Introduction to Cable Modems

Cable Television Systems

Cable television systems provide video and data services through a system of high bandwidth coaxial cables and fibers. The cable network includes a head-end amplifier that combines the broadcast and data signals for transmission to the subscribers. High-speed Internet access is obtained by including a cable modem termination system (CMTS) function within the head-end that connects to a 10/100Mbps Ethernet router. The head-end is connected to fiber or coax trunks that carry the signals into the neighborhoods where they are tapped off to provide service to the residence.

Earlier cable TV systems provided only one-way broadcast type services such as standard and premium channel television. Upgrading these earlier systems to support the two-way communications necessary to offer Internet access, pay-per-view, voice and video-on-demand services requires large capital investments. Many cable TV carriers have merged with large telecommunications companies in order to take advantage of the enormous market potential that exists. Cable TV systems can deliver high-speed Internet access at costs that are far below that of digital subscriber line (DSL).

Figure 1.1 shows a typical cable television network. This diagram shows that cable television systems can be simple one-way video distribution systems to advanced two-way high-speed digital networks. The head-end is the initial distribution center for a cable television (CATV) system. The head end is where incoming video and television signal sources (e.g., video tape, satellites, local studios) are received, amplified, and modulated onto TV carrier channels for transmission on the CATV cabling system. The cable dis-

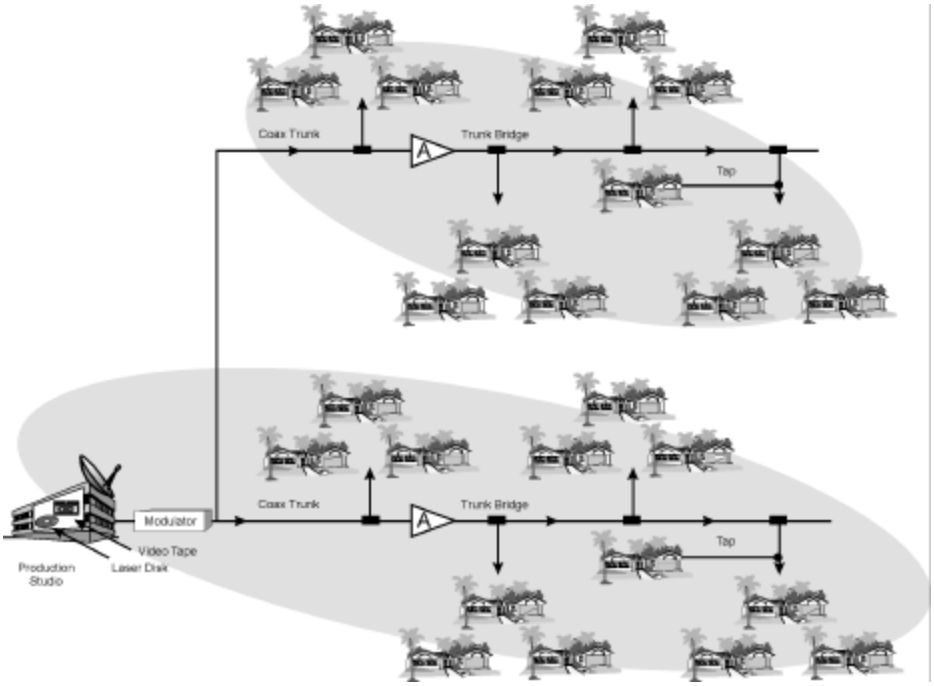

Figure 1.1, Cable Television Network

tribution system is a cable (fiber or coax) that is used to transfer signals from the head end to the end-users. The cable is attached to the television through a set-top box. The set-top box is an electronic device that adapts a communications medium to a format that is accessible by the end-user.

Also in the mid 1990's, a major shift occurred in the broadcast industry. The conversion from analog systems to digital systems provided broadcasters with the tools they needed to bundle multiple types of services onto a television channel signals. This included cable modems, digital television, and even telephone service. The ability to integrate several services into one transmission signal allows the cable television operator to offer many new services without significant investment in new cable systems. Analog CATV systems typically provide 50-100 video channels while digital CATV systems to provide hundreds of video channels, high-speed Internet access, and telephone service.

As cable systems evolved to include fiber (optical) cable and two-way amplifiers, cable networks evolved to allow data transmission in both directions. On the coaxial (RF) cable, the return path was assigned to frequencies in the range below 50 MHz. This frequency range was unassigned for television operation. Fiber optic cables use separate strands for each direction as each fiber cable often has many (30+) fiber strands.

The two-way cable system requires cable modems at the user end and a coordinating modem at the head-end of the system. The cable modem is a communication device that modulates and demodulates (MoDem) data signals to and from a cable television system. A modem at the head-end coordinates the customer's modem and interfaces data to other networks (such as the Internet).

Figure 1.2 shows a two-way cable television system. This diagram shows that the two-way cable television system adds a cable modem termination system (CMTS) at the head-end and a cable modem (CM) at the customer's

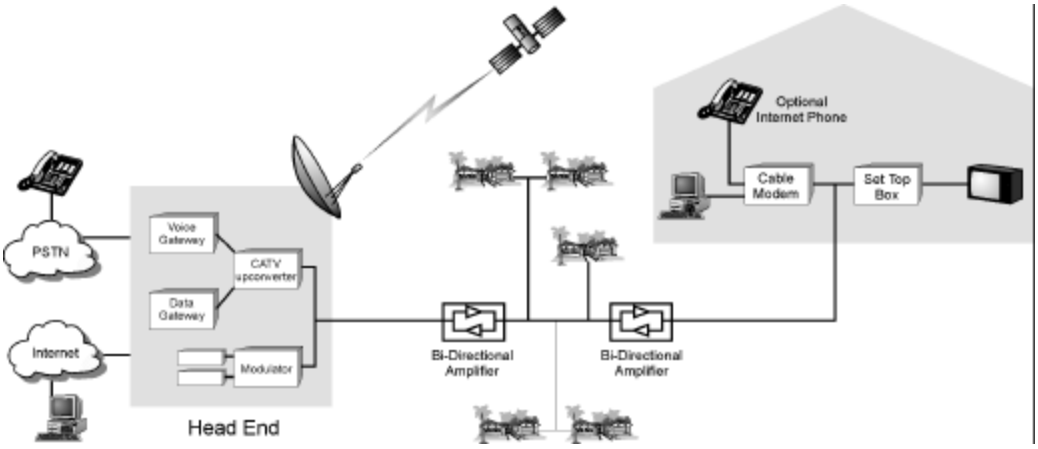

Figure 1.2, Two-Way Cable Television System

location. The CMTS also provides an interface to other networks such as the Internet.

A cable modem is a device that MOdulates/DEModulates data signals on a coaxial cable and divides the high data rate signals into digital signals designated for a specific user. Cable modems are often asymetrical modems as the data transfer rate in the downstream direction is typically much higher than the data transfer in the upstream direction. The typical gross (system) downstream data rates range between 30-40 Mbps and gross upstream data rates typically range up to 2 Mbps.

Usually 500 to 2000 users share the gross data transfer rate on a cable system. Cable modems also have the requirement to divide the high-speed digital signals into low-speed connections for each user. In 2001, the average data rates for a cable modem users was approximately 720 kbps.

Figure 1.3 shows a block diagram of a cable modem. This diagram shows that a cable modem has a tuner to convert an incoming 6 MHz RF channel to a low frequency baseband signal. This signal is demodulated to a digital format, demultiplexed (separated) from other digital channels, and is

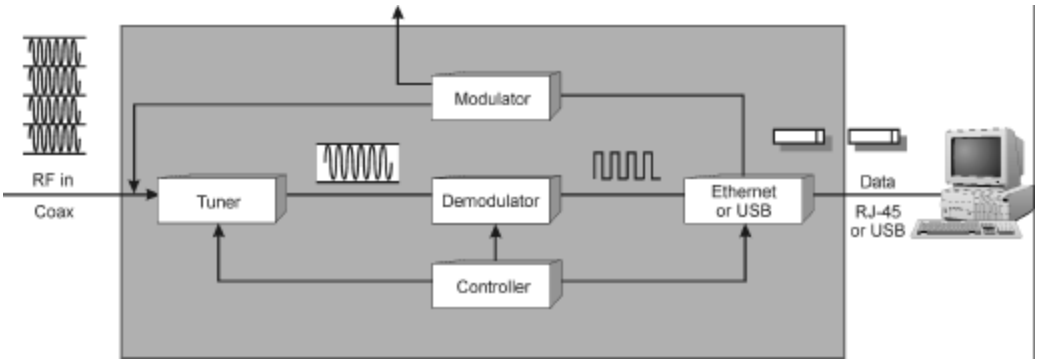

Figure 1.3, Cable Modem

decompressed to a single data signal. This data signal is connected to a computer typically in Ethernet (e.g. 10 Base T Ethernet) or universal serial bus (USB) data format. Data that is sent to the modem is converted to either audio signals for transfer via a telephone line (hybrid system) or converted to an RF signal for transmission back through the cable network.

Data Over Cable Service Interface Specifications (DOCSIS)

The data over cable service interface specifications (DOCSIS) is a standard used by cable systems for providing Internet data services to users. The DOCSIS standard was primarily developed by equipment manufacturers and CATV operators. It details most aspects of data over cable networks including physical layer (modulation types and data rates), medium access control (MAC), services, and security. The DOCSIS cable modem specifications are available from CableLabs® at http://www.cablemodem.com/specifications.html.

The downstream information flows to all users that are tuned to a specific RF channel on the cable system. There may be several RF channels used to serve many cable modem users in a system. Each individual cable modem decodes their portion of the data on a specific RF channel. For transmitting on the upstream side, each user is assigned time of a few milliseconds each where the user can transmit short bursts of data. Dividing the channel into small slices of data is well suited for short delays to keyboard commands.

To convert the Internet data into a format suitable for delivery on a cable channel, a CATV upconverter is used at the head-end of the cable system. The CATV upconverter handles both digital and analog television signals. Usually 10-20 upconverters are installed into a single equipment chassis. To allow cable modems to connect to data networks (such as the Internet), a cable modem termination system (CMTS) is used. The CMTS an interface device (gateway) that is located at the head-end of a cable television system to send and adapt data between cable modems and other networks.

A single 6 MHz wide television channel is capable of 30-40 Mbps data transmission capacity. This is because coaxial cable offers a communication medium that is relatively noise free (compared to radio or unshielded twist pair

cable) that allows the use of complex modulation technologies (combination of amplitude and phase modulation). These modulation technologies can transfer several bits of data for each Hertz of bandwidth (bits per Hertz). In 2001, cable modems could transmit data using 64 QAM modulation technology. To increase the data rate, even more complex modulation technologies such as 256 QAM or even to 1024 QAM have been demonstrated [1].

The DOCSIS system is focused around packet service such as Internet Protocol (IP) and asynchronous transfer mode (ATM) to provide a variety of services (e.g., variable bit-rate, constant bit-rate) with the ability to offer varied levels of quality of service (QoS). This allows the DOCSIS system to offer multiple channels to a home or business that can provide for various services such as voice (constant bit-rate), data (high reliability), and video (high-speed data).

Cable Telephony

Cable telephony is the providing of telephone services that use CATV systems to initiate, process, and receive voice communications. Cable telephony systems can either integrate telephony systems with cable modem networks (a teleservice) or the cable modem system can simply act as a transfer method for Internet telephony (bearer service). Because of government regulations (restrictions or high operational level requirements) in many countries, some cable operators are delaying the integration of telephone services with cable network. In either case, cable telephony systems are data telephony systems that include a voice gateway, gatekeeper, and a media interface.

Voice gateway is a network device that converts communication signals between data networks and telephone networks. A gatekeeper is a server that translates dialed digits into routing points within the cable network or to identify a forwarding number for the public telephone network. A multimedia transfer adapter converts multiple types of input signals into a common communications format.

Figure 1.4 shows a CATV system that offers cable telephony services. This diagram shows that a two-way digital CATV system can be enhanced to offer cable telephony services by adding voice gateways to the cable network's head-end CMTS system and media terminal adapters (MTAs) at the residence or business. The voice gateway connects and converts signals from the public telephone network into data signals that can be transported on the cable modem system. The CMTS system uses a portion of the cable modem signal (data channel) to communicate with the MTA. The MTA converts the telephony data signal to its analog audio component for connection to standard telephones. MTAs are sometimes called integrated access devices (IADs).

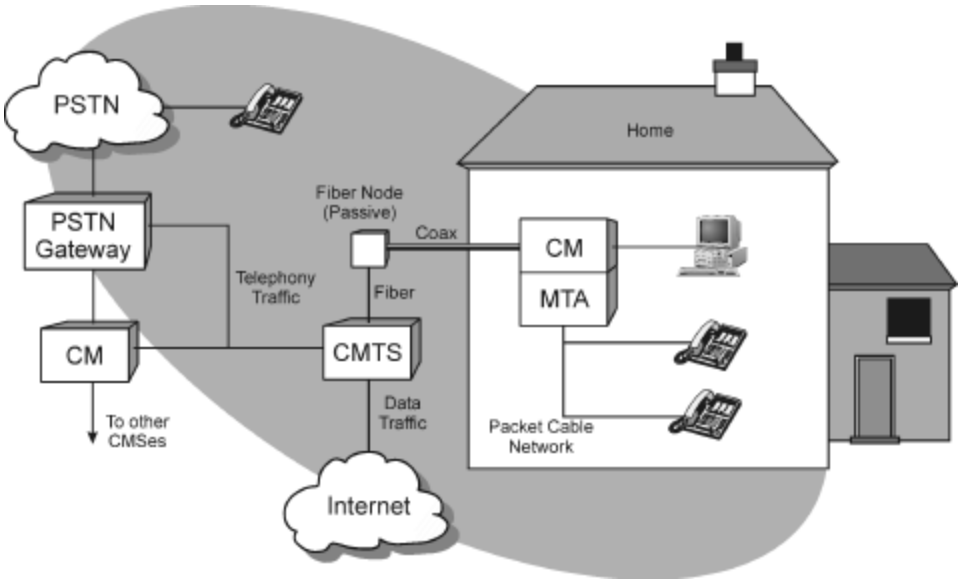

Figure 1.4, Cable Telephony

Because of the high data transmission capability of cable television systems, cable telephony system can provide video telephony service. Video telephony is a telecommunications service that provides customers with both audio and video signals between their communications devices.