Cable Data Modems

A Primer for Non-Technical Readers

Cable television companies are in the midst of a transition from their traditional core business of entertainment video programming to a position as a full-service provider of video, voice and data telecommunications services. Among the elements that have made this transition possible are technologies such as the cable data modem.

Table 1: Comparative Data Transmission Speeds

Time to Transmit a Single 500 kbyte Image	
Telephone Modem 28.8 kbps	6 – 8 minutes
ISDN 64 kbps	1 – 1.5 minutes
Cable Modem 10 Mbps	Approximately 1 second

Source: CableLabs (see discussion under the section entitled Cable Modems).

Cable companies have historically carried a number of data services. These have ranged from news and weather feeds, presented in alphanumeric form on single channels or as scrolling captions, to one-way transmission of data over classic cable systems. There are now a host of information providers targeting an upgraded cable network architecture as the delivery mechanism of choice for advanced high-speed data services.

These changes stem from those taking place in the commercial and residential data transmission markets. The PC explosion of the 1980s was rapidly followed by leaps in computer networking technology. More and more people at work and at home were becoming familiar with computer networking, ranging from commercial services such as CompuServe or Prodigy to the wide ranging global Internet. Moreover, most home PCs today include a CD-ROM drive. This indicates strong demand for content-based services running over PCs. Increased awareness has led to increasing demand for data service, and for higher speeds and enhanced levels of service.

Cable is in a unique position to meet these demands. The same highly evolved platform that enables cable to provide telephony and advanced video services also supports high-speed data services. There appear to be no serious barriers to cable deployment of high-speed data transmission. Table 2 shows a partial list (out of more than a dozen) technology trials or commercial rollouts of high-speed data services by cable companies already in progress.

Table 2: Cable Modem Deployment

Cable Company	Location
Cablevision Systems	Long Island, NY
Cogeco	Trois Rivieres, Quebec
Comcast	Philadelphia, PA
Continental	Boston, MA
Cox	Phoenix, AZ
Greater Media	Boston, MA
Le Groupe Vidéotron	Montreal, Quebec
Rogers	Newmarket, Ontario
TCI	Sunnyvale, CA
Time Warner	Elmira, NY
Viacom	Castro Valley, CA

System Upgrades

The cable platform is steadily evolving into a hybrid digital and analog transmission system.

Cable television systems were originally designed to optimize the one-way, analog transmission of television programming to the home. The underlying coaxial cable however has enough bandwidth to support two-way transport of signals. Recent growth in demand for Internet access and other two-way services has dovetailed with the trend within the industry to enhance existing cable systems with fiber optic technology. Upgrades of cable plant are transforming cable systems into hybrid fiber-coaxial, or HFC networks. Replacement of a part of the distribution plant with fiber optics unleashed the inherent two-way capability of the coaxial plant, without the need to replace individual subscriber connections. Systems are currently being designed with fiber running out to “nodes” serving between 500 and 2,000 homes.

Many cable companies are in the midst of the upgrade to HFC plant to improve the provision of existing cable services and support data and other new services. Some companies expect to complete the transformation of all their individual cable systems as early as 1998. Many metropolitan areas will complete this transition well before then.

Companies may take different or evolving approaches to online service access. For some applications, customers may be accessing information stored locally at or near the cable headend or regional hub. This may serve as a transitional approach until wide area cable interconnections and expanded Internet backbone networks are in place to allow information access from any remote site. Some forms of frequently updated material may require such networked access from the start, and so will be prioritized accordingly.

Cable Modems

Digital data signals are carried over radio frequency (RF) carrier signals on a cable system. Digital data utilizes cable modems, devices which convert digital information into a modulated RF signal and convert RF signals back to digital information. The conversion is performed by a modem at the subscriber premises, and again by headend equipment handling multiple subscribers.

A single 6 MHz channel can support multiple data streams or multiple users through the use of shared Local Area Network (LAN) protocols such as Ethernet, commonly in use in business office LANs today. Different modulation techniques are being tried to maximize the data speed that can be transmitted through a 6 MHz channel. Modulation techniques include Quadrature Phase Shift Keying (QPSK), Quadrature Amplitude Modulation (QAM) and Vestigial Side Band (VSB) amplitude modulation. The varying approaches yield different data rates, as shown in Table 3.

The information in Table 1 is based on a side-by-side demonstration of modems accessing information from a common server. The actual speed at which a customer receives data depends not only on the modem, but also the server one is connecting to, the load on the Internet backbone, and the speed of the computer on the customer's desktop.

Careful traffic engineering is being performed on cable systems so that data speeds are maximized as customers are added in any given fiber node. Just as office LANs are routinely subdivided to provide faster service for each individual user, so too can cable data networks be custom tailored within each fiber node to meet customer demand. Multiple 6 MHz channels can be allocated to expand capacity as well.

Table 3: Sample Cable Modem Speeds

	Upstream	Downstream
General Instrument	1.5 Mbps	30 Mbps
Hybrid/Intel	96 kbps	30 Mbps
LANcity	10 Mbps	10 Mbps
Motorola	768 kbps	30 Mbps
Zenith	4 Mbps	4 Mbps

kbps = kilobits per second
Mbps = megabits per second

Some manufacturers have designed modems providing asymmetrical capabilities, using less bandwidth for outgoing signals from the subscriber. Cable systems in some locations may not have completed system upgrades, and so manufacturers have built migration strategies into such modems to allow for eventual transmission of broadband return signals when the systems are ready to provide such service and customers demand it.

The modems shown in Table 3 are the first or second generation technology. Improved models are under development by all of the companies listed, and next generation modems will be characterized by improved flexibility, and also by a number of common elements that will result from a standardization effort that is already underway. Cable companies have already placed orders with several manufacturers for over half a million new modems to be delivered in 1996.

Standards

Modems are available today from a variety of vendors, each with their own unique technical approach. These modems are making it possible for cable companies to enter the data communications market now. In the longer term, modem costs must drop and greater interoperability is desirable. Customers that buy modems that work in their current cable system need assurance that the modem will work if they move to a different geographic location, served by a different cable company. Further, agreement on a standard set of specifications will allow the market to enjoy economies of scale and drive down the price of each individual modem. Ultimately, those modems will be available as standard peripheral devices offered as an option to customers buying new personal computers at retail stores.

Cable companies and manufacturers came together formally in December 1995 to begin working toward an open standard. To spearhead this effort, CableLabs has been asked to coordinate the process which its members hope will result in specifications for these connection points, called interfaces. Leading U.S. and Canadian cable companies are involved in this endeavor and hope to build upon the valuable early work done by the cable modem manufacturers and the lessons to be learned from deployment of various modems in 1996. These specifications will be developed in three phases, and will then be presented to recognized standards-setting bodies for approval as standards.

Individual vendors will be free to offer their own implementations with a variety of additional, competitive features and future improvements. CableLabs will work with vendors and others on intellectual property rights issues, to ensure a continuing supply of modems to meet the high early demand.

A data interoperability specification will comprise a number of interfaces, as shown in Figure 1 on the following page. Interface specs will be developed in the following phases:

Phase 1
- connection between the cable television modem and the subscriber's computer
- link between cable plant and the next level of wider area networks

Phase 2
- interface to operational support systems, e.g., billing systems

Phase 3
- connection between the cable modem and the cable distribution plant
- security management interface

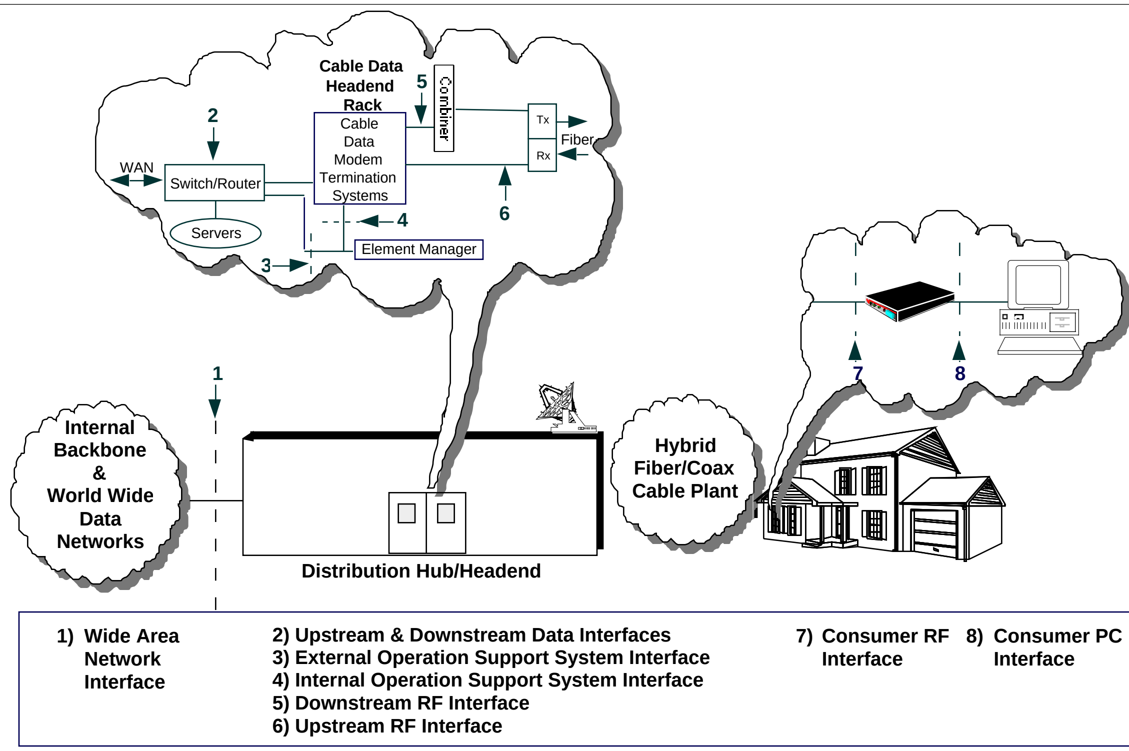

Figure 1: Elements of a Cable Data Standard

Some interfaces reside within the cable network. Several of these system-level interfaces also will be specified in order to ensure interoperability of such important functions as authentication for login/logout, ease of installation of cable modems for reliable customer activation, and spectrum management over the cable network's hybrid fiber/coaxial plant.

Return Path

The portion of bandwidth reserved for return signals (from the customer to the cable network) is usually in the 5-40 MHz portion of the spectrum. This portion of the spectrum can be subject to ingress and other types of interference, and so cable systems offering two-way data services have been designed to operate in this environment.

Industry engineers have assembled a set of alternative strategies for return path operation. Dynamic frequency agility (shifting data from one channel to another when needed) may be designed into modems so that data signals may avoid unwanted interference as it arises. Other approaches utilize a "gate" that keeps the return path from an individual subscriber closed except for those times when the subscriber actually sends a return signal. Demarcation filters, different return laser types, and reduced node size are among the other approaches, each involving tradeoffs between capital cost and maintenance effort and cost. Improved maintenance, in general, will significantly increase the performance of cable return path.

Return path transmission issues have already been the subject of two years of lab and field testing and product development. The full two-way capability of the coaxial cable already passing most U.S. homes is now being utilized in many areas, and will be available in most cable systems beginning in the next 12-18 months. Full activation of the return path in any given location will depend on individual cable company circumstances ranging from market analysis to capital availability.

Applications

Cable modems will open the door for customers to enjoy a range of high-speed data services, all at speeds hundreds of times faster than telephone modem calls. Subscribers can be fully connected, 24 hours a day, to services without interfering with cable television service or phone service. Among these services are:

- Information Services – access to shopping, weather maps, household bill paying, etc.
- Internet Access – electronic mail, discussion groups, and the World Wide Web.
- Business Applications – interconnecting LANs or supporting collaborative work.
- Cablecommuting – enabling the already popular notion of working from home.
- Education – allowing students to continue to access educational resources from home.

The promises of advanced telecommunications networks, once more hype than fact, are now within reach. Cable modems and other technology are being deployed to make it happen.

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