Cable Data Networks

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The existing Cable-TV infrastructure can be used to deliver multi-megabit data network service directly to the home via "cable modems." Examined here are current issues in providing this service, a comprehensive survey including physical wiring, RF issues, developing standards, access to the Internet, and existing products.

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Why cable data networks?

The rapidly growing popularity of the Internet has brought a rapidly growing appetite for more and more bandwidth. People using 28.8 kbps or 33.6 kbps modems on their phone lines are finding that their modems are woefully inadequate for doing large data transfers, multimedia audio/video, and viewing graphics intensive Web sites. The limited bandwidth on a standard phone line (3.3 kHz) has become the limiting factor for standard modems. Even the newer 56 kbps asymmetric modems and 64 or 128 kbps ISDN connections are still an order of magnitude too slow for even a low quality 1.5 Mbps MPEG-1 video stream [Bee]. A TV-quality MPEG-2 stream at 4 to 6 Mbps is completely out of the question. Faster links, such as a 1.5 Mbps T1, 1.5 Mbps primary-rate ISDN, or 45 Mbps DS3 are available, but can cost thousands of dollars per month, and are thus out of the reach of the average consumer [Halfhill][Gingold].

Because of this bandwidth crunch, there is great interest in exploring new ways of cheaply delivering high-speed data. It might seem that the obvious solution would be to bypass the limits of the telephone network by running new fiber-optic links directly to the home (or business). This approach is known as "Fiber to the Home" (FTTH). However, this would be an enormously expensive proposition, requiring billions of dollars and many years to implement. So, at least for the short term, any increase in bandwidth will have to come from existing infrastructures, such as the telephone network or cable TV network. Meanwhile, these infrastructures are slowly bringing the fiber closer and closer to the home. Fiber to the Neighborhood (FTTN) is already becoming common in both types of infrastructures. Fiber to the Curb (FTTC) becoming the next step, where the fiber stops just short of the home, allowing the transition to existing copper wiring, or reducing the cost and complexity of fiber optic connections inside the home [Bell and Gemmell][Gingold].

Currently, there are two major approaches for providing a solution until the cost and availability of FTTH reached mainstream levels. Asynchronous Digital Subscriber Lines (ADSL, and variants) focus on bringing new technology to the twisted-pair copper wiring between you and your phone company. The competing approach uses excess bandwidth on the coaxial Cable-TV (CATV) networks, available in over 90% of the homes in America, to deliver data -- a cable data network (CDN) [IBM].

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Network Topology

In their original role of a pure CATV network, CDNs started out as relatively simple, one-way, all-copper networks in a "tree and branch" topology. Video feeds were gathered at a central "headend," and propagated down through a hierarchy of splits and branches until they reached the home. The modern version of these networks replace the copper branches in the upper levels with fiber optic links directly to "fiber nodes," which serve neighborhood-sized areas. Such networks are known as Hybrid Fiber/Coax (HFC) networks (Figure 1). The deployment of fiber allows the end user to receive less noisy (cleaner) signals. Beyond the fiber nodes, the network is very much the same -- coax trunks from the fiber nodes split into feeders, which can split further until "drops" go to each house.

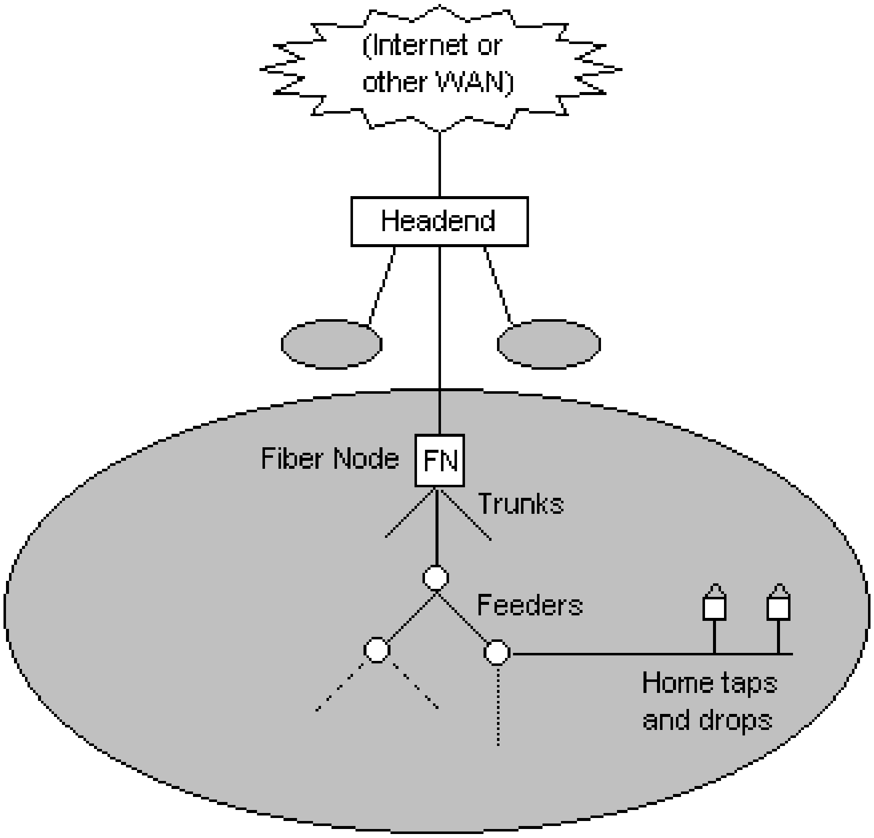

Figure 1. A typical HFC CATV network topology.

Due to the requirement for transmitting many video signals, CATV networks have been designed to provide an enormous amount of bandwidth. The shielded coaxial cable used in the network essentially provides an isolated RF spectrum, entirely for use by that network. In the downstream direction (from the head-end to the end users), video is transmitted on channels from around 110 to 862MHz. Some newer systems are being designed to support frequencies up to 1 GHz. Each channel is 6 MHz wide for NTSC formatted video, or 8MHz in European systems using PAL formatted video. Many cable systems also carry FM radio stations between 88 and 108 MHz, in order to provide high quality audio to their customers. Frequencies below 88MHz can be used to carry video, but they tend to be noisy, and are generally not used for video signals. Instead, the range from about 5 to 30 MHz is reserved for "upstream" transmission -- signals sent from the end user at home to the headend. This was originally used for services like "impulse" pay-per-view, where a button on the cable descrambler box allows instant access to special movies or sporting events for a modest charge. This upstream band can be used in CDNs to allow two-way communication, although it must be shared by all users connected to a particular fiber node.

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Using the CATV Infrastructure for Data

In order to transmit and receive data over CDNs, one must first settle upon the actual method of transmission, and coordinate access to the shared transmission media. Respectively, these are Physical (PHY) and Media Access Control (MAC) layer issues in the ISO/OSI network reference model. A number of proprietary techniques have already been implemented in cable modems, for use in trials by cable operators. For widespread use, however, firm standards must be designed in order to lower costs and allow interoperability. There are two main efforts underway to do so. The Institute of Electrical and Electronics Engineers (IEEE) has started work on one standard for cable modems, while a consortium of CATV operators and manufacturers has been developing their own standard under the name of "Multimedia Cable Network System Holdings" (MCNS).

IEEE 802.14 PHY/MAC standards

The standards from the IEEE LAN/MAN Standards Committee (a.k.a. Project 802) have formed the basis of many network technologies since the committee's beginning in 1980, including Ethernet and Token Ring networks. Thus, their involvement in the development of a set of standards for CDNs is not surprising. The IEEE 802.14 Cable TV Protocol working group was formed to develop standards for the PHY and MAC network layers, a necessity for cable modem interoperability. The 802.14 standards have not yet been finalized; the material presented here is based on incomplete drafts, and will likely change by time the 802.14 standards are ratified [IEEE 802.14 PHY Draft], [IEEE 802.14 MAC Draft].

802.14 Downstream PHY

For downstream transmission (from the headend to the cable modem), two transmission formats are defined. Type A frames are 204 bytes long, consisting of 1 sync byte, 187 data bytes, and a 16 byte Forward Error Correction (FEC) field. The FEC field allows the cable modem to detect errors in the data bytes, and may even correct them if the error has affected no more than 8 data bytes. Type A frames may be sent over the physical media using either 64 or 256 Quadrature Amplitude Modulation (QAM). 64 QAM transmits 6 bits per baud, whereas 256 QAM transmits 8 bits per baud. The draft 802.14 standard does not specify the rate at which either of the QAM encodings is to transmit at.

Type B frames consist of 53760 data bits followed by 42 sync bits (for 64 QAM), or 78848 data bits followed by 40 sync bits (or 256 QAM). The differences between Type A and Type B frames are largely a result of their different FEC encodings. For Type B frames, the draft standard does specify modulation rates, which yield a raw 30 Mbps for 64 QAM, or 42 Mbps for 256 QAM (both assuming 6 MHz available bandwidth).

Frames are transmitted on one of a number of CATV channels between 110 and 862 MHz. Each channel is 6 MHz wide in North America, or 8 MHz wide in Europe and Japan. Thus, cable operators seeking to provide CDN services must reallocate an existing video channel for data, or use a currently unused channel.

802.14 Upstream PHY

The PHY standard for upstream frames ("bursts") is considerably more complex, due to the variety of capabilities and qualities of existing CATV networks. The headend controller for a particular CDN is able to specify both a set of parameters for all attached modems, and a set of parameters for each specific user. Parameters common throughout the network include modulation type (Quartenary Phase-Shift Keying [QPSK] or 16 QAM), baud rate (5 rates from 160 kBaud to 2.56 MBaud), preamble length and content, FEC paremeters, and guard time. Per-user parameters include the power level for transmission, channel frequency offset, and burst length. Raw data rates from 320 kbps to 5.12 Mbps are possible with

QPSK modulation, 16 QAM allows a raw data rate of up to 10.24 Mbps.

Upstream burst are transmitted on one of a number of shared channels between 5 and 42 MHz, although future expansion may raise the upper frequency into the 108 to 174 MHz range.

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802.14 Downstream MAC formats

Whereas the PHY layer specifies the mechanisms for sending bits over the network, the MAC layer provides the services to map higher layers onto these bits. The MAC layer views the downstream data flow over the network as a continuous stream of allocation units, each 6 bytes long. An allocation unit can be marked as idle when the headend has no data or messages to send, or it can be part of a larger logical unit. Multiple allocation units are grouped together to form one of two formats for sending data -- fixed length Asynchronous Transfer Mode (ATM) style cells, or variable length "fragments." All cable modems and headend controllers must support the ATM cell format, which is used for both MAC layer messaging, and user data transfer. Fragments are an optional feature that may be implemented for more efficient data transfer.

The ATM cell format is 54 bytes long, 1 byte longer than a standard ATM cell. The "extra" byte is prepended to the standard header in order to support additional header fields, and to extend part of the existing ATM header (Figure 2).

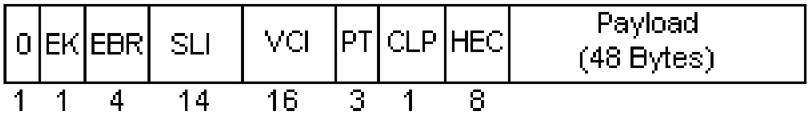

Figure 2. Structure of an 802.14 MAC layer ATM cell (field lengths in bits).

The PDT (PDU Type) bit is used by the MAC layer to determine if the PDU that is arriving is an ATM format cell (if set to 0) or a variable length fragment (if set to 1). The EK (Encryption Key) bit is for "maintaining a consistent encryption key" between the cable modem and headend controller, but its exact role is not yet defined in the 802.14 draft. The EBR (Extended Bandwidth Request) field is not used in the downstream direction, it is kept for consistency with the upstream ATM cell format. The DLI (Destination station Local Identifier) field contains the address of the cable modem (or broadcast/multicast group) that the cell is being sent to. Although each cable modem is assigned a globally-unique 48 bit IEEE 802.1 address by the manufacturer, just like Ethernet and Token Ring products, this long address is not used during normal communication. Instead, a 14 bit "local identifier" is assigned to the cable modem by the headend controller when the modem connects to the cable network. [If you're familiar with the format of true ATM cells, you may notice that the DLI field is actually the 12 bit VPI (Virtual Path Identifier) ATM header field, extended by 2 bits. Whereas a the VPI is used as a label, the DLI is used as a true address.] The VCI (Virtual Circuit Identifier) field is used to multiplex virtual circuits, or connections, to the modem. The PT (Payload Type) bit indicates if the cell contains user data or a MAC layer message, among other uses. The CLP (Cell Loss Priority) bit can be used to indicate cells which should be preferentially dropped if congestion is encountered, a property that has little use within the actual CDN. The 8 bit HEC (Header Error Check) is used to ensure that the receiver will detect a corrupted header. Finally, the user data or MAC message is carried in the 48 byte payload of the cell. However, the data that is desired to be sent may obviously not be exactly 48 bytes in length. So, all user data and MAC messages are carried in ATM Adaptation Layer 5 Protocol Data Units (AAL5 PDUs). AAL5 provides a mechanism to segment and later reassemble variable length data into multiple ATM cells.

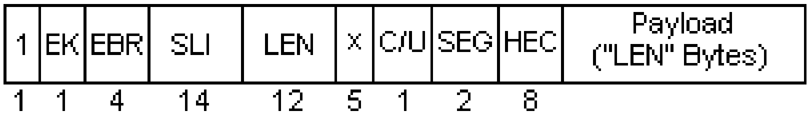

Figure 3. Format of an 802.14 MAC layer variable length fragment (field lengths in bits).

The MAC layer is also capable of using variable length "fragments" to send user data (Figure 3). ATM cells can be inefficient for sending data, as every 48 bytes of data requires 6 additional bytes for an ATM cell header. Fragments are able to send up to 4096 bytes of data (this may be limited by PHY constraints) with only 6 additional header bytes. The PDT, EK, EBR, DLI, and HEC fields are the same as in the ATM cell format. The LEN field indicates the length of the data in the fragment in bytes. The C/U (Control/User indicator) field determines if the data is user data or a control message from the upper layer. The SEG (Segmentation Control) field indicates if the fragment is a complete frame, or if it is the beginning, middle, or end of a multi-fragment frame. If the frame spans multiple fragments, the headend guarantees that it will send fragments in order. If a cable modem receives an out of order fragment (e.g., because the expected fragment was dropped due to a transmission error), all out of order fragments are dropped until the missing one is resent. This header is followed by user data, the length of which was specified in the LEN field.

802.14 Upstream MAC formats

Data sent in the upstream direction is viewed as being put into timed "minislots." A minislot is a period of time long enough for the cable modem to transmit 8 bytes of data, plus PHY overhead and a guard time. In order to reduce the number of collisions that may occur on the shared media, specific minislots are assigned to those cable modems with a need to send data. Collisions are confined to minishots that the headend controller advertises as being available for use to request bandwidth/minislots. If two modems request bandwidth during the same minislot, they will collide, and need to retry later. If a modem does not collide, it will be assigned specific minislots by the headend controller. A minislot can contain a single PDU (a "minipdu"), or minislots can be combined to allow the transmission of larger ATM cells, or variable length fragments. The format of the cells and fragments in the upstream direction is identical to the downstream formats, although some of the fields are used for different purposes.

In both the ATM cell and variable length fragment formats, the EBR (Extended bandwidth request) is now used. The EBR field allows a modem to request additional minislots without going through the contention process which may result in collisions. In other words, it provides a mechanism to request additional bandwidth using bandwidth that has already been assigned to it.

Additionally, the downstream DLI field (which specifies the destination address) is now renamed as the SLI (Source station Local Id), which specifies the source address. There is no need to explicitly give a destination MAC address when data is sent upstream, because all data is implicitly going to the headend controller -- there is no modem-to-modem communication.

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Collision Avoidance

Any network that is based upon a shared media must deal will collisions -- the result of two or more stations attempting to transmit at the same time. Early techniques, such as "Aloha," did nothing to prevent collisions. Stations would simply transmit whenever they had data to send, which often led to poor throughput. In contrast to this, the Ethernet MAC uses CD/CSMA (Collision Detect/Carrier Sense Multiple Access) to both help prevent collisions (by listening before sending data), and to quickly recover from collisions by detecting them as soon as they occur. This results in improved efficiency, but can require a large minimum frame size in networks with high data rates or high propagation delays.

Cable Data Networks can have both high data rates (up to 10 Mbps upstream, 42 Mbps downstream) and high propagation delays, up to 200 microseconds in each direction. The 802.14 MAC reduces collisions by using a type of TDMA (Time Division Multiple Access), where the transmitter is given a reserved period of time in which it may send its data without the risk of a collision. This technique is well suited for use in a CDN, where the contention is only for upstream bandwidth. The downstream direction originates from a single headend on a different channel, and is thus collision free. Stations with data to send upstream request bandwidth from the headend, and then transmit their data in the minislot(s) assigned by the headend.

The headend periodically broadcasts a MAC layer Request Minislot Allocation Elements message that indicates an upcoming group of contiguous unassigned minislots. If a modem has data it wishes to send, but has not yet been assigned any minislots, it may transmit a request for bandwidth in one of these unassigned minislots. The headend controller should then reply with a downstream message acknowledging that the request was received. However, another modem may also have made a bandwidth request in the same minislot, resulting in a message from the headend indicating that a collision has occurred. This in the only time when collisions will occur. In this case, the station must resend the request in a later free minislot.

This is a somewhat simplified view of how stations request bandwidth. In actual operation, a "ternary tree contention resolution algorithm with variable entry persistence" is used to make the process more efficient by reducing the probability of collisions, even under heavy load. When the Request Minislot Allocation Elements message is received, the station extracts a value (R) from the Contention Entry Range field, and then picks a random integer (Rs) between zero and R. If this random number is less than or equal to the number of unassigned minislots in the group, the station can transmit its request in the Rs-th minislot of the group. Otherwise, it must wait and repeat this process with the next RMAE message. Thus, the headend can set R to the number of minislots in the group during periods of few collisions, or set R to a larger number during periods of many collisions. If a collision should still occur during a station's request, the collision message from the headend will promote the stations that collided to a higher request queue. The station can then use unassigned minislots in future Request Minislot Allocation Elements messages that belong to a request queue less than or equal to the stations newly assigned request queue value. This process repeats until the station has successfully made a request for bandwidth.

Upper Network Layers

The IEEE 802.14 group is primarily concerned only with defining the lowest two network levels (PHY and MAC). These levels are designed with the expectation that ATM or 802.2 Logical Link Control (LLC) type traffic will run on top, but these upper layers are not defined. Instead, these issues are being dealt with by the Internet Engineering Task Force (IETF) and ATM Forum.

The IETF, the group that establishes standards for the Internet, has created a working group to define a method to support the Internet Protocol (IP) on a CDN [IPCDN WG]. The group is currently discussing issues such as multicast, broadcast, address resolution/neighbor discovery (IPv4 and V6, respectively), as well as network management issues. Specifically, the working group's charter is to provide documentation for:

- Informational RFCs covering the framework, architecture, requirements and terms of reference for Cable Data Networks
- IPv4 over HFC access networks, covering the mapping of IP over RF channels, encapsulation and framing of IPv4 packets, IP to modem and/or PC address resolution, multicast, and broadcast.
- IPv6 over HFC access networks, covering the mapping of IP over RF channels , encapsulation and framing of IPv6 packets, IP to modem and/or PC address resolution, neighbor discovery, multicast, and broadcast.
- A media-specific MIB for managing the HFC spectrum.
- A MIB for managing cable data network service including management of IP over cable data networks.

The group's last two goals for providing Management Information Bases (MIBs) for use with SNMP (the Simple Network Management Protocol) are both well underway, in the form of Internet Drafts. The working group has also released a "terms of reference" Internet Draft that seeks to define the basic terminology and framework for the creation of a more formal RFC (as defined in the charter). According to their agenda, the working group hopes to finalize all documents and conclude its activities by the end of 1997.

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MCNS standards

The MCNS consortium, led by members Time Warner Cable, TCI, and CableLabs, has decided to pursue their own set of standards. It is still too early to determine which group's proposed standards will become the most widely accepted. However, the MCNS draft standards have received an early "thumbs-up" at the industry's Cable '97 show, where a number of cable operators endorsed the MCNS standard. Public information on the MCNS standards is hard to come by, as the early versions of the technical PHY/MAC issues require a Non-Disclosure Agreement. Information from third parties indicates that the MCNS standards are somewhat similar to the IEEE 802.14 PHY and MAC drafts [CATV Standards]. For example, both use 64 or 256 QAM for downstream transmission, and QPSK or 16 QAM for upstream transmission, and both use some form of TDMA mini-slots for upstream access. Both specs support variable length MAC PDUs; but, whereas fixed length ATM cells are mandatory in the IEEE specs, the MCNS specs provide only extensions to support ATM cells in the future.

A major difference between the IEEE and MCNS specs is their treatment of the network layers above the PHY and MAC. Whereas the IEEE drafts leave upper layer issues unresolved, the MCNS drafts explicitly call for using Ethernet (to connect the modem and computer), and expect TCP/IP to be the protocol running on the network. Additionally, the group has made two comprehensive Interim drafts available for two aspects of their standards which the IEEE has not yet fully addressed -- link security and telephony return.

MCNS Security Specification

One of the unique aspects of CDNs is that they are a shared, *public* media. Whereas privacy and security may not be large concerns on a small corporate Ethernet LAN, these are very important issues for a shared network deployed over a large residential area. The data transmitted to (or by) your modem could be intercepted and read by anyone along the path between you and the headend. Additionally, some form of security is needed to protect the cable system operators and owners of intellectual property from theft or denial of service. Providers of copyrighted or for-profit multicast data need these assurances before such services will prosper. The MCNS security specification seeks to address these needs by providing for privacy, authentication, and service integrity through the use of strong cryptography.

The basic form of privacy is achievied by encrypting all upstream and downstream data with DES, a well-known encryption algorithm. DES is a "symmetric" algorithm; that is, both the sender and receiver must have the same "frame key" in order to encrypt or decrypt the data being communicated. This key is essentially a string of random bits; DES uses a key that is 56 bits long. Guessing which of the 2^56 (over 72 quadrillion) possible keys is being used for communication is difficult enough to be impossible for even a well equipped individual. The frame key is derived from a "service key" that is unique for different unicasts and multicasts. The service key can be changed by the head end when needed, either at periodic intervals to maintain security, or on a "billing cycle" basis so that users only have service keys for services they have paid for.

Service keys are distributed using a different form of encryption -- RSA public-key cryptography. Communication with public key cryptography uses two keys. A "private" key is kept secret, and a "public" key can be widely distributed, to anyone. A message encrypted with the public key can only be read by someone with the private key. When the cable modem joins the network, it sends its public key to the headend. The headend encrypts the service keys with this public key, thus ensuring that only this modem will be able to decrypt and use the service keys. Interestingly, public key cryptography can also work in reverse. A message encrypted with the private key can only be read by someone with the public key. This is useful for authentication -- if we assume only one person has the private key and that everyone has the public key, a meaningful decrypted message could only have been generated by that one person holding the private key. This form of authentication is used to prevent malicious users on the network from impersonating the headend, or other cable modems [MCNS Security].

MCNS Telephony Return

Some CATV systems were never designed to include the ability for upstream transmissions; upgrading these networks to a 2-way CDN may be extremely expensive. This is one of the factors that hinders the introduction of cable modems. Still, these older systems are often capable of carrying downstream data without any major upgrades to the network. One solution for using these older CATV networks as a CDN is to use a standard analog modem and telephone line for the "upstream" path. Although users will be limited to transmitting at 28.8 kbps or 33.6 kbps from their homes, they will still be able to receive data at speeds much faster than are possible over a phone line. This provides a reasonable solution, since the average user does not generate a large amount of upstream traffic. For example, a web browser will make its small HTTP requests to a web server at the slow modem speed, but will receive large graphics, hypertext, and other multimedia content on the CDN at megabit speeds. The MCNS spec accomplishes this by using the same standard Internet Point-to-Point protocol (PPP) that normal modem-only users use when connecting to an ISP. Upstream IP traffic is simply forwarded over the PPP link to the cable company, which routes the return traffic over the CDN to the user [MCNS Telephony].

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Existing Products

The standards being developed by MCNS and IEEE will help to standardize the operation of cable modems, but these standards are not required to produce a working modem. Indeed, a number of manufacturers have begun production of first-generation cable modems. Because there are not yet any finalized industry standards, modems from different manufacturers are incompatible. Even with this limitation, these early modems are of value to CATV operators wishing to test the feasibility of providing CDN service.

One of the largest CATV operators, Time-Warner Communications, has already run a number of trial in select markets, and is now rolling out its "Road Runner" service in parts of Hawaii, Maine, Florida, New York, Ohio, and California. The Road Runner service is available to consumers for a $35 to $45 monthly fee, and a $100 setup charge. By the end of 1997, Time-Warner expects to have as many as 100,000 subscribers.

Another of the nation's large cable operators, TCI, is implementing a cable modem service for $40 a month, with a $150 installation fee. TCI also plans to offer a scaled down, e-mail only service for as low as $5 to $10 a month.

The cable modems used in these tests and rollouts come from a number of the vendors offering cable modems. Major vendors include:

- Motorola's CyberSurfer is a primary supplier for Time-Warner, which has committed to purchasing 300,000 of Motorola's 2-way cable modems.
- The $300 Intel CablePort combines a 100 Mbit Ethernet card and telephony-return cable modem on a single PCI card.
- Scientific-Atlanta produces a number of modems, from a $400 set-top box, to a low-cost $200 telephony-return model that interfaces to the PC through existing parallel printer ports.
- Bay Networks, who shipped 3,000 modems a week in early 1997.
- 3Com, Cisco, Com21, and General Instrument are developing MCNS-compliant devices.

One of the keys to driving down costs is to use standardized chipsets. These are also being developed by a number of IC producers:

- Broadcom has developed a chipset that conforms to the current MCNS specs. The 3-chip set (for each end) is expected to sell for $30. The chipset supports both telephony-return and upstream coaxial transmission.

- Texas Instrument's $100 TMS320C6201 200 MHz DSP can be used in both cable modem and ADSL applications, with it's 1,600 MIPS performance.
- Harris Semiconductor has introduced chips to support QAM and QPSK modulation at under $10.
- Stanford Telecom has introduced a single-chip ASIC (STEL-2176) for transmitting and receiving data on a cable modem.

As cable modems become more mainstream, prices are expected to drop well below $300 for an industry standard modem [EBN1][EBN2][EBN3][EET][EBN4][Telecom].

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Conclusion

Cable modems are finally beginning to deliver on the promise of providing multi-megabit data service at low cost to home consumers. Although the IEEE and MCNS are still working on creating a final set of standards, a number of cable TV operators have already started to offer cable modem services on their networks. Until fiber optic networks are extended to the home, cable data networks are a very reasonable way to satisfy the bandwidth appetites of Internet users frustrated with the limitations of their phone lines.

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Abbreviations

AAL5

ATM Adaptation Layer 5. Allows transmitting variable length PDUs using fixed-length ATM cells.

ADSL

Asynchronous Digital Subscriber Line. A developing technology to provide multi-megabit data speeds over existing telephone cabling.

ATM

Asynchronous Transfer Mode. A method of transmitting data in fixed-length cells.

CATV

Cable TV. Provides dozens of TV channels over a coaxial cable.

CDN

Cable Data Network. Uses existing CATV networks to provide data as well as video.

DES

Data Encryption Standard. A secure method of scrambling data created by IBM and the US

Government in 1975.

DS3

A standard for providing digital data at 44 Mbps from/to the telephone company's network.

FTTN

Fiber To The Neighborhood. Refers to providing high-speed fiber optic links to the neighborhood, with conventional copper networks then reaching to individual homes.

HFC

Hybrid Fiber/Coax. Modern CATV networks are usually comprised of FTTN, and copper coaxial cable to the homes.

IEEE

Institute of Electrical and Electronics Engineers. IEEE Project 802 creates many network standards.

IETF

Internet Engineering Task Force. Oversees the creation of Internet standards.

ISDN

Integrated Services Digital Network. Usually refers to providing 64 or 128 kbps data service over the telephone system.

ISP

Internet Service Provider. Provides access to the Internet via analog modems, ISDN, cable modems, etc.

LLC

Logical Link Control. Controls the transmission of Datalink layer PDUs through the MAC layer.

MAC

Media Access Control. Deals with coordinating access to a network, is immediately above the PHY layer.

MCNS

Multimedia Cable Network System Holdings. A consortium of CATV operators and manufacturers developing a specification for CDNs.

MPEG

Motion Picture Experts Group, MPEG-1 and MPEG-2 refer to their specification for compressing motion video.

NTSC

The format used for television signals in North America.

PAL

The format used to television signals in Europe and Japan.

PDU

Protocol Data Unit. A generic term for the headers and data sent by any network layer.

PHY

Physical network layer. Handles the actual transmission of bits onto the network.

PPP

Point to Point Protocol. Provides a point to point link, usually used by ISPs to provide dialup access to the Internet.

QAM

Quadrature Amplitude Modulation. A method of modulation that changes the amplitude and phase of a carrier to transmit digital data.

QPSK

Quartenary Phase Shift Keying. A method of modulation that changes the phase of a signal to one of four phases to transmit digital data.

RF

Radio Frequency.

RSA

Rivest-Shamir-Adleman, the creators of a public-key cryptography algorithm.

T1

A telephone company standard for providing 1.5 Mbps service.

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