PROCEEDINGS

Computer Networks

Computer Networks

Computer Networks

Computer Networks

Computer Networks

IEEE Catalog No. 82CH1796-2
Library of Congress No. 82-82343
IEEE Computer Society Order No. 427

September 20-23

COMPCON 82 fall

TWENTY-FIFTH IEEE COMPUTER SOCIETY INTERNATIONAL CONFERENCE
CAPITAL HILTON HOTEL, WASHINGTON, D.C.

IEEE COMPUTER SOCIETY

IEEE COMPUTER SOCIETY PRESS

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

Order from: IEEE Computer Society
Post Office Box 80452
Worldway Postal Center
Los Angeles, CA 90080

IEEE Service Center
445 Hoes Lane
Piscataway, NJ 08854

#38

CATV FOR COMPUTER COMMUNICATIONS NETWORKS

TERRENCE P. MCGARTY
BRENDA POMERANCE
MIKE STECKMAN

Warner Amex Cable Communications, Inc.

ABSTRACT

CATV systems can provide many communication services for the support and expansion of computer networks. This paper addresses in particular, the architecture of the networks and discusses the specific hardware and system considerations to implement large scale computer networks in urban environments. The issues addressed include candidate existing cable architectures technologies, experimental business applications, and future trends.

INTRODUCTION

Over the past few years, cable plant in the United States has been growing in geographic extent and technical capability. This paper gives an overview of CATV system technology and discusses alternative ways to utilize the burgeoning CATV plant. The status of CATV systems in other countries is briefly noted. In conclusion, forthcoming developments are identified and their effects upon operations are anticipated.

CABLE FACILITIES

New large metropolitan CATV systems have broadband two-way capability which could make low cost computer communication networks easily accessible to household users. This capability is provided on what is called the subscriber cable. Additionally, the institutional cable provided in recently laid systems is an ideal facility for computer-to-computer links.

As shown in Figure 1, the cable systems that appear in large metropolitan areas consist typically of dual cables. Each cable provides a bandwidth of up to 400 MHz. As shown in Figure 2, this bandwidth is generally channelized into 6 MHz bands. The two major types of cable that are provided in the metropolitan areas are the subscriber cable and the institutional cable.

The subscriber cable is used primarily to provide service to the home. This type of cable is provided with a low split frequency division in terms of its upward and downward transmission capabilities. The upward (reverse) transmission direction is from the home to the cable headend. The downward (forward) transmission direction is the path from the headend to the home user. In many of the two-way cables in the large metropolitan areas, the bandwidth allocated to forward transmission is much greater than the bandwidth allocated to reverse direction transmission. This division of bandwidth is well suited to user-computer links, which have inherent asymmetry in magnitude of data streams.

This institutional cable, absent from older cable systems allows for the interface of commercial users to the network. The cable bandwidth is typically mid-split and provides equal bandwidth to both directions. This permits symetric full duplex operation, ideal for computer-computer links.

The cable headend is a central point of control. The headend also acts as a gateway for access to off-net communications networks. In most systems, the cable headend is a single unit employing trunk cables to distribute the same signal to the cable hubs. Each hub provides service to roughly 25,000 subscribers and can be up to about 12 miles in radius. Each headend can support an unlimited number of hubs.

The basic cable headend unit provides for the RF demodulation-remodulation (frequency translation) of the signals of the cable. However, in response to digital requirements in many of the cable networks, the headend has the capacity to provide for regenerative repeating which in turn facilitates signal regeneration and retransmission from the headend back down to the subscriber network for digital signals. The typical architecture utilizing such regenerative repeaters would be one whereby signals originating on, for example, the institutional loop would be transmitted up to the headend. The headend would regenerate the signal and then transmit it back down along the tree structure of the cable. This tree structure of the cable. This tree structure can be viewed as a ring network with the message propagated around the ring by regenerative repeater action at the headend.

The multiple system operators (MSO's) in the United States operated the majority of the cable networks. The largest five at the present time are Warner Amex Cable Communication, Cox Cable, Group W Cable, American Television and Commuication (ATC) and Telecommunications, Inc. (TCI). Together these five companies represent roughly

CH1796-2/82/0000/0309$00.75©1982 IEEE

8 million subscribers.

Currently, there are over 24 million cable households in the United States, i.e. about thirty percent of all American households subscribe to cable. By 1986, roughly 60 million homes will be passed by cable and cable penetration is anticipated at 40 million households. The majority of households will be in large metropolitan areas such as New York, Boston, San Francisco, Pittsburgh, Houston, Dallas, Chicago and Los Angeles and their surrounding suburbs.

MODULATION AND MULTIPLE ACCESS

In the data systems that are presently used in Warner Amex's network, both simple biphase PSK and coherent FSK modulation schemes are used. The data rate is 256 Kbps in a 4 MHz channel. The choice of channel bandwidth is typically a result of cost factors and television allocation frequencies; systems have not had to be optimized for digital data transmission.

One of the major considerations in utilizing cable networks for the transmission of computer communication data, is that the modulation scheme has to be such that the cable interface devices themselves are cost effective. For the utilization of highly efficient modulation schemes in the spectral sense, where there are large bit per second per hertz factors involved (typically 1.0 and above) it is necessary to provide all of the modulating terminals with a phase locked loop and excellent bandpass filters. These techniques significantly increase the cost of the local modem and in many cases have been found prohibitive. The techniques used for the consumer networks utilize FSK and BPSK where the costs tend to be in the tens of dollars for the full network interface device, as compared to thousands of dollar costs typical of those in many of the local area networks.

Care has to be taken at the repeaters (bridger amplifiers), spaced at about one-third mile intervals along the cable, to protect against excessive noise ingressing elements on the cable. At the junctions, the cable may be provided with a computer controlled on-off switch for the upstream path.

The multiple access schemes that have been proposed for the cable systems are variants of existing multiple access schemes operational on local area networks. Cable is a broadband system, i.e., the signal transmitted onto the cable is modulated up to a carrier frequency and is typically frequency division multiple accessed onto the cable itself. So the overall multiple access scheme that is utilized in all cable systems is FDMA. Within each of the frequency allocated bands, or channels, additional multiple access schemes are employed to allow the users of that particular channel to share the available bandwidth. Multiple access schemes in use at the present time or planned to be operational in the near future are carrier sensed multiple-access with collision dection (CSMA/CD), token passing schemes, TDMA and FDMA within the allocated frequency band.

NETWORK ARCHITECTURE

A constraint within which many computer communication network designers have to work are the computer network architectures. The major classes of configurations are centralized and distributed. The cable system that is employed in many of the large metropolitan areas nowadays can readily support either of these alternatives. It is important to note that the support of these alternatives results from the fact that most cable systems are proposing the installation of gateways. These gateways will interface to other offnet communication circuits, such as the value-added networks (Telenet and Tymnet) and satellite networks such as SBS and American Satellite.

As a result of the gateway utilization, there is a great deal of flexibility in providing a specific computer architecture. Terminals can be connected to the network in a totally distributed fashion and can through the gateway, interface other terminals that are similarly distributed in other metropolitan area networks. Due to its broadband capacity, the cable can interface to local area networks in existing office buildings. The interface is also through a gateway which would pass the local area network traffic out of the office building onto the cable network. In turn it would be passed through the headend of the destination gateway.

Four areas must be considered when implementing a computer communications network for cable subscribers, also referred to as an extended local area network (ELAN). First, the equipment at the headend must satisfy service requirements. Second, the cable itself must provide adequate performance as a signal carrier in both directions. Third, the subscriber terminal should be within an acceptable price range. Fourth, the interface unit connecting the subscriber to the cable must be reliably designed so that it cannot bring down the entire cable in the event of a failure. Fortunately, the abundant bandwidth allows selection of a line protocol commensurate with cost and complexity objectives.

EXPERIMENTAL BUSINESS SERVICES

There are several existing experiments that have been used to demonstrate the capability of CATV broadband cable and its support of computer communication networking. One of these is the effort of Manhattan Cable in New York City, a subsidiary of TIME which is providing networks for the financial community point-to-point basis for the last two to three years. Users prefer the cable, rather than a telephone network, because of its greater reliability and bandwidth and lower cost. The extra bandwidth allows the network to support video services which are beyond the capacity of telephone lines.

Warner Amex has demonstrated the use of CSMA in several experiments in the Boston, Mass. area as well as applications for military communication in the Hampton, Virginia area, specifically at Fort Monroe. Broadband cable on Army bases, such as Fort Monroe and Fort Eustis, supports on-base communications and many of the Army's future upgrades. In addition, Warner Amex is having discussions with Carnegie-Mellon University in its franchise area in Pittsburgh to develop for the University as part of the cable distribution network in Pittsburgh, a local area network extending to the University's campus and other areas where students may live, and provide for a fully distributed remote application for the University.

In San Francisco, LDD (Local Digital Distribution), in conjunction with SBS and Tymnet demonstrated use of satellite and packet-switching networks with a cable system to transmit computer data on a national basis. Instead of using leased telephone lines for the local loop, cable systems owned by Viacom and ATC's Manhattan operation were employed. Cable and readily compete with the telephone company in inter- and intra- city data transmission due to its wider bandwidth and lower costs.

INTERNATIONAL CABLE SYSTEMS

Cable is more widespread in Belgium than in any other country. The Belgian PTT owns and operates the cable. It is used to broadcast channels received at headends from the United Kingdom, France the Netherlands and Germany as well as two Belgian channels, in French and Flemish.

In the rest of Europe, only the United Kingdom, Holland and Switzerland have cable and what is there is limited. This is due to the fact that European telecommunications are controlled by government PTTs, which focus primarily on provision of telephone service.

Two-thirds of Canadian households are passed by cable. The penetration, or percentage of households subscribing to cable is very high, about 82% nationwide. Cable operators are privately owned companies, as in the United States. The largest is Rogers Cable Systems with about 1.5 million subscribers. Canadian cable is subject to utility-type regulation with a guranteed rate of return; the governing agency is the Canadian Radio and Television Council (CRTC). Subscribers pay a flat rate of about $8 per month. Basic service is twelve channels. If the subscriber so desires, he may purchase a converter at a store; this will enable access to about thirty-five channels.

Japan has one cable system in Kohfu, outside Tokyo, with about 30,000 subscribers. CATV has apparently not developed in Japan for two reasons. First, Japan does not have many rurl areas; its urban households do not need cable since they can receive microwave broadcasts. Secondly, even in these rural areas, there are very few televisions per household.

ANTICIPATED DEVELOPMENTS

Some trends expected to impact the future of CATV use in computer networks are:

- Two-way Cable Plant - Virtually all newly laid cable has two-way capability. Many existing systems are undergoing retrofit, and simultaneously being upgraded to two-way capability. By the end of the decade, about 90% of all systems will have a two-way capability. This will facilitate dissemination of interactive services.

- Home Terminal Evolution - Consumer acceptance of computer technology in rapidly increasing. As software and equipment becomes more user-friendly, a lifestyle incorporating a terminal approaches realization. This will spur demand for cable and communications network services.

- Protocol Adoption - Standards for the lower levels of the ISO protocol model have been defined (CCITT Recommendation X.25 and X.75). In May '81, AT&T proposed a standard for the presentation layer protocol. Eventually a comprehensive and generally accepted protocol with facilitate communications services accessible to a broad range of users. The cable sommunity is beginning to understand and accept these protocols.

- Fiber Optic Cable - Fiber optic cable will provide extremely high bandwidth point-to-point digital capacity. Presently, virtually no fiber optic cable is in commercial use. The major business challenge will be in transitioning to innovative design approaches which exploit the available bandwidth.

- Gateways - The proliferation of gateways will accelerate assimilation of cable into existing applications and foster new applications. Interesting and efficient systems can be expected as local area networks in various buildings become capable of cost-effecting communication.

- MSO Interconnect - In the future. a multiple system operator (MSO) will be able to interconnect with other adjacent systems. Assuming these interconnects can be accomplished in a way which is transparent to the application, cable will provide an important national communications resource. Eventually, its connectivity may rival that of the telephone network, and it will provide much greater bandwidth.

- ISDN - Contemporary interest in establishing a globally compatible integrated services digital network will certainly impact future computer networks using cable. The place of cable in the ISDN would, logically, be as a local/regional conduit. A typical scenario would have a set of channels on the cable marked for the ISDN application; connecting, perhaps, a local area network in a building to an earth station shared with other buildings.

- Distributed Data Bases - Cable can support extremely high data rates, and thus make it feasible to use distributed data bases despite stringent response time requirements. As understanding of how to exploit cable capability in the design of distributed systems evolves, other attractive performance features may also become apparent.

CONCLUSION

It is clear that the CATV networks present a new medium of communication for the computer network user. Cost efficiencies as a result of the scale economies associated with CATV networks make cable one of the most economical alternatives to local loop distribution available. This will be particularly so as telephone tariffs for local loop service increase drastically in the next two to three years.

One of the more serious outstanding issues, however will be the resolution of many of the standards that are being proposed by various committees. At the present time, the cable network interfaces are being developed on an ad hoc basis with careful attention to the standards efforts that are being proposed.

References:

1. McGarty T.P., "Financial Data Networking and Technological Impacts," Intelcom '80, pp. 411-416.
2. McGarty T.P.,"Growth of EFT Networks," Cashflow, Nov. 1981, pp. 24-28.
3. McGarty T.P., "Local Area Wideband Data Communications Networks," EASCON 1981.
4. McGarty T.P., "Cable Television Technology Cost Considerations for Integrated Services," ICC '82.

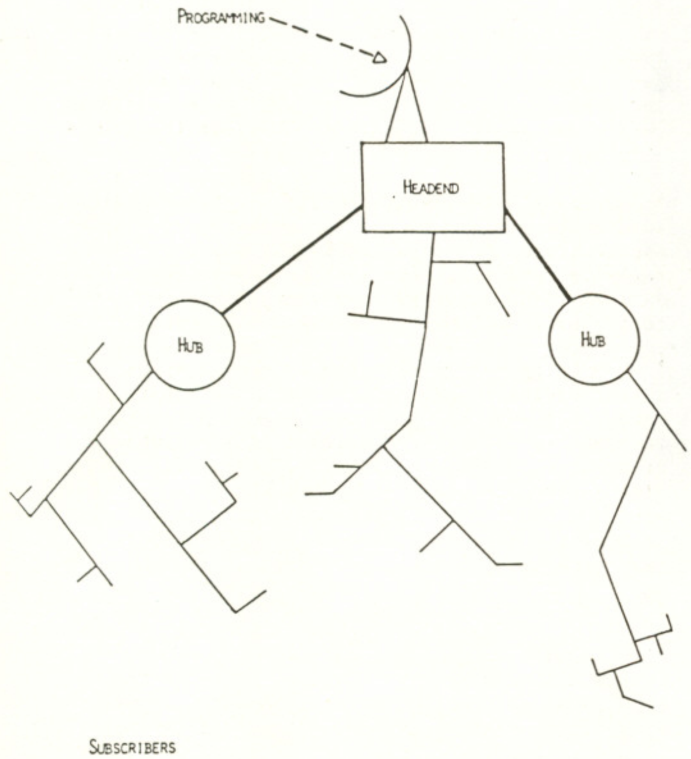

Figure 1. Typical modern cable system configuration

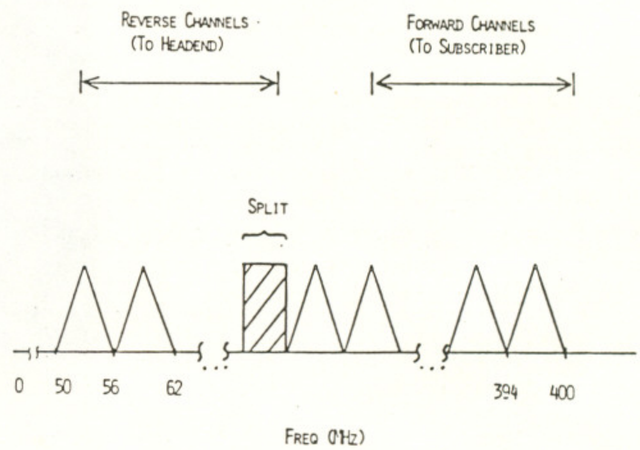

Figure 2. Typical available cable bandwidth