Access to Data & Computer Networks – Physical Level

- **Terminology**
- **Serial Interface**
- **Cable Modems**
- **DSL technologies**

ISP (Internet Service Provider)
- An Internet service provider company that provides other companies or individuals with access to, or presence on, the Internet
- Individual hosts and LANs are connected to an (ISP) through a point of presence (POP).

POP (Point of Presence)
- An Internet access provider may operate several POPs distributed throughout its area of operation and represents a collection of telecommunications equipment

CPE (Customer Premises Equipment)
- is the communications equipment located onsite with the host (example: modem)

Local loop" or "last mile
- the infrastructure between a provider's installation and the site where the host is Located

NAP (Network Access Point)
- a physical facility that provides the infrastructure to move data between connected networks; serve to tie the ISPs together; ISP also connect using peering arrangements and interconnections within geographic regions

CO (Central Office)
- the place where telephone companies terminate customer lines and locate switching equipment to interconnect those lines with other networks

Common connections for SOHO (small office home office) LANs

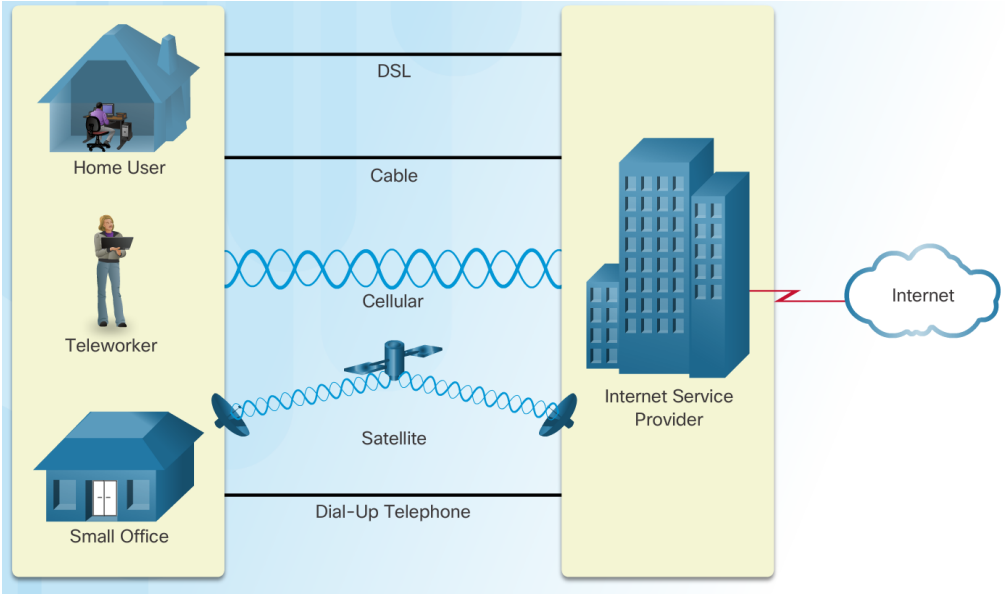
Cable - offered by cable television service providers, where data signal is carried on television cable;
- high bandwidth, always on connection

DSL – on telephone lines (usually ADSL)
- high bandwidth, always on connection

Cellular - using cell phone network; performance limited by phone and cell tower the capabilities.

Satellite – using satellite dishes
- requires a clear line of sight to the satellite.

Dial-up Telephone - inexpensive option using phone line and modems.
- low bandwidth not recommended for large data transfer.



Cisco CCNA1

Serial Interface

Serial Transmission – all bits (of an octet) are transmitted (received) on a single line
Parallel Transmission – each bit (of an octet) uses a line

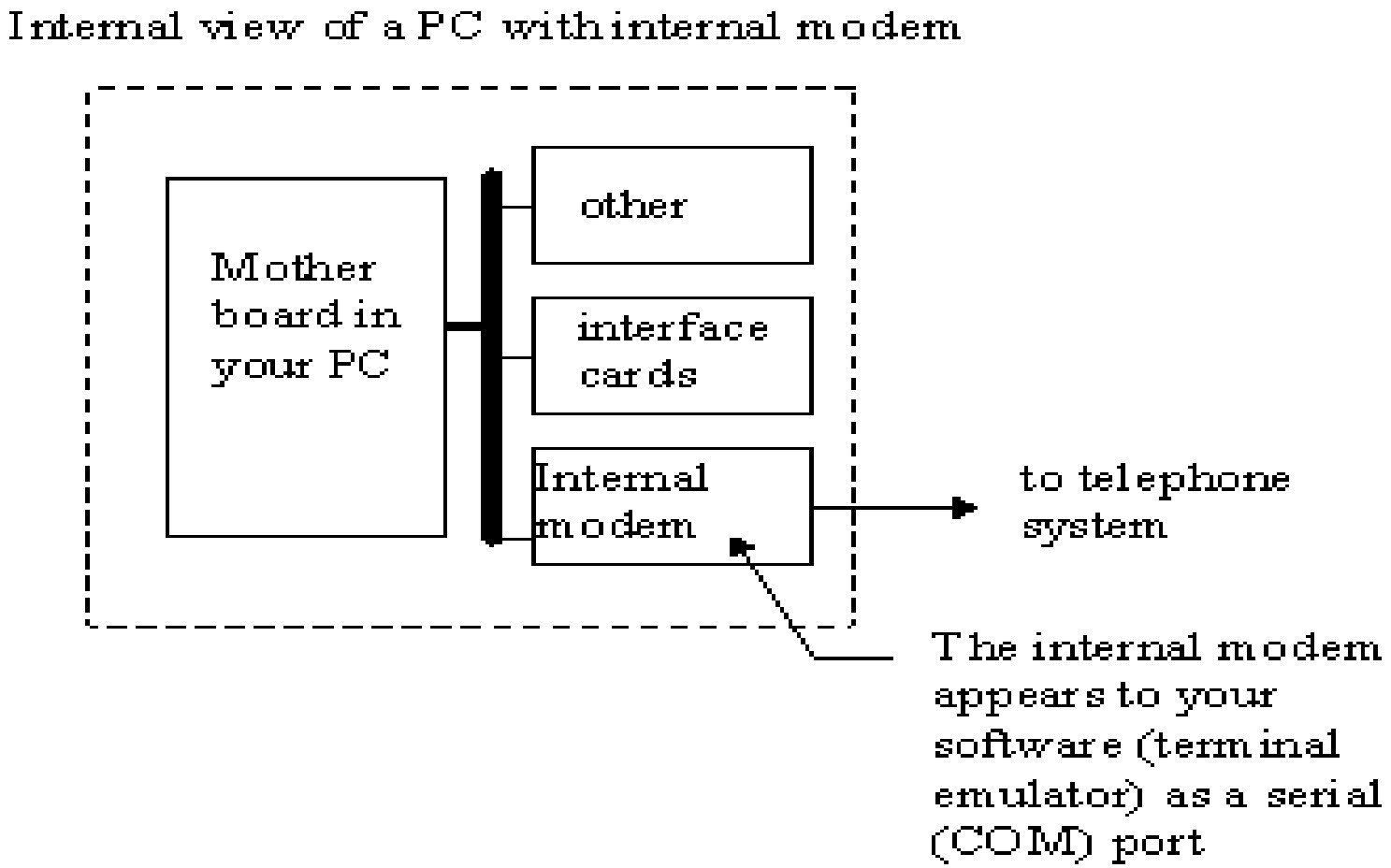
Data processing devices (or Data Terminal Equipment, **DTE**, like computers, terminals, printers) do not (usually) include data transmission facilities, are stand alone equipment.

Need for an interface, called Data Circuit terminating Equipment (**DCE,** e.g. modem, NIC –Network Interface Card)

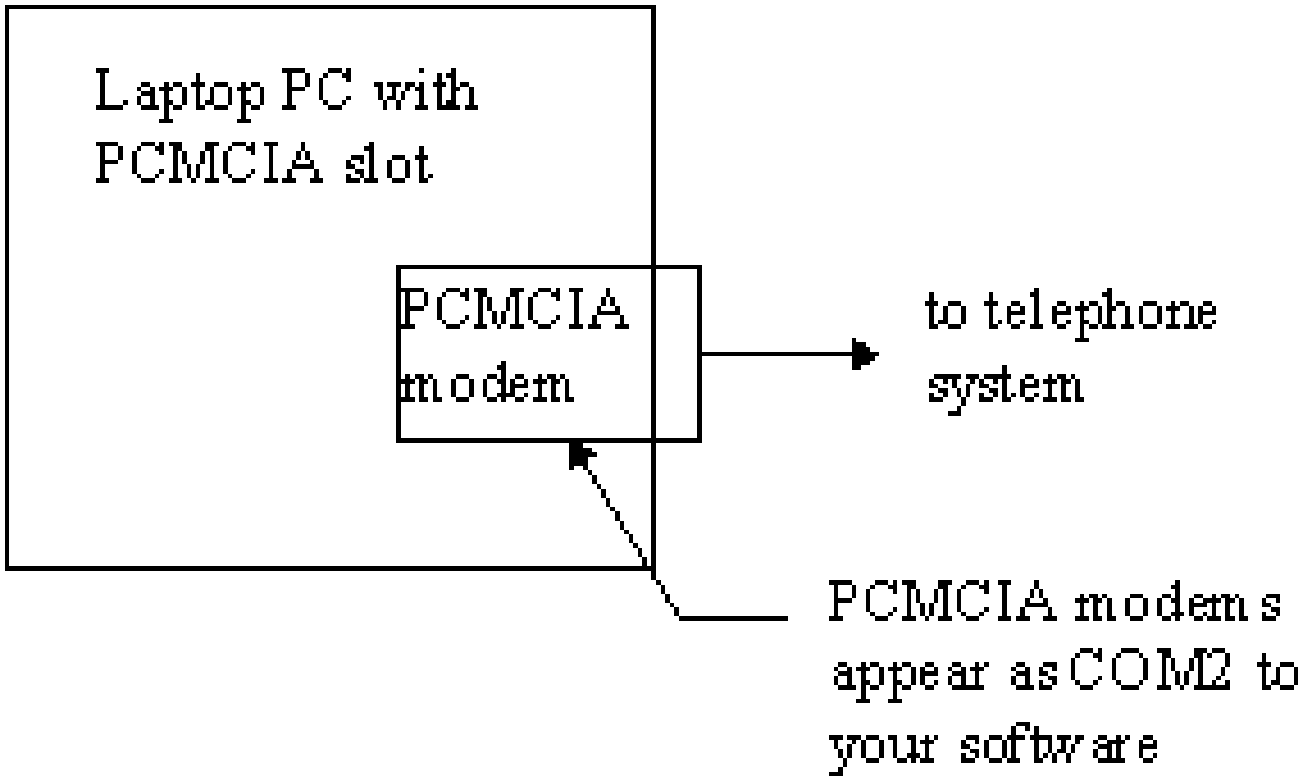
First data transmissions used the telephonic system, a normal phone and a modem, so a **dial-up line** (line established by circuit switching); takes time, unsafe =>
Use of **leased lines**, but are expensive!

Digital telephony – all signals and equipment are digital => big digital telecommunication networks, with high speed and great reliability
Still remains (yet) analog the **local loop**, connecting the subscriber to Telecom office
All DTEs use for connecting to telephone line (either analog or digital) the **serial interface**, so for the PCs the COM ports will be used.

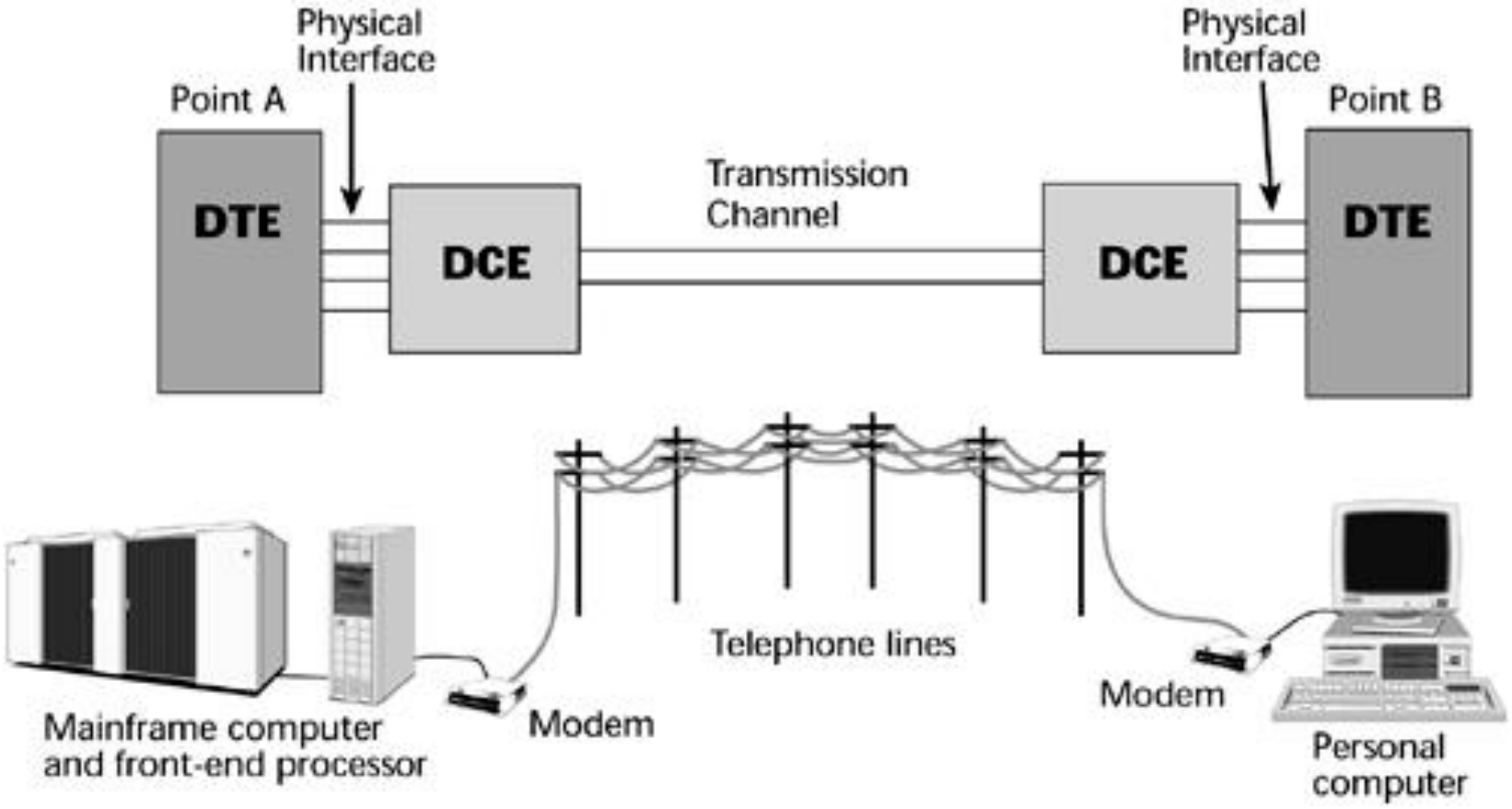
For PCs the modem may be external or internal, today's internal.



For your Laptop with interface adapter PCMCIA slot:



- In OSI terminology, communications interface act where data processing terminals (computers, hosts, terminals, printers) connect to the transmission system, i.e. where is the ‘end system to the network’ (data-circuit terminating equipment).
- Communications interface contains : DTE, DCE & interchange circuits.



Physical layer protocols describe this interface, in many aspects:

-electrical (voltages, currents, encoding techniques)

-electromechanical (connectors, pins location)

-functional (what circuits belongs to what pins & what signals on them mean: data, control, timing, grounding)

-procedural aspects (sequence of events, ex.: protocol of using the standard for answering calls…)

Physical aspects of connecting a DTE to a DCE – object of many standards:

EIA RS 232 (RS 232-D, from 1986, now RS 232-E, from 1991)

equivalent to ITU-T/CCITT V.24; V28 & ISO 2110

RS-449, followed by RS-530

Useful link for all kind of serial interfaces: www.arcelect.com

Modem standards issued by:

-Bell standards (old standards), ITU-T (former CCITT) recommendations, concerning modulation and coding techniques

-EIA/TIA, ITU-T for interfaces

Categories of modems: (see table on next slide)

-**operating speed** –low, medium & high speed

-**implemented standard**

-**type of transmission** (asynchronous, synchronous)

-**type of modulation** (FSK, PSK, QAM)

-**type of telephonic lines** (dial-up or leased)

-**complexity** (traditional or smart)

-**other modems** (ISDN modems, coax cable modems, LAN modems, wireless and cellular modems)

Cable Modems

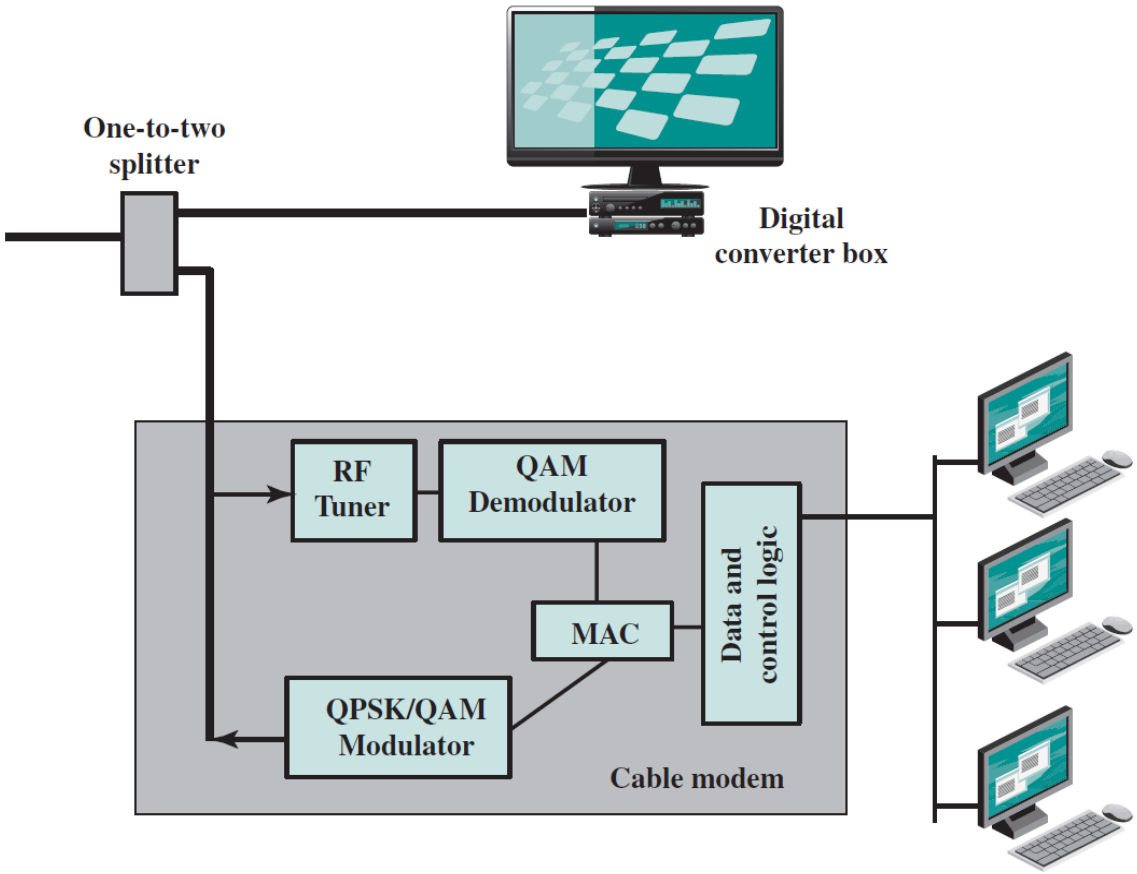
Devices allowing high-speed access to the Internet via a cable television network. Even similar with voice-band modems, more than 500 times faster. Voiceband modems operate up to 56kbps, cable modems deliver 30-40Mbps of data on a 6MHz TV channel

In a cable network:

-data from the network to the user: **downstream**

-data from the user to the network: **upstream**

Downstream and upstream bandwidths may be configured after application (domestic user-low upstream bandwidth, business office may require a higher upstream band)



Simple layout:

-one-to-two splitter for transmitting TV services to set top box, and for transmitting data through cable modem to the computer

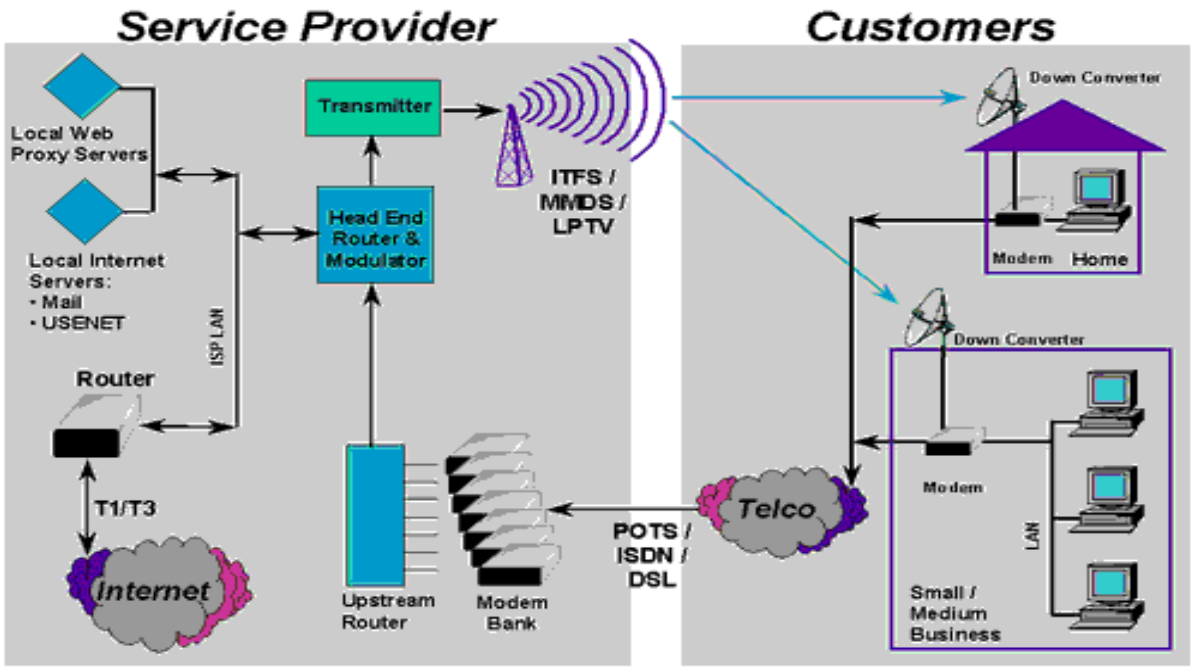
At the other end of the cable there is the head-end, may be a CATV provider or an ISP (Internet Service Provider), let's say a **head-end point-of-presence**, allowing, by use of a multiplexed network interface, the access to the Internet.

- User-to-network data (upstream): 5–40 MHz
- Television delivery (downstream): 50–550 MHz
- Network to user data (downstream): 550–750 MHz

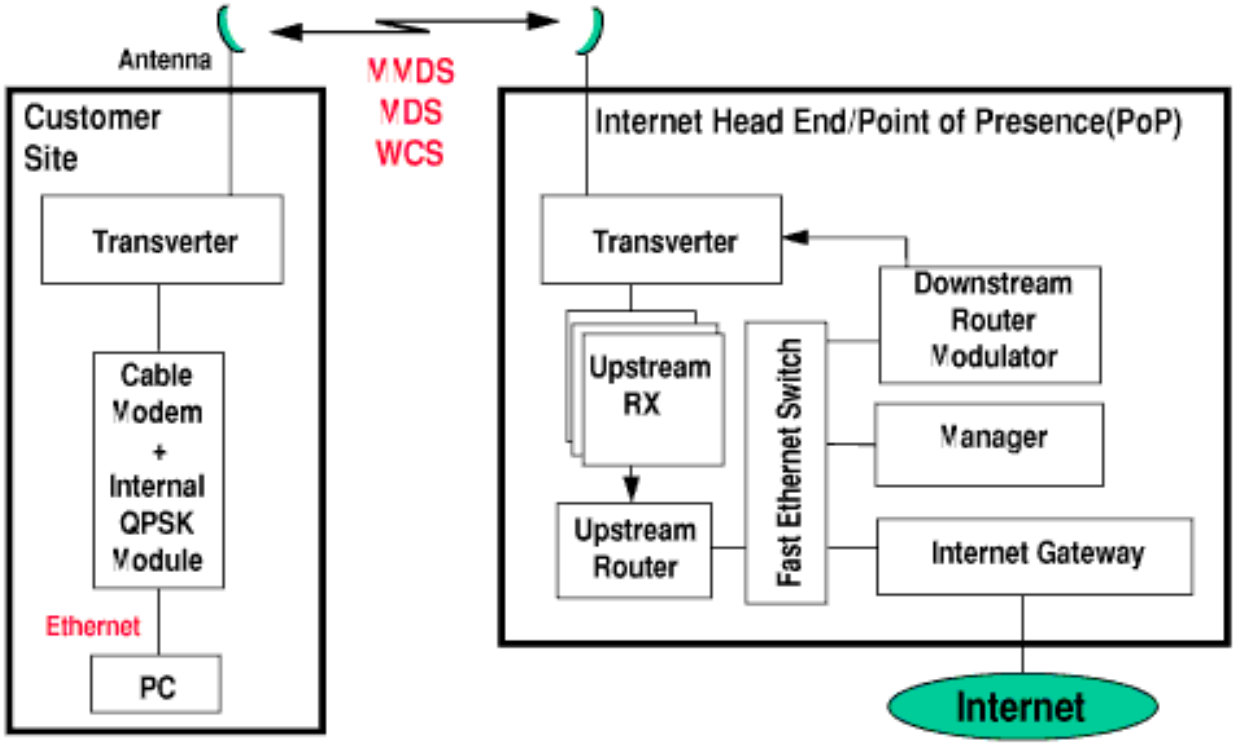
The front of a cable modem showing its various indicators.

The back of a cable modem with standard coaxial television cable connector, telephone jacks and Ethernet jacks - connects the modem to a computer.

Other application with the downstream offered by CATV and upstream by cable modems.



Other application, with the use of the QPSK Signal from a Cable Modem and use of a transverter, for full wireless communications using CATC antennas.



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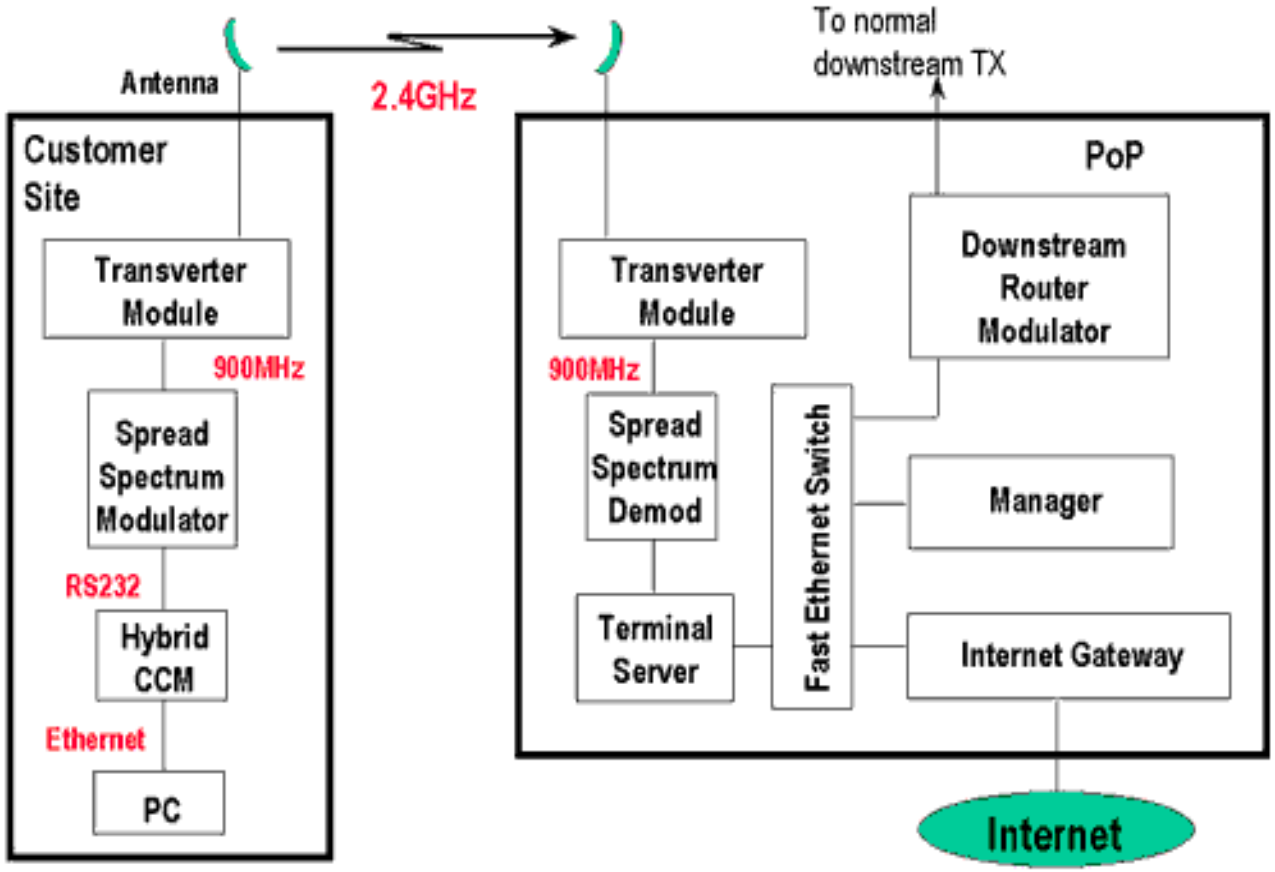
Wireless modems

Many kinds of wireless modems:

-RF modem for a wireless network (use of ISM bands)

-cellular modem for cellular communications, attached to the phone

Example: use the ISM Band for Wireless Return 900 MHz/2.4 GHz:

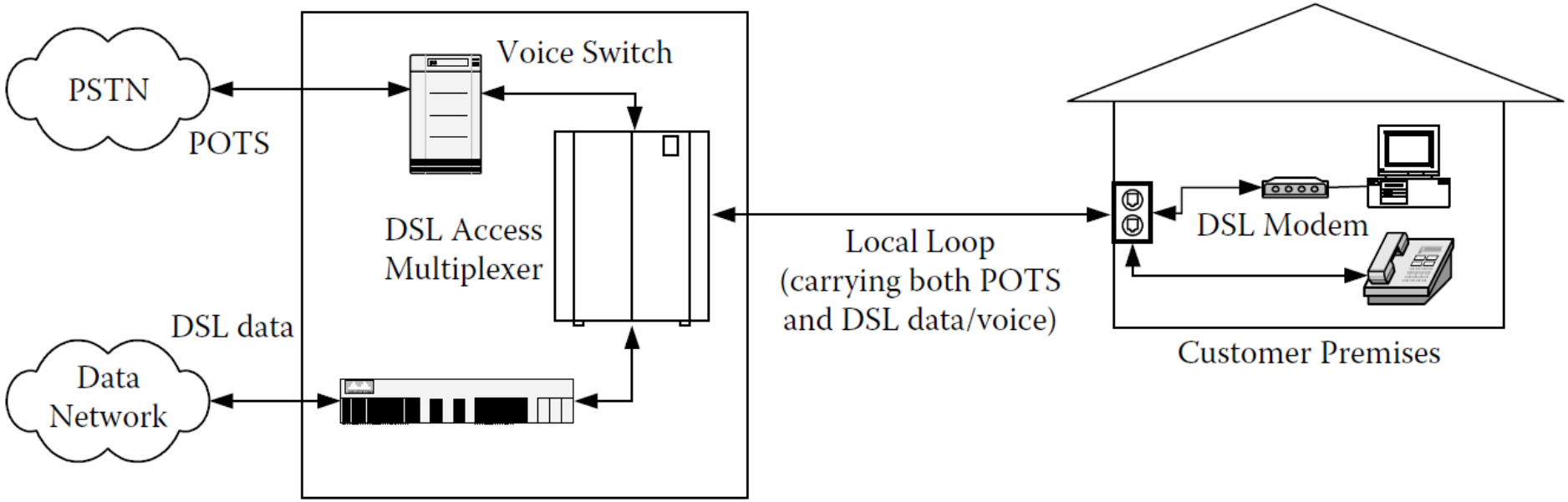


DSL (Digital Subscriber Line)

Link between subscriber and network (local loop); tens of millions installed; Reinstall?

⇒need for exploiting the existing base of TP wired structure; initially designed for voice-grade analog transmissions with 4kHz bandwidth, TP may carry data using signals over a spectrum of more than 1MHz => use of modems for digital high rate data transmissions, using currently installed twisted pair cable.

- DSL refers to the analog local loop between each customer premises and its local central office, and a DSL modem is required at each end of the loop



ADSL (Asymmetric Digital Subscriber Line)

ADSL initially designed for video-on-demand, now appropriate for high-speed Internet access.

Asymmetric because, from the user point, there is greater capacity downstream (from service provider to customer) than upstream.

ADSL uses FDM for managing the 1MHz bandwidth:

-Lowest 25kHz for voice (Plain Old Telephone Service): 0 to 4kHz for voice, rest for guard, avoiding interference with other channels

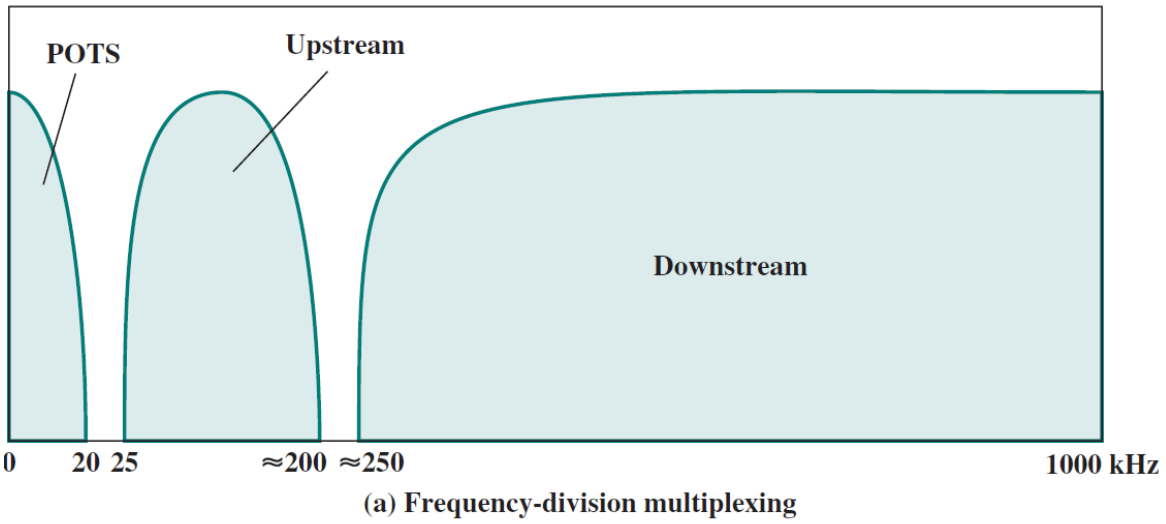
-Use echo cancellation or FDM to give (to allocate) two bands: one for upstream , one for downstream

-Use FDM within each of two bands.

Supports loop length in the range of 5.5km.

Echo Cancellation

Signal processing technique, allowing digital transmissions in both directions on a single line simultaneously. The transmitter must subtract the echo of its own transmission from the incoming signal, to recover the signal sent by the other side.

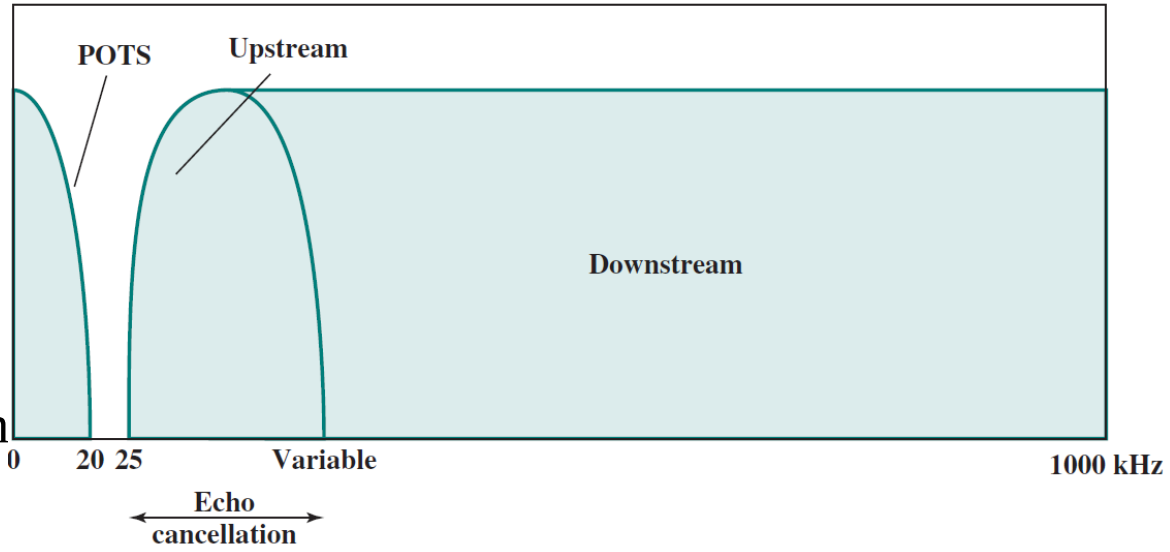


(a) Frequency-division multiplexing

Advantages:

-more flexibility for upstream bandwidth changes, simply extending the area of overlap

-downstream bandwidth in the good part of the spectrum (not so many HFs) => a lower attenuation



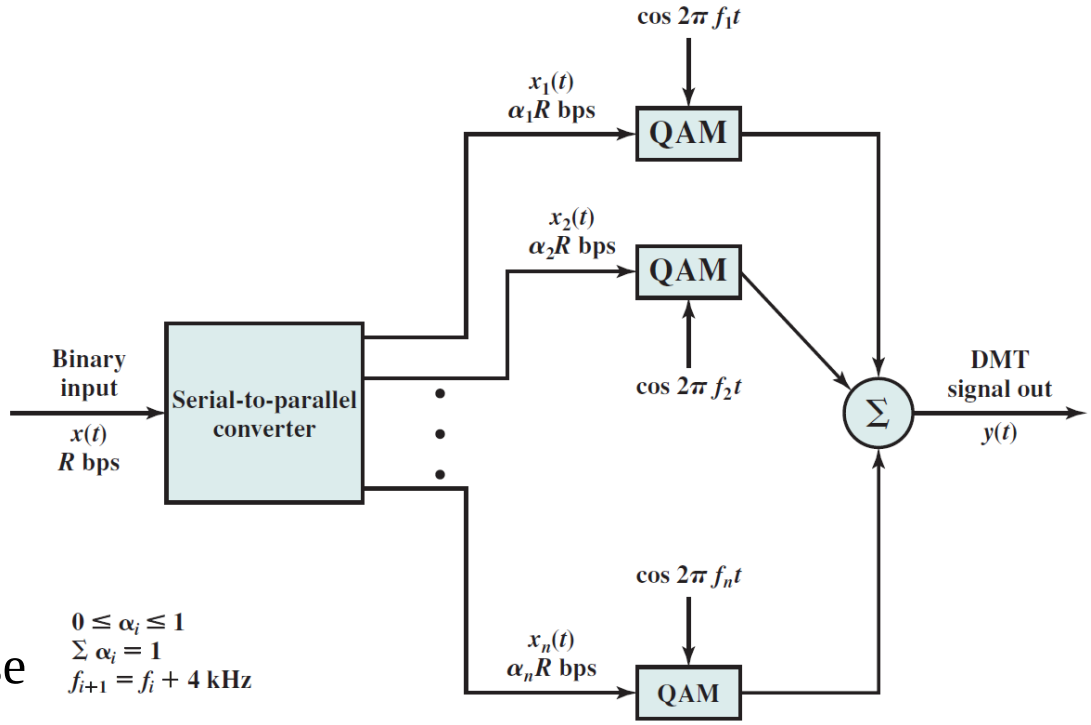
(b) Echo cancellation

DMT (Discrete Multitone)

DMT modem allows multiple carrier signals at different frequencies;

-upstream and downstream bandwidths are split in a number of 4kHz sub-channels, transmitting a number of bits on each channel.

Initially modem send test signal on each subchannel, and then use those subchannels with better signal to noise ratio.



If used 256 downstream subchannels at 4kHz, carring data at 60kbps, will result a data rate of 15.36Mbps. Transmission impairments bring this down to 1.5Mbps to 9Mbps.

Use of **QAM (Quadrature Amplitude Modulation)** – analog signaling technique, a combination of AM and PM. May assign different number of bits/transmitted signal.

Sample example: data string is split in two sub-strings. One sub-string modulates the carrier, the other modulates the carrier shifted with 90º. The composed QAM signal is the sum: s(t) = d1(t)cos 2πft + d2(t)sin 2πft. => signal has 4 states, for coding 2 bits.

xDSL – recent schemes for high-data speed transmissions on ADSL

High data rate DSL

Single line DSL

Very high data rate DSL

	ADSL	HDSL	SDSL	VDSL
Data Rate	1.5–9 Mbps downstream 16–640 kbps upstream	1.544 or 2.048 Mbps	1.544 or 2.048 Mbps	13–52 Mbps downstream 1.5–2.3 Mbps upstream
Mode	Asymmetric	Symmetric	Symmetric	Asymmetric
Copper Pairs	1	2	1	1
Range (24-Gauge UTP)	3.7–5.5 km	3.7 km	3.0 km	1.4 km
Signaling	Analog	Digital	Digital	Analog
Line Code	CAP/DMT	2B1Q	2B1Q	DMT
Frequency	1–5 MHz	196 kHz	196 kHz	≥10 MHz
Bits/Cycle	Varies	4	4	Varies

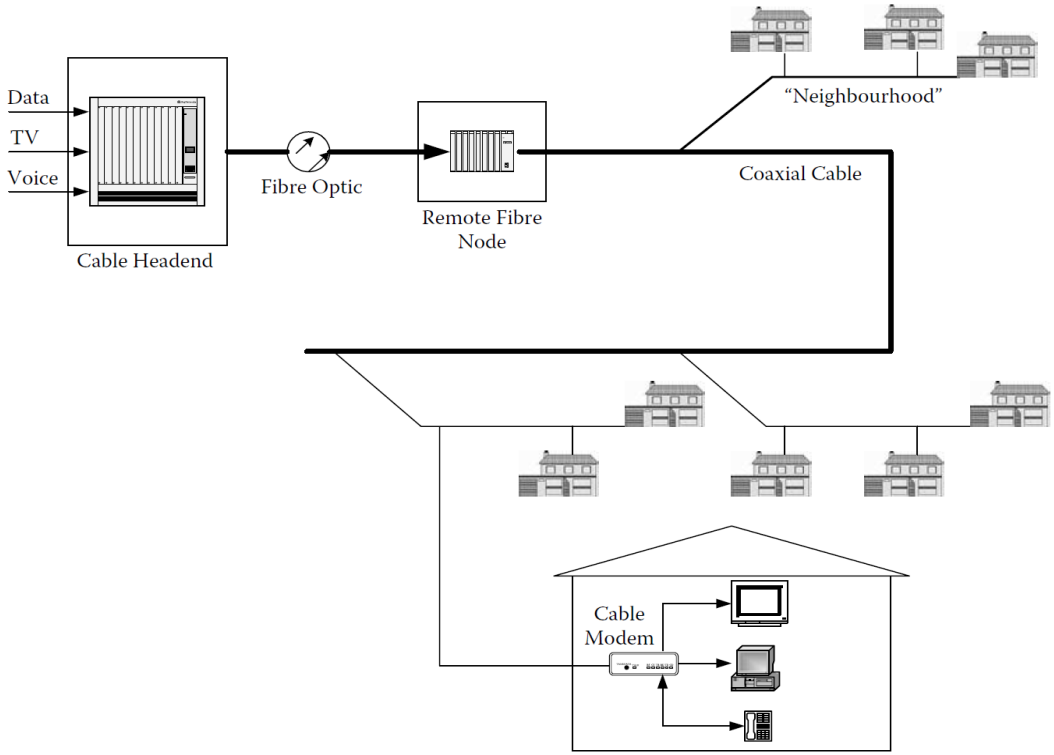
Alternative Broadband Access Technologies

Fiber-to-the-home (FTTH)

- common solution: using passive optical network (PON)
- a single transceiver in the CO serving multiple customers
- splitters and couplers to distribute the service among the different subscribers

Cable

- hybrid fiber-coax (HFC)
- fiber-optic cable carrying signals between the cable headend and fiber nodes in the network, from which existing coaxial cable is used to cover the “last mile” to the subscribers’ premises.



Alternative Broadband Access Technologies

Wireless

- wireless local loop with the advantage that it doesn't need the installation of a transmission medium
- higher frequencies systems: 20 to 40 GHz, sometimes requiring line-of-sight (LOS) availability
- Lower frequency systems: 2,4GHz– 5GHz, with non-LOS transmission

BPL (Broadband over Power Line)

- use of the electric power supply network for the transmission of broadband data

Example: *IEEE 1901-2010 (IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications)*

- high-speed (>100 Mbps at the physical layer) communication
- transmission frequencies below 100 MHz
- BPL devices used for the first-mile/last-mile connection (<1500 m to the premise) and BPL devices used in buildings for local area networks (LANs) and other data distribution (<100 m between devices).