METROPOLITAN DATA NETWORK STANDARDS

Dr. James F. Mollenauer

Codex Corporation
Mansfield, MA 02048

Abstract

The CATV system holds great potential for high-speed data communication. Equipment standards in this area will accelerate development, lower costs, and will make interconnection of franchises much easier Such standards are now evolving under the IEEE Project 802, originally formed to standardize local area networks on a smaller geographic scale. Participation by cable operators and users is needed in order to insure that the standards will provide the equipment and services that customers want.

Introduction

The idea of sending data on CATV systems is a hard one to resist. The situation is similar to the early days of computers, when telephone lines were used because they were available. The telegraph was designed as a digital system, but the analog telephone lines had the advantage of universal availability.

Now we are approaching availability of CATV cables in every city, at a time when the requirements of data traffic in speed and volume are beginning to overflow the telephone system. The fit of data to CATV is in many ways a natural one, but there are several problems to be overcome.

The first is that the CATV system is much more fragmented than the telephone system. The economies of modern electronics are highly dependent on large-quantity production, and the demand created by one franchise or MSO cannot drive costs down far enough to be competitive with telephone-based transmission. In addition, passing data from one franchise to another is not necessarily a trivial task. Uniformity of implementation is needed.

The economics of data transmission look favorable, in the sense that the cables have already been installed for entertainment purposes or to meet institutional requirements of the franchise contract. The next largest expense, the network access units, can be borne by the users via purchase of equipment or fixed-term leases. This leaves reverse amplifiers and head-end equipment as costs that the franchise operator must incur before providing data services.

The Role of IEEE 802

One of the most significant developments in the data communications area has been the advent of high-speed local networks utilizing a shared medium, usually coaxial cable. The IEEE has set up a standardization effort (Project 802) for such networks, driven principally by the cost reductions possible with high-volume integrated circuits. The advent of desktop computers and other distributed computing devices has created a demand for data transmission within buildings that is well beyond the capabilities of conventional telephone circuits and modems.

Several different protocols have been standardized under the IEEE 802 umbrella, optimized for different applications. CSMA/CD, for example, represents an evolution of early work in packet radio, and provides very fast response under light load but tends to degrade under heavy load. Token-passing systems behave well under load but have larger delays than CSMA/CD under light load. They also require complex recovery procedures when one unit fails.

Expansion of the charter of the IEEE group to larger networks, 50 km in diameter, made it possible to add metropolitan networks to the set of standards, with all the same benefits. The focus of technical development in a few directions rather than many is likely to provide faster improvements in the technology than dozens of independent corporate efforts.

The best protocols for metropolitan data networks are not necessarily the same as for local area networks, which are optimized for distances of a mile or two in cable length. The longer propagation time of signals in a 50-km system means that a price must be paid in data rate or efficiency if other considerations are unchanged.

In the case of CSMA/CD, collision detection depends upon a collision existing everywhere on a cable if it happens at all; this requires that the packet transmission time be at least twice the maximum cable propagation time. Unless the packet size is made excessively long, an extension of the system size by a factor of 10 results in a speed reduction of a factor of 10.

Similarly, a token bus system that requires tokens to circulate to all units on the system, whether they have anything to send or not, will spend far too much time in token propagation relative to data transmission.

An additional difference between local area networks and metropolitan systems is that local area networks are owned by the same organizations that use them. There is no billing and control issue. Shared systems operated by a third party need centralized control of the network for maintenance and billing purposes. This is not provided by the peer protocols used by the strictly local area networks. An additional advantage in the case of large networks is that it is more economical to concentrate the intelligence of the network in one place--with redundancy--than to put highly complex logic in each access point.

The result of these considerations is that new protocols are needed for metropolitan networks. Initially it was assumed that the metropolitan area networks working group (known officially as 802.6) would work out a standard for TDMA. Since then, some of the initial proponents of TDMA have fallen by the wayside, and the proposal that has received the most attention has been one based on polling.

Participation

The participants in the standards effort have mostly been equipment manufacturers. Some of these have been computer manufacturers, others have been radio and cable equipment companies, and others have been in more traditional data communications. In addition, there has been a heavy degree of participation by the telephone industry, mainly Bell Laboratories and its various successors.

We have not seen a high degree of participation by the cable operators. A few individuals have attended, but the work of the committee has not been driven by the expressed needs of the CATV industry and its customers. Rather, it has been secondhand perceptions on the part of the manufacturers that have provided most of the impetus thus far.

End users have been scarce also. This seems to be normal in standards committees: users don't get involved until they have actual equipment to consider buying. The conclusion seems obvious enough: those who put their two cents in early will stand a better chance of seeing the standards they want.

Work to Date

Once the immediate pressure to produce a TDMA standard had dissipated, the committee took the opportunity to consider the basic question: what kind of applications did we expect to serve? This would dictate the properties of the protocols chosen for standardization. Figure 1 shows the results of the deliberation. From a lengthy list of particular applications we abstracted the most significant properties: overall rate and burstiness. We can assume that some applications such as interconnection of local area networks can afford relatively complex protocols in order to achieve high performance. Others, such as small business and home access, will require simpler protocols in order to meet price goals comparable with inexpensive telephone modems.

Digital voice and video, will also require high performance and will support higher-price interfaces, at least where multiplexed voice is generated by a PBX. In the future, digital compressed video may be a factor, but at the present it is cheaper just to provide analog bandwidth for video.

It is quite possible that two or more standards will emerge to support the application matrix of Fig. 1. In the case of a fixed-bandwidth service like voice, TDMA is ideal. A contention mechanism is needed to permit requests for time slots, but once established, a time slot will be allocated to the same source until it is released. Connections from one source to multiple destinations are possible; the source unit simply includes an address in each data packet that it sends in its time slot. Assignment of time slots and system housekeeping functions are performed by a computer at the head end; the user interface unit requires a microprocessor to request and release the time slots.

For lower cost systems, polling has an advantage in cost. In particular, the user-end interface is quite simple, being required simply to respond when addressed. Such systems have been in use for years in various computer-terminal clusters. The problem of delays while the poll propagates up and down the cable can be handled by polling in order of increasing distance from the head end. So long as the time per response is no less than the time per poll, responses from different units will not pile up at the head end and garble the data. At the end of the polling sequence, or when shifting from one priority list to another, the cable is allowed to run down.

To support digital voice in such a scheme, a maximum priority polling class is established with guaranteed polling interval driven by a real-time clock. On clock interrupt, perhaps every 50 milliseconds, the current polling list is suspended and the fixed-bandwidth list is polled. Since each side of a telephone conversation is polled separately, demand channel assignment (know as TASI in the telephone industry) follows automatically. The overhead to allow all responses to come back in is only about 1% of the capacity.

Calculations assuming reasonable parameters for packet size and distribution of active and inactive users indicate that cable efficiency of about 55% is achievable.

Other protocols have been proposed but not as yet examined thoroughly. These include a cellular form of CSMA/CD and a high-speed token system which requires a non-branching cable.

Interconnect Issues

If we look at the businesses that might be served by metropolitan networks, we see that some are concentrated in center cities and others tend to be located in suburban areas. Financial industries such as banking and insurance are usually located downtown and could take good advantage of a network provided within a city franchise. However, most high-tech industry has located in suburban areas, and it is quite common for a company's facilities to exist in a number of different CATV serving areas. Likewise retail chains are distributed throughout suburban areas.

In order to serve customers that are located in multiple franchises, data must move freely from one cable system to another. In the telephone area, the equivalent problem is solved by a hierarchy of switching offices, but nothing of the sort exists for institutional TV networks.

The simplest way to interconnect the franchises for data purposes is to establish bridges that pick up data packets on the boundary between two franchises and put it down on another system. This can be accomplished readily if the same protocols are used in the two franchises.

However, if the protocols are different, the problem becomes very difficult to solve. There are too many possibilities for arbitrary data formats for anyone to produce a system that will convert between them automatically.

With the present fluidity in the telecommunications business, it is possible that some carrier will step forward with a system designed to provide interconnection of franchises. This would be a natural extension of the long-haul carriers' interest in cable systems as the "last mile" of their satellite and microwave systems. Once again, the use of standardized protocols within the franchises makes interconnecting them very much easier.

Where favorable terrain permits, DTS systems may also serve as CATV data interconnection media. Although DTS has been designed to go directly to the end user, many applications will not be able to support the expense of a dedicated installation, or there will be no available rooftop. Here the CATV system can provide the connection to the customer's building, and the link between head ends can be done via DTS. For longer haul systems, satellites can serve a similar function, with two-way earth stations located where receive-only antennas now pick up TV programming.

In the Future

In the IEEE 802 metropolitan area networks committee, we expect to have our first draft of at least one protocol by the end of this year. We would encourage more participation by cable operators to make sure that the standards meet the cable industry's needs. Additional interest on the part of the cable operators, in turn, will encourage additional manufacturers to participate.

As a result, the users, the CATV operators, and the manufacturers will all benefit.

		SPEED: LOW	SPEED: HIGH
BURSTINESS	LOW	CONVENTIONAL DATA COMMUNICATION	BULK DATA, VIDEO, MULTIPLEXED VOICE
	HIGH	INTERACTIVE TRANSACTIONS	LOCAL AREA NETWORK INTERCONNECT

Figure 1. Metropolitan network parameters for different applications.