense residential area which generated only modest bandwidth digital traffic might benefit from a hybrid system (assuming a lower cost for analog components than digital ones).

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

9. Service Gateways/Kiosks. Assuming that a broadband network provides a wide variety of services, there has to be a mechanism for a subscribers getting access to these services on a simple basis. In many countries there are no policy implications in this area since the networks and the services are controlled by the same entity. This is clearly not the case in the U.S. As the CCITT standards evolve they will start getting into this gateway/kiosk issue.

In the U.S. we have recently nearly completed the conversion to equal access and replaced a system where it was very difficult to access certain services, *e.g.* using OCCs required dialing 20+ extra digits. The new 10XXX codes handle the same function more efficiently. Similarly, in broadband networks, nondiscriminatory ways must be found to access the expected large number of services provided by large numbers of suppliers.

Since most CCITT members are countries with little competition in telecommunications it is likely that CCITT deliberations will not focus on policy-sensitive solutions to this issue unless U.S. policy makers keep the issue on the agenda and provide feedback to the U.S. standards community in this area. The goal is to have an access mechanism which is both competition neutral and user friendly.

Recently several BOCs have made efforts to provide such gateways in the context of videotext-like services (Communications Daily-88). Such gateways provide a uniform access to a number of services and handle billing details. These concepts will have to be extended to deal with the much wider variety of services expected in broadband networks. The billing arrangements and need for comparison shopping between services may be more detailed than other CCITT members will need.

10. Trunking Standards. This area deals with formats used internally inbroadband networks to multiplex information streams together for trunking between locations. Bellcore has proposed to CCITT its SONET standard as a mechanism for doing this and it has been well received. This area is full of fascinating technical problems, but it appears unlikely that the details of the techniques ultimately used will have much impact on public policy.

Conclusions

The broadband network area is marked by a plethora of standards issues. Enough to keep technical standards experts almost continually hopping from one meeting to another. There is a need for the policy community to impact 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 dialogue in these areas. It is also important to note that excessive policy discussion of the numerous pending standards issues may have the impact of slowing down the already slow process. A recommended approach is to develop a strategy of focusing on a limited number of key issues and let the technical standards community fill in the technical details around these.

References

(Armbrüster-87) Arbrüster,Heinrich & Arndt, Gerhard,"Broadband Communications and Its Realization with Broadband ISDN",IEEE Communications Magazine, Vol. 25, No. 11,(11/87) p. 8

(Barrett-88) Barrett, Anthony C., "Why Fiber to the Home? A Regulator's View", Proc. Nat. Comm. Forum 1988, p. 340

(Bellcore-87) Bell Communications Research, "Preliminary Special Report on Broadband ISDN Access", SR-TSY-000857 (12/87)

(Broadcasting-88) "Fiber, home satellite to deliver HDTV before broadcasting, says panel", Broadcasting, 11/21/88, p. 63

(CCITT-88a) CCITT, "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-88b) CCITT, "List of Questions for Study During the 1989-1992 Study Period", Study Group XVIII Report R 64, IXth Plenary Assembly Document 149

(Calhoun-88) Calhoun,George,"The Next Generation of Cellular Radio",Telecommunications, Vol. 22,No. 6,(6/88) p. 41

(Cerni-85) Cerni, Dorothy M., "The United States Organization for the CCITT", IEEE Communications Magazine,Vol. 23, No.1 (1/85) p 38

(Communication Daily-88) "First Independent 'Test Drive' held for Competing Gateways", Communications Daily, Vol. 8, No. 250, 12/29/88, p. 3

(Crane-78) Crane, Rhonda J.,"Communications Standards and the Politics of Protectionism", Telecommunications Policy,12/88, p. 267

(FCC-82) Federal Communications Commission, "Report and Order in Docket 21313", 3/4/82

(FCC-84a) Federal Communications Commission, "Report and Order in Gen Docket 83-841", 4/2/84, 98 FCC 2d 249

(FCC-84b) Federal Communications Commission, "Second Report and Order in CC

Docket 81-216", FCC 84-522 (Released 11/26/84)

(FCC-86) Federal Communications Commission, "Third Report and Order in CC Docket 81-216 and CC Docket 84-490", 51 Fed. Reg. 929, (1/9/86)

(FCC-87) Federal Communications Commission, "Notice of Proposed Rulemaking in GEN Docket 87-390", (10/13/87)

(Habara-88) Habara, Kohei, "ISDN: A Look at the Future Through the Past",IEEE Communications Magazine,Vol. 26, No. 11,(11/88), p. 25

(Kraus-82) Kraus, C. Raymond, "A Reader's Commentary: The Case Against Deregulation", IEEE Communications Magazine, Vol. 20, No. 9, (9/82), p. 26

(Krauss-82) Krauss, Jeffrey,"Implications of FCC Regulation of Telecommunications Technical Standards", IEEE Communications Magazine, Vol. 20, No. 9,(9/82), p. 28

(Lifchus-85) Lifchus, Ian M.,"Standards Committee T1 - Telecommunications",IEEE Communications Magazine, Vol. 23, No.1 (1/85) p. 34

(Marcus-87) Marcus, Michael J., "Deregulation: A Trend in U.S. Telecommunications Policy", IEEE Communications Magazine, Vol. 25, No.1 (1/87) p 66

(Mesiya-88) Mesiya, M. Farooque, "Implementation of a Broadband Intergrated Services Hybrid Network", IEEE Communications Magazine, Vol. 26, No.1 (1/88) p 34

(Pepper-88) Pepper, Robert M., "Through the Looking Glass: Integrated Broadband Networks, Regulatory Policies, and Institutional Change", OPP Working Paper No. 24, Federal Communications Commission, 11/88

(Rosner-88) Rosner,Roy. D., "Can Packet Switching Survive ISDN and Fiber",Telecommunications, Vol. 22, No. 4,(4/88) p. 83

(Rutkowski-86) Rutkowski, A. M., "An Overview of the Forums for Standards and Regulations for Digital Networks",Telecommunications, Vol. 20, No. 10, (10/86) p. 84

(Schutz-74) Schutz, Gerald C. & Clark, George E., "Data Communications Standards", IEEE Computer, Vol. 7, No. 2, (2/74) p. 32

(Sirbu-85) Sirbu, Marvin A. & Zwimpfer, Laurence E., "Standards Setting for Computer Communications: The Case of X. 25", IEEE Communications Magazine, Vol. 23, No.

3,(3/85), p. 35

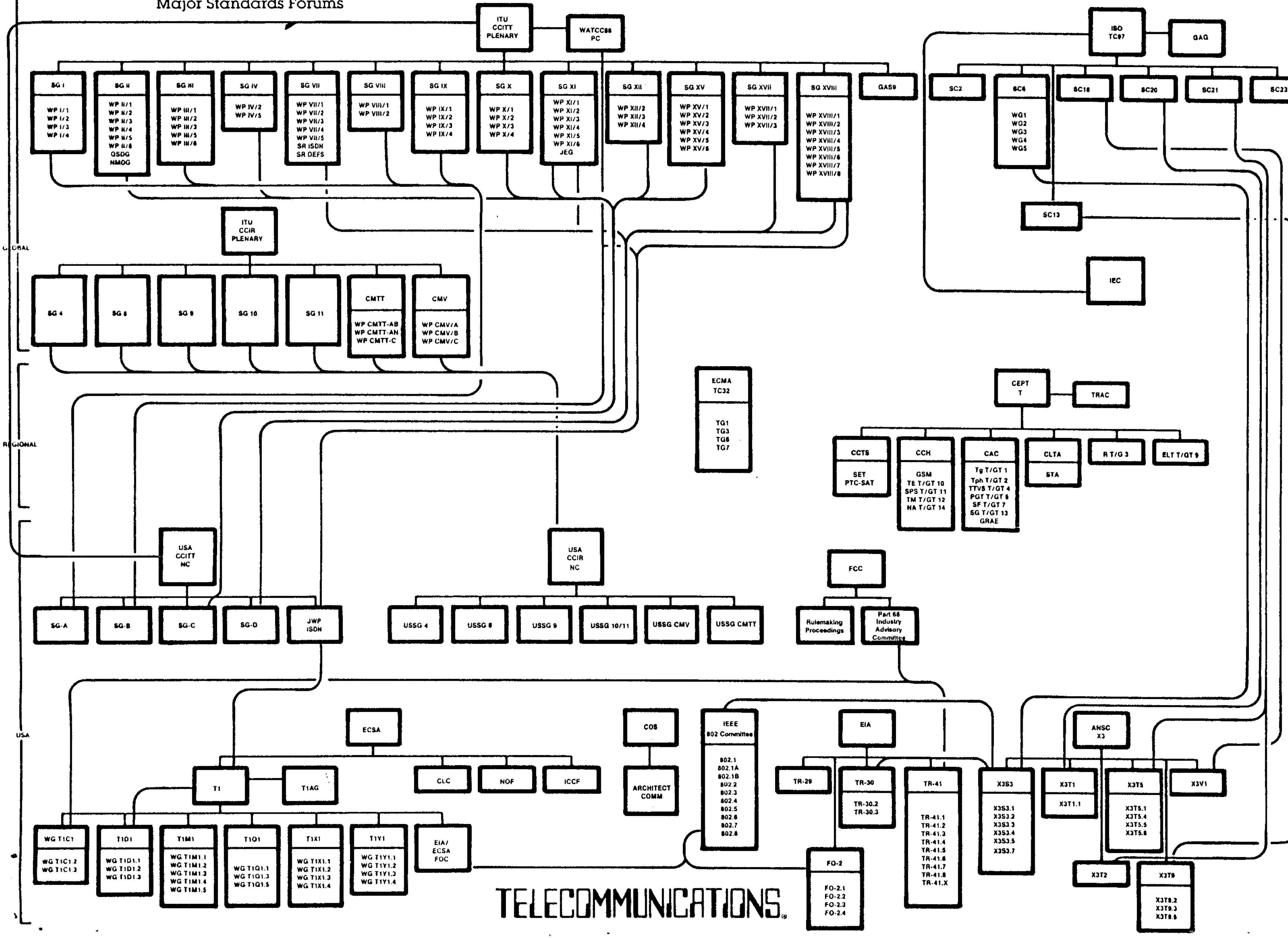
(Sirbu-88) Sirbu, Marvin, et al., "An Engineering and Policy Analysis of Fiber Introduction into the Residential Subscriber Loop", Department of Engineering and Public Policy, Carnegie Mellon University, 6/88

(Sterling-82) Sterling, Christopher H., "The FCC and Changing Technological Standards", J. Communication, Vol. 32, (8/82), p. 137

(USSG-88a) U.S. (CCIR) Study Group, "Architecture of, and Interfaces Among, HDTV Broadcasting and Distribution Media", USSG JIWP10-11/3-3, 12/23/88

(USSG-88b) U.S. (CCIR) Study Group, "HDTV Emission Formats Under Development in the United States and Satellite Transmission Applications", US JIWP10-11/3-1

Digital Networks
Major Standards Forums



TELECOMMUNICATIONS®