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AN INTRODUCTION TO CABLE MODEM SYSTEMS

Part - I

Cable modems are being increasingly deployed on Indian CATV networks. This article provides a simple overview of the overall Cable Modem system, as well as specific sections of the system. Cable TV in India has been classically plagued by low revenues & minimal scope to value add in terms of delivery of services. As a result, a professionally installed & managed CATV network can fall prey to small networks poaching it by quoting absurdly low monthly rentals from customers.

India currently boasts of over 15 Million Internet users. While the tariff charged by the Internet Service Providers (ISPs) is less than Rs 10 per hour, the cost of telephone access stands at Rs 28 per hour, making Internet access surfing exorbitantly expensive. The introduction of Cable Modems for Internet delivery, promises to do away with the high cost of telephone access, potentially provide over 100 times the data delivery capacity & offer CATV networks a high revenue, value added service that they can offer their subscribers.

Clearly, the Cable modem service is a dream-come-true for both, the subscribers & CATV network owners. The following are estimates of the number of Cable Modems installed in various parts of the world, as of June 2001.

Country	Cable Modems Installed
USA	5.5 Million
Asia Pacific	2.7 Million

Of this, India accounts for less than 0.1 Million Cable modems purchased. In comparison, during last year, North American cable operators added an average of 8,200 new cable modems each day ! There is a significant growth opportunity for Internet services in India. Technology research firm Gartner Inc has projected the number of regular Internet users in India to rise 32% to 7.9 million by end-2001 from 6 million currently and to 40 million by end-2005.

CATV IDEAL ?

Today, CATV offer the best delivery mode for cost-effective delivery of video, data and voice. Modern HFC-based cable networks have substantial bandwidth, which simultaneously can support hundreds of TV channels, high-speed Internet access, telephony. As well as advanced services such as near-video-on-demand (NVOD) and video-on-demand (VOD),

Unlike the largely one-way broadcast architectures used for cable TV signal distribution in the past, today's CATV networks need to deliver high capacity in both the downstream and upstream directions--that is, to and from the subscriber. Fortunately, Internet delivery calls for a higher bandwidth to the subscriber, rather than back to the Head-End. This is an inherent strength for CATV networks.

When it comes to launching a high-speed Internet access service, cable operators have 2 choices : Develop and operate their own broadband service, or partner with a third party ISP that will provide bandwidth & the operating ISP license. Let us now take a look at the evolution of the

Cable Modem.

EARLY DEPLOYMENTS

First-generation cable modem systems were based on manufacturer-specific proprietary technology. That is, the Cable Modem Termination System (CMTS) located at the Head-End and the cable modems had to be purchased from the same manufacturer. Equipment sourced from one vendor was incompatible with the CMTS and cable modems from other vendors. This was termed as lack of "interoperability". The early adopters, despite their lack of interoperability, entered the market early & gained valuable experience in delivery of the service.

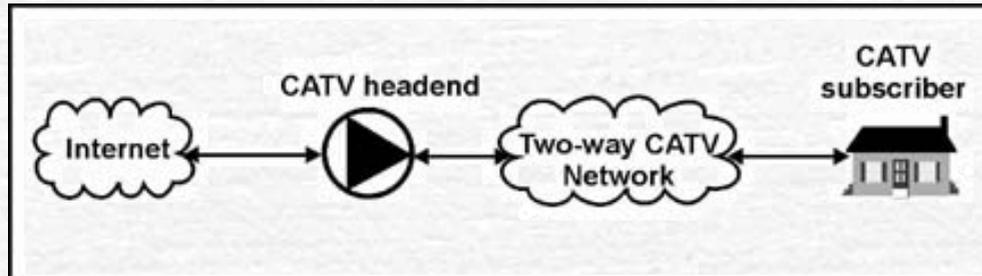


Figure -1 shows a Cable Modem service on a two-way CATV network. Data is sent from the CATV headend to the Cable modems in the downstream path (50 MHz to 860 MHz) along with the TV content. The Cable Modems send data back to the headend in the reverse path - usually from 5MHz upto 50MHz.

STANDARDIZATION

In 1996, the CATV decided to establish Cable Modem standards, primarily to promote interoperability. Similar work had started two years earlier by the Institute of Electrical and Electronics Engineers (IEEE) 802.14 Cable TV Media Access Control and Physical Protocol Working Group. In January 1996, four US based MSOs - Cox Communications, Comcast Cable Communications, Tele-Communications, Inc. (TCI), and Time Warner Cable--formed a coalition known as Multimedia Cable Network System Partners Limited (MCNS). MCNS issued a request for proposal (RFP) for the research and publication of interface specifications for high-speed data services using cable modems.

In December 1996 the preliminary Data Over Cable Service Interface Specification (DOCSIS) was announced. The final MCNS specification, emerged in March 1997. It provided for downstream data rates from 27 Mbps to 38 Mbps and upstream data rates from 320 kbps to 10 Mbps. DOCSIS 1.0 was officially approved as an international standard by the International Telecommunications Union (ITU) in March 1998. Given the success of DOCSIS, the IEEE's 802.14 efforts were formally disbanded at the end of 1999.

CERTIFICATION

Manufacturers submit cable modems and CMTSs to CableLabs for certification and qualification respectively. A certified cable modem has been tested to comply with the DOCSIS standard and will inter-operate with any other certified cable modem or a qualified CMTSs. CableLabs recently changed the name of the DOCSIS certification program to "CableLabs Certified Cable Modems." Details are available at their website : <http://www.cablemodem.com/>.

INSIDE THE CABLE MODEM

The word MoDem is coined from MOdulator + DEModulator. A Cable Modem is required to modulate the data that it sends out & demodulate the signal that it receives, to extract the data. However, from a systems point of view, a Cable Modem can also be perceived to simply be an interface between the CATV network & the subscriber's personal computer (PC). Cable Modems use Quadrature Amplitude Modulation (QAM) to receive data from the HeadEnd. The system can use either 16, 64 or 256 QAM. 64 QAM supports 27 Mbps and 256-QAM supports 38 Mbps

nominal data throughputs. Higher orders of QAM demand lower system noise (Better c/n ratios) for satisfactory operation. The QAM system used is typically dictated by C/N ratio that the system can consistently maintain. As we will see later, in greater detail, the forward path data is delivered as bursts.

Reverse path data sent out by the Cable Modem to the CMTS at the Head End, uses either QPSK (Quadrature Phase Shift Keying) or 16-QAM digitally modulated carriers. Data rates range from 320 kbps to 10.24 Mbps and utilised bandwidths range from 200 kHz to 3.2 MHz. The reverse path data is beamed continuously.

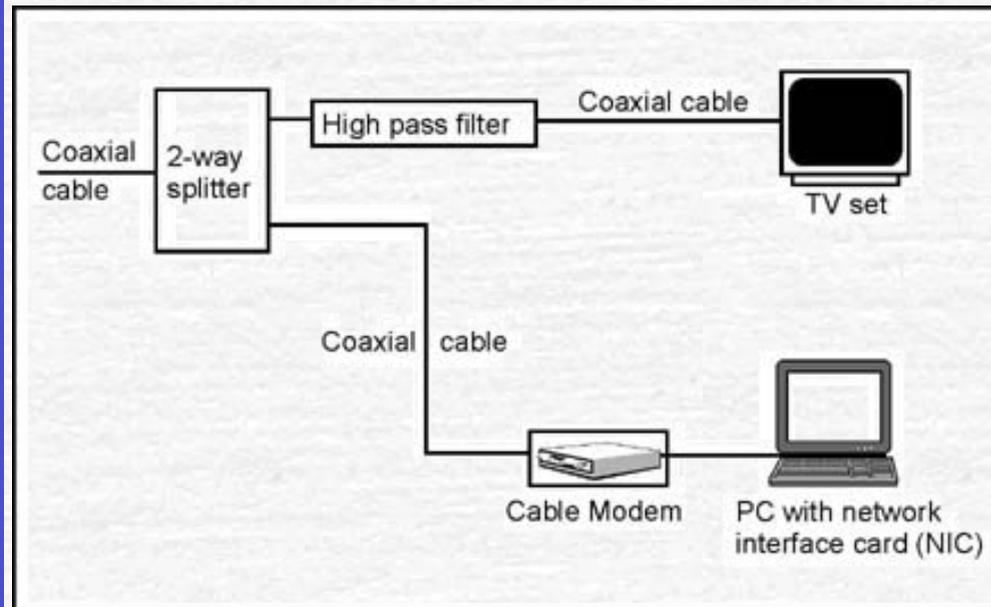


Figure 2 shows how a Cable Modem is typically connected at a subscriber's premise. A normal splitter divides the signal & routes it separately to the TV & the Cable Modem - PC. The splitter also provides an isolation of 18dB to 20dB between the TV & the Cable Modem. Hence, interference emanating from the TV antenna socket (such as the TV's Local oscillator leakage) will not reach the Cable Modem. Note that any reverse path noise reaching the 2 way splitter will get injected back into the CATV network and will add upto increased noise at the CMTS-Head End. This is because, the splitter provides isolation between the outputs, not between inputs & outputs !

In the US, CATV networks often also install a High Pass filter, which prevents any reverse path noise from being injected back into the system.

CABLE MODEM-PC CONNECTION

The cable modem is connected to the PC using a standard Ethernet cable, typically a category 5 (CAT 5) cable. The PC must have a 10BaseT or a 100BaseT network interface (NIC) / LAN card installed.

Recent cable modems are equipped with a Universal Serial Bus (USB). This eliminates the LAN card, but requires a PC with a USB port. Internal - Peripheral Component Interconnect (PCI) bus based cable Modems will soon be available.

AT THE HEADEND

The Cable Modems are infact controlled & coordinated by the Cable Modem Termination System (CMTS) equipment at the Headend. The CMTS forms not only the control centre for all the Cable Modems, but also interfaces with the external Internet Data, delivered through a leased / dialup line. The example in figure 3 is a simplified CMTS system, that is installed at the Headend. The system in figure 3 incorporates, a dial-up access server also, so that the system delivers Internet facilities, both, through a Cable TV network and through telephone dial-up modems. The actual

configuration will vary from system to system, and may be quite complex.

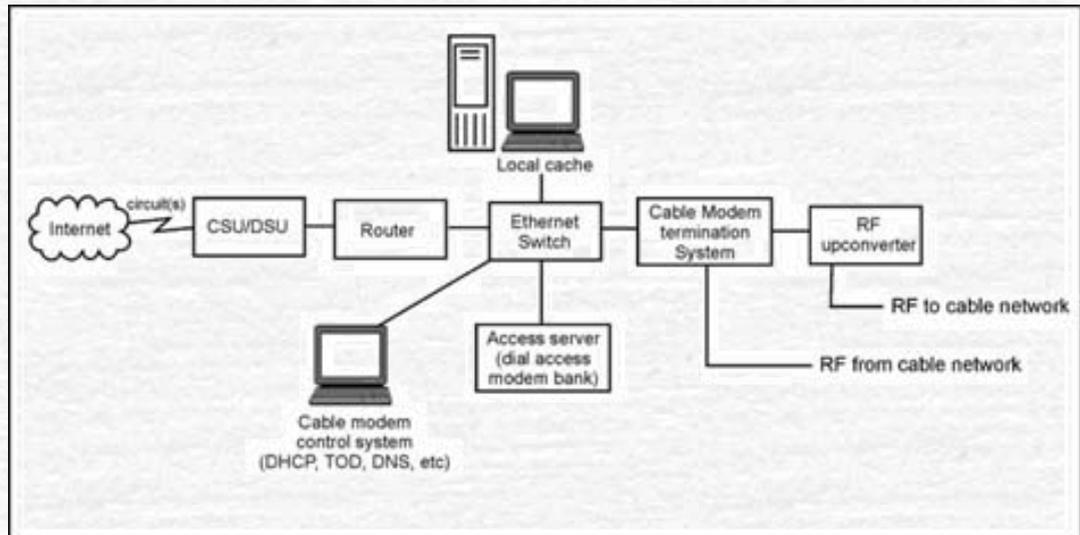


Figure 3 shows the functional block diagram of a CMTS

In figure 3, the Internet feed is fed to the Head End router. Often, a Channel Service Unit / Digital Service Unit (CSU/DSU) is inserted before the router. The CSU / DSU unit functions as remote access test equipment that helps identify whether potential problems are in the headend or in the circuit to the Internet.

THE INTERNET FEED

Before we move on to the CMTS, it must always be kept in mind that the entire system can only deliver the bandwidth that it receives. Hence an adequately large Internet "Pipe" should be established. A minimum feed of 2 MBps is mandatory, if even a reasonable throughput is to be maintained to 200 Cable Modem users. In the US, where bandwidth is cheap, systems often deploy more than 1 T3 line - each T3 line delivers approx. 45 MBps !

THE ROUTER

The network router is a device that essentially translates and directs the data packets going between the cable modems and the Internet at large. The router is installed between the CSU/DSU and the Ethernet switch. Some routers may be equipped with a built-in CSU/DSU.

THE SWITCH

The Ethernet switch links all of the headend's high-speed data equipment. In addition to being connected to the router, the switch is connected to various application servers, which are essentially PCs dedicated for as particular function such as e-mail, Web servers, and authentication, authorization and accounting servers, newsgroups or even Video On Demand.

CACHING

A caching engine ("local cache" in figure 3) is connected to the Ethernet switch and is used to store updated copies of popular Internet Web sites that are heavily accessed by the cable modem subscribers. When a subscriber surfs to one of these sites, he or she actually is connected to a copy of the Web site that exists on the local cache rather than the real Web site on the Internet. This helps reduce data traffic through the Internet connection, the external bandwidth required and speeds network performance.

DIAL UP MODEMS

Sometimes, the same system may be designed for both, internet delivery through telephone lines, or through Cable Modems. In such an installation, a bank of modems is installed. One modem is required to address each logged on dial-up subscriber. These are provided by "Access Servers",

which are high-density dial-up modem banks.

DHCP & DNS

The cable modem control system acts as a server for Dynamic Host Configuration Protocol (DHCP), Time of Day (ToD), Domain Name System (DNS), and manufacturer-specific operating features for cable modem operation and management, billing interface and so forth.

CMTS The CMTS provides the link between the headend equipment and the cable system. One side of the CMTS is connected to the Ethernet switch. The other side of the CMTS is connected to the cable network's Forward Path headend combiner and distribution equipment, as well as the Reverse Path RF splitters & combiners.

The RF upconverter converts the CMTS's intermediate frequency (IF) output to the desired cable TV Forward Path frequency. The upconverter may be an external unit or may be an integral part of the CMTS.

DON'T FORGET THE UPS !

One critical piece of equipment not shown is an appropriately sized uninterruptible power supply (UPS) that includes surge suppression, line conditioning and suitable backup capability to allow a generator to come online during power failure. Next month, we'll discuss the cable modem initialization process, take a closer look at DOCSIS, and highlight a few of the challenges an operator might encounter when deploying cable modem service.

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