Cable Access Q&A - Part Two

This is the second part of the Cable Modem Q&A that takes a more in-depth technical look at Cable Modem technology. If you are in doubt about any of these topics relating to Cable modem technology the previous section, Part One provides a grounding on this subject.

Cable modems are a new product category which have dramatically accelerated the growth of Internet. The Q&A should help extend the readers knowledge and understanding of cable modem technology and explains some of the issues that cable operators must resolve before deployment of the technology can be facilitated to the consumer mass market.

Part Two: Questions

Setting up your network

1. What Does The Term Cable Modem Mean?
2. What Are Different Types Of Cable Modems?
3. What Changes Have Been Made To The Traditional Cable Network?
4. How Do Cable Operators Allow Signals To Flow In Both Directions?
5. How Does The Traditional Cable Network Compare To That Of Today's
6. What Is The Bandwidth Capacity Of The Cable Network?
7. What Proportion Of The Bandwidth Capacity Is Assigned To Carry Upstream and Downstream Signals?
8. What Is A Cable Modem Termination System (CMTS)?
9. Why Are Cable Operators Changing Coaxial Cables To Fiber Optic Cables?
10. Can A Cable Modem Communicate To Another Cable Modem?
11. What Is A Fiber Coaxial Neighborhood Node?
12. What Is The Main Difference Between Upstream And Downstream Signals?
13. What Is A Media Access Control Layer (MAC) And Logical Link Control Layer (LLC)?
14. What Is A QPSK And QAM?
15. What Are The Standards?
16. Who Are The MCNS?
17. Who Are The IEEE?
18. Who Are The ITU?
19. What Is The Difference Between The Two Specifications?
20. Who Makes Cable Modems?
21. What Are Cable Vendors Plans For The Future?

Part Two: Answers

1. **What Does The Term "Cable Modem" Mean?**

The term "Cable Modem" refers to a modem that operates over the ordinary cable TV network cables. Basically you just connect the Cable Modem to the TV outlet for your cable TV, and the cable TV operator connects a Cable Modem Termination System at the Head-End (The Cable

Company main office). The term "Cable Modem" is a bit misleading, as a Cable Modem works more like a Local Area Network (LAN) interface than a modem.

2. What Are The Different Types Of Cable Modems?

Cable modems are available as an internal, external or set-top box device. An external cable modem is a small box that will typically have two connections, one to the cable wall outlet and the other to a computer through a standard 10Base-T Ethernet card. An internal cable modem is typically a PCI bus add-in card for a PC. To date, they can only be used in desktop PC's. To find out if they are available for Mac's and laptops call your local Cable Operator. An interactive set-top box is a cable modem in disguise. It usually provides a return channel through the Plain Old Telephone System (POTS). It allows the user to browse the web, read email, etc., on the TV screen.

3. What Changes Have Been Made To The Traditional Cable Network?

Traditionally, the cable network was designed to deliver TV signals in one direction from the Head-End to the subscribers homes. To provide TV services Cable Operators had to recreate a portion of the over-the-air radio frequency (RF) spectrum within a sealed coaxial cable line.

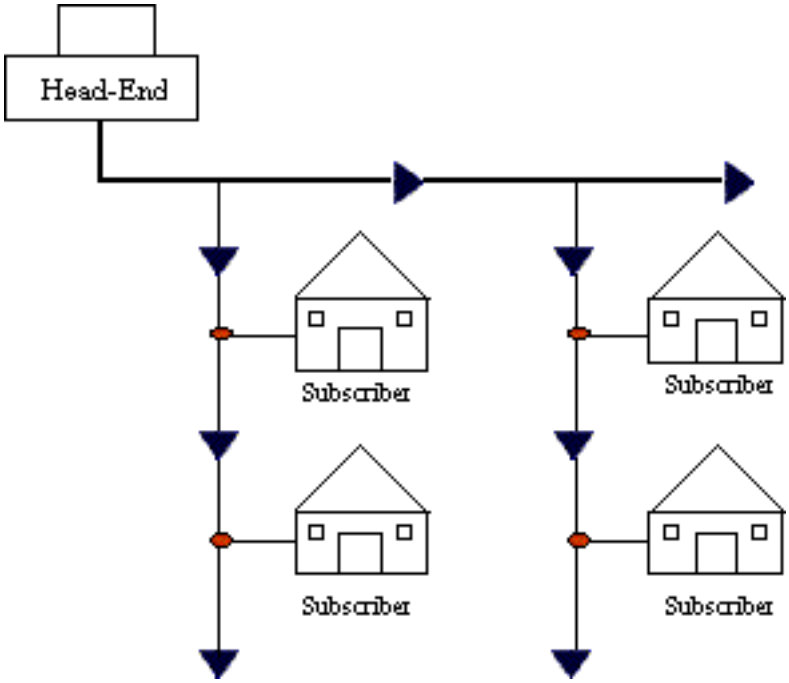
To provide Internet services Cable Operators had to upgrade the cable network so that signals could flow in both directions. They also had to build a sophisticated end-to-end IP networking infrastructure in each community they served that was robust enough to support tens of thousands of data subscribers. These included items like Internet backbone connectivity, routers, servers, network management tools, as well as security and billing systems.

4. How Do Cable Operators Allow Signals To Flow In Both Directions?

Cable Operators assign a spectrum of signal frequencies to the cable network. One spectrum is used for the signals that move from the Head-End towards the cable subscriber, and another spectrum of signal frequencies are used for the signals that move from the cable subscriber towards the Head-End. By replacing existing one way amplifiers with two way amplifiers Cable Operators are able to separate the upstream and downstream signals and amplify each direction separately in the right frequency range.

5. How Does The Traditional Cable Network Compare To That Of Today's?

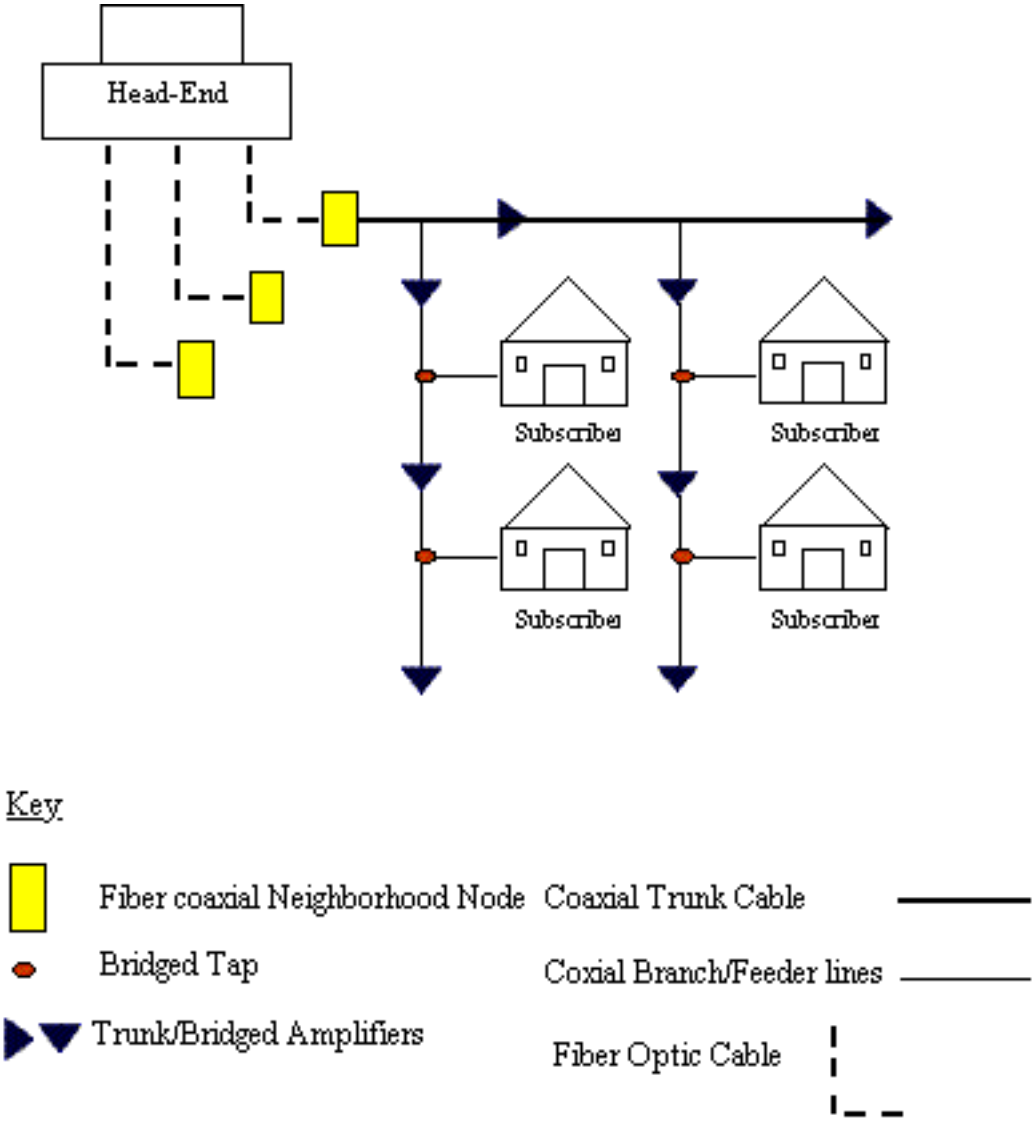
The traditional cable network was fairly straightforward for Cable Operators to implement. The heart of the cable network is the Head-End. Connected to the Head-End is a trunk cable that enters various sections of a city. Connected to the trunk cable are a number of branch networks that connect to feeder cables (or taps), which enter the subscribers homes and connect to a cable set-top box.



Traditional Cable network

The modern day cable network is different. Located at the Head-End is the Cable Modem Termination System (CMTS). Connected to the CMTS are multiple fiber optic cables that enter various neighborhood locations that serve a smaller number of homes. A fiber optic neighborhood node is placed between every fiber optic cable and trunk cable. Connected to the trunk cable is a branch network that connects to feeder cables (or taps) that enter the subscribers homes and connect to a set-top box (receiver) and/or a cable modem.

The modern day cable networks of installing fiber infrastructure in a neighborhood and then splitting out coaxial (copper) cable to individual homes is known as Fiber To The Neighborhood (FTTN) or Fiber To The Curb (FTTC) depending on how close the optical nodes are to the homes.



Hybrid/Fiber Coax cable network

6. **What Is The Bandwidth Capacity Of The Cable Network?**

Traditional coaxial cable networks typically operate with 330MHz or 450MHz of bandwidth capacity, whereas modern hybrid fiber/coax (HFC) networks are expanded to 750 MHz or more. In all, HFC networks with 750MHz of bandwidth have the capacity for some 110 TV channels where each TV channel requires 6MHz of the frequency spectrum. Like a TV channel, downstream and upstream data channels usually require 6MHz of the frequency spectrum.

7. **What Proportion Of The Bandwidth Capacity Is Assigned To Carry Signals Upstream And Downstream?**

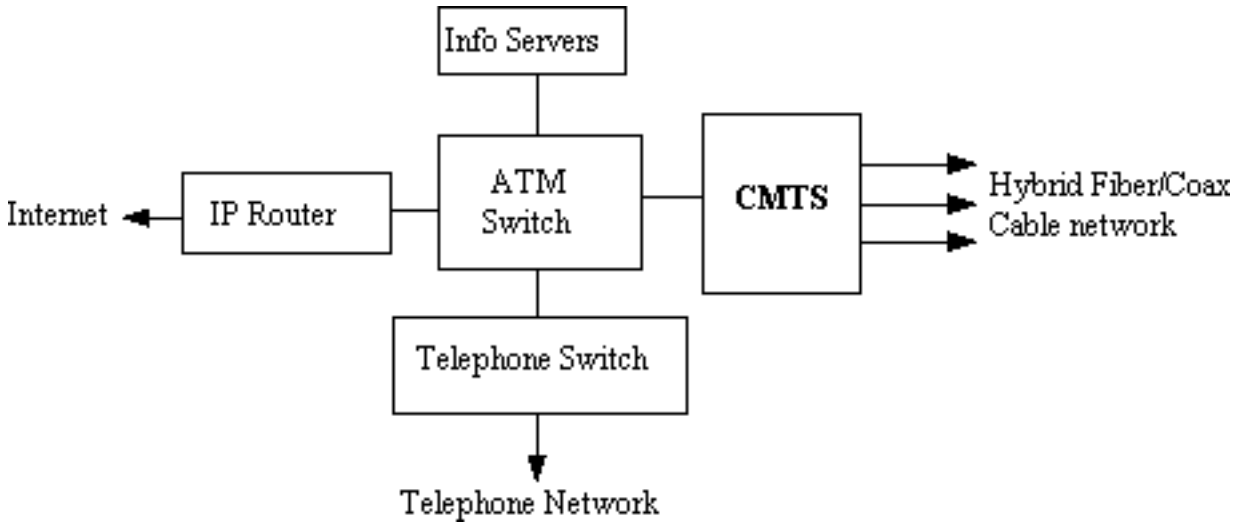
For data transmission across the cable network cable operators assign a single 6MHz channel within the 50MHz - 750MHz frequency spectrum to carry signals downstream to the cable subscribers homes and a 6MHz channel within the 5MHz - 42MHz frequency spectrum to carry signals upstream to the Head-End.

8. **What Is A Cable Modem Termination System (CMTS)?**

A Cable Modem Termination System (CMTS) is a vital component that Cable Operators must install at the Head-End. A CMTS instructs a cable modem when to transmit signals upstream and which channel to use.

A CMTS demodulates upstream signals, translates them back into IP packets and redirects them to a central switch. The central switch redirects the IP packets to a IP router for transmission across the Internet. In the opposite direction it modulates downstream signals for transmission across Hybrid Fiber Coax (HFC) cables to the subscribers homes.

One CMTS will normally provide support for up to 1000 simultaneous cable modem subscribers across a single 6MHz channel. If more cable modems are required the number of channels are increased by adding more channels to the CMTS.



Equipment located at the Head-End

9. **Why Are Cable Operators Changing Coaxial Cables To Fiber Optic Cables?**

The are several reasons. Firstly, the maximum bandwidth capacity of fiber optics is much higher than coaxial (copper) cables. Secondly, crosstalk and attenuation are more likely to be present in coaxial cables than fiber optic cables which are almost resistant to crosstalk and attenuation. Thirdly, fiber optic cables can run much longer distances before attenuation becomes too much, reducing the need to put more amplifiers all across the network.

Today, Cable Operators do not connect Fiber Optic cabling to every subscriber home because the cost of fiber optic cabling is 10 to 20 times more expensive than copper. In addition, the maintenance costs can be expensive and time consuming. However, in the future the deployment of fiber optics will become more significant and widespread when the price of fiber optic cabling is reduced.

10. **Can A Cable Modem Communicate Directly To Another Cable Modem?**

No. All cable modems can only receive from and send signals to the CMTS, but not directly to other cable modems on the network.

11. **What Is A Fiber Coaxial Neighborhood Node?**

Fiber coaxial neighborhood nodes are deployed in various neighborhood locations. They are placed between a fiber optic cable and trunk cable. All fiber optic cables terminate in fiber coaxial neighborhood nodes. A fiber coaxial neighborhood node may be feeding up to two thousand cable modem users.

Downstream signals are transmitted as optical signals. A fiber coaxial neighborhood node converts the optical signals so they can be transmitted across the trunk cables, branch networks and feeder cables that connect to the cable modems in the subscribers homes. The cable modem demodulates the incoming signals and translates them back into IP packets which the computer can understand.

To transmit signals upstream the process is reversed. When the signals reach the Fiber Optic Neighborhood Node they are converted back to optical signals and then transmitted across fiber optic cables back to the Cable Modem termination System at the Head-End.

12. **What Is The Main Difference Between Upstream And Downstream Signals?**

Downstream signals from the Head-End are broadcast to all cable modem subscribers on the same network. Each cable modem filters out the signal it needs from the stream of signals. In the upstream direction every cable modem is trying to place a different signal onto the network that will eventually share the same piece of transmission spectrum. Therefore, some form of access method is required to regulate which signal is actually carried. Access methods come in different varieties, such as Time or Frequency Division Multiple Access (TDMA or FDMA), Asynchronous transfer mode (ATM), Carrier Sense Multiple Access/ Collision Detection (CSMA/CD) etc. Which method is appropriate depends on the expected application (TV, Internet, Phone).

13. **What Is A Media Access Control Layer (MAC) And Logical Link Control Layer (LLC)?**

They are protocol layers that ensure the upstream and downstream transmission of signals across the same piece of transmission spectrum occurs in an orderly and fair way. Both the CMTS and the Cable Modem implement these protocol layers for several reasons which include:

* To ensure that upstream signals from all cable modems are received at the Head-End.
* To assign frequencies to cable modems so they know where to transmit signals.
* To assign time-slots to the cable modems so they know when to transmit signals to the Head-End.

The two main approaches are the common Carrier Sense Multiple Access / Collision Detection (CSMA/CD) used in Ethernet networks and Asynchronous Transfer Mode protocols (ATM).

14. **What Is A QPSK And QAM?**

Quadrature Phase Shift Keying (QPSK) and Quadrature Amplitude Modulation (QAM) are two different forms of modulation techniques used with cable modem technology.

Quadrature Phase Shift Keying (QPSK) is easy to implement and fairly resistant to noise. It is used primarily for sending data from the cable subscriber upstream to the Head-End, but sometimes it can also be used to send data downstream.

Quadrature Amplitude Modulation (QAM) is primarily used for sending data downstream. QAM is very efficient, but QAM's susceptibility to interfering signals makes it ill-suited to noisy upstream transmissions from the subscriber to the Head-End. There are three variations, 16QAM, 64QAM and 256QAM. A single downstream 6 MHz channel may support up to 27 Mbps of data throughput from the Head-End using 64QAM while speeds can be boosted to 36 Mbps using 256QAM. A single 6MHz upstream channel may support between 500Kbps to 10Mbps of data throughput from cable subscribers homes using 16QAM or QPSK depending on the amount of frequency spectrum allocated for the service.

15. **What Are The Standards?**

Two main standards have been developed. They include the Multimedia Cable Network Systems (MCNS), Data Over Cable System Interface Specification (DOCSIS) and the Institute of Electronic and Electrical Engineering's (IEEE) 802.14 specification. In terms of communications speed, bandwidth efficiency, performance, robustness, and power consumption the MCNS DOCSIS specification is a better choice. It has also been approved as the standard for the transmission of data over cable networks by the International Telecommunication Union (ITU).

16. **Who Are The MCNS?**

MCNS, a consortium of CableLabs whose partners include Comcast, Cox, TCI, Time Warner, MediaOne, Rogers Cablesystems, CableLabs and Arthur D. Little, was developed to create a quick and safe standard for the transmission of data over cable networks. The MCNS group has worked closely with the vendor community to put the industry on a fast track to a retail-driven market. The MCNS group currently represents more than 85% of the cable subscribers in the United States and 70% of the subscribers in Canada. To date, more than 35 vendors have announced plans to build products based on the MCNS's DOCSIS specification.

17. **Who Are The IEEE?**

The Institute of Electrical and Electronics Engineers (IEEE) is the world's largest technical professional society. Founded in 1884 by a handful of practitioners of the new electrical engineering discipline, today's Institute is comprised of more than 320,000 members who conduct and participate in its activities in 152 countries.

18. **Who Are The ITU?**

The ITU (International Telecommunications Union) is the primary international body for fostering co-operative standards for telecommunications equipment and systems.

19. **What Is The Difference Between The Specifications?**

The MCNS specification supports 64/256QAM modulation for sending data downstream and Quadrature Phase Shift Keying (QPSK) and 16QAM for sending data upstream. For Media Access Control (MAC) and Logical Link Control (LLC), which sets the rules for network access by users, they chose CSMA/CD (Carrier Sense Multiple Access / Collision Detection) which is based on variable-length packets that favours the delivery of Internet Protocol (IP) traffic. By supporting a variable-length packet implementation, MCNS members plan to capitalize on the favourable pricing associated with Ethernet and IP networking technology.

The IEEE 802.14 specification supports 64/256QAM modulation for sending data downstream and Quadrature Phase Shift Keying (QPSK) and 16QAM for sending data upstream. For Media Access Control and Logical Link Control (LLC), the IEEE chose Asynchronous Transfer Mode (ATM). They see ATM as a long-term solution that will provide the flexibility to deliver more than just Internet access. MCNS members on the other hand believe cable operators are more focused on delivering high-speed Internet services to consumers and believed ATM would add unnecessary complexity and cost to cable modem systems.

20. **Who Makes Cable Modems?**

There are many companies who are producing or have announced cable modem products. They include: 3Com, Bay Networks, Com21, General Instrument, Hayes, Hybrid Networks, Motorola, NEC, New Media Communication, neighborhood, Scientific Atlanta, Terayon, Toshiba, U.S. Robotics and Zenith.

21. **What Are Cable Vendors Plans For The Future?**

By the end of 1999 virtually all computers in the future will be USB and IEEE1394 (Firewire bus) capable. Several cable vendors have developed and are shipping today cable modems that will turlasbus ouy c0 1ndors havll be MCNS DOCSIS Specification,s)ca's ndors308ly all e0 1rnetcpdj /fac11 Tm T ll-anFndors358ly all e0 1rnetccardl 595 50 l 595 842 l-358l-31 all Glossaryors j /msndors ha31 all AmplifierFcp

Downstream - Signals transmitted to a subscriber.

Drop - The cable and hardware from tap to subscriber is called the drop.

Drop Cable - Generally 330 feet or less of coaxial cable, starting at a tap and continuing on to the subscriber's connection.

Dual cable - Two independent distribution systems operating side by side, providing double the channel capacity of a single cable.

Duplex - In a communications channel, the ability to transmit in both directions.

Ethernet - The name of the local area network originally invented by the Xerox Corporation Palo Alto Research Center. It operates using the CSMA/CD medium access control method. It is the most popular LAN technology used today.

Feeder Cables - The cables that take signals from the trunk line to the subscriber area and to which the subscriber taps are attached.

Fiber Optics - A method of transmitting signals over light waves sent through extremely thin fibers spun from glass.

Frequency - The number of times a complete electromagnetic wave cycle occurs in a fixed unit of time, usually one second. The rate at which a current alternates, measured in Hertz on a telecommunications medium.

Frequency Modulation (FM) - A common method of transmitting information over a carrier wave by changing its frequency.

Head-End - The control center of a cable television system, where incoming signals are amplified, converted, processed and combined into a common cable along with any original cablecasting, for transmission to subscribers. The system usually includes antennas, preamplifiers, frequency converters, demodulators, modulators, processors and other related equipment.

Head-End Router - The computer, at the cable Head-End, responsible for gateway operations between the Head-End and the Internet.

Hybrid Fiber Coax (HFC) - A network consisting of fiber optical cables and coaxial cables.

IEEE - Institute of Electrical and Electronics Engineers.

MAC Address - An address that identifies a particular medium access control (MAC) sub-layer service access point.

MCNS (Multimedia Cable Network System) - A consortium of CableLabs and North American Multi-system operators that developed DOCSIS, a specification for the transmission of data over a cable network that has been approved by the ITU as an international standard.

Medium Access Control (MAC) Protocol - In a subnetwork, that part of the protocol that governs access to the transmission medium, independent of the physical characteristics of the medium , but taking into account the topological aspects of the subnetworks in order to enable the exchange of data between nodes.

MegaHertz (MHz) - One million cycles per second.

Modulation - When some characteristics of an electromagnetic wave are deliberately changed or manipulated for the purpose of transmitting information.

Multiple System Operator (MSO) - A company that owns and operates more than one cable system.

Multiplexer - A device that allows several users to share a single circuit. It funnels different data streams into a single stream. At the other end of the communications link, another multiplexer reverses the process by splitting the data stream back into the original streams.

Multiplexing - Transmitting multiple signals simultaneously on a single chain.

Narrowband - Generally refers to delivery channels capable of carrying sub T1 speeds.

National Cable Television Association (NCTA) - The major trade association for the cable television industry.

Network Congestion - A state of overload within a network, where there is a risk of service degradation.

On-demand Service - A type of telecommunication service in which the communication path is established almost immediately in response to a user request brought about by means of a user-network signalling.

Optical Fiber - An extremely thin, flexible thread of pure glass, able to carry one thousand times the information possible with traditional copper wire.

Packet - A series of bits containing data and control information, including source and destination node addresses, formatted for transmission from one node to another.

Physical Layer - Layer 1, the lowest layer of the OSI model, is implemented by the physical channel. The Physical layer insulates Layer 2, the Data Link layer, from medium-dependent physical characteristics such as baseband, broadband or fiber-optic transmission. Layer 1 defines the protocols that govern transmission media and signals.

Point of Presence (POP) - The point where the inter-exchange carrier's responsibilities for the line begin and the local exchange carrier's responsibility ends. Location of a communications carrier's switching or terminal equipment.

Public Access - A non-commercial channel set aside by a cable system for use by the public, on a first come first serve, non-discriminatory basis.

Quality of Service (QoS) - The accumulation of the cell loss, delay, and delay variation incurred by the cells belonging to a particular ATM connection.

Radio Frequency (RF) - Analog electrical signals sent over the cable. Conventional (broadcast) television and radio, as well as cable TV, deliver RF signals to your television/radio. RF is quickly becoming yesterday's news to many cable TV providers who are installing fiber-optic lines that will replace today's cables.

Ranging - The process by which a cable modem learns its distance from the Head-End. Ranging is a continual process, due to the expanding and contracting of cable that occurs during the day.

Repeater - A repeater is a network device that repeats signals from one cable onto one or more other cables, while restoring signal timing and waveforms.

Receiver - Electronic device which can convert electromagnetic waves into either visual or aural signals, or both. For cable television, usually the subscriber's television set.

Return Path - or Upstream, or Reverse Path - The term used to describe traffic and paths that go from the subscriber to the Head-End.

Reverse Path Forwarding - A technique where a router receives a packet, then floods the packet out on all paths, except the path on which it received the packet.

Router - A device used to interconnect two or more local area networks, each of which operates with a different medium access control method.

Service user (Subscriber) - A person, organization, or telecommunications system that accesses the network in order to communicate via the services provided by the network.

Set-Top Box - A part of the Network Access which performs application-specific functions such as decoding digital TV.

Share - The percent of television households tuned to a particular program or category of programming.

Signalling - The process by which an end system notifies a network that it wants service.

Splitters - Passive devices that divide the traffic on trunk cables and send it down feeder cables.

Subscriber - A household or business that legally receives and pays for cable and/or pay television service for its own use.

Subsplit - A frequency division scheme that allows bi-directional traffic on a single cable. Return path signals come to the Head-End from 5 to 30 MHz. Forward path signals go from the Head-End from 54 to the upper frequency limit.

Switch - A mechanical or electric device that is used to deliberately interrupt, or alter the path of the current through the circuit.

Switched Network - Any network in which switching is present and is used to direct messages from the sender to the ultimate recipient. Usually switching is accomplished by connecting and reconnecting lines in different configurations in order to set up a continuous pathway between the sender and the recipient.

System Integrators (SI) - Companies that provide installation of networking equipment and possibly other services such as training or network management.

Tap - A tap is a device which splits off a portion of the feeder line signal for the subscriber.

Telecommunications - Communicating over a distance through wire, radio, optical or other electromagnetic means.

Transmission Control Protocol/Internet Protocol (TCP/IP) - Are the standard network protocols used over the Internet. It is also used as the standard communications protocol in private networks called Intranets and Extranets.

Trunk Amplifiers - The amplifiers along the trunk line responsible for maintaining signal strength.

Trunk Cable - Cables that carry the signal from the Head-End to groups of subscribers.

Trunk Line - Radiating out from the Head-End are trunk lines which carry the main CATV signal to be distributed.

Upstream - or Reverse Path or Return Path. The term used to describe traffic and paths that go from the subscriber to the Head-End.

Wide Area Network (WAN) - A computer network which usually spans larger geographic area, such as cities, counties, states, nations and planets. WAN's usually employ telephone-type topologies, like T1, T3 and ATM etc. The Internet is held together by lots of WAN's which hold together LAN's, which network computers.