The Physical Layer

COMPUTER NETWORKS – UNIT II

Transmission Media (1)

- **Magnetic media**
  - Tapes, diskettes
  - High bandwidth
  - A 8 mm tape = 7 GB ➔ A 50*50*50 Cm box = 1000 tapes =7000 GB
    7000GB/24 Hrs= 648 Mbps 7000GB/1Hr=15Gbps
  - Sometimes it's cheaper and faster to load a box of tapes in your car!
  - Problem: Delay !

- **Twisted pair (1)**
  - Simply two wires twisted together – thickness=1mm
    The twisting cuts down on electrical interference.
  - Heavily used in the phone system
    Typical office has four pairs for phones.
  - Until some Kilometers/ Some Mbps
  - For Analog and Digital

Transmission Media (2)

- Twisted pair (2)
  - Bandwidth depends on thickness and distance

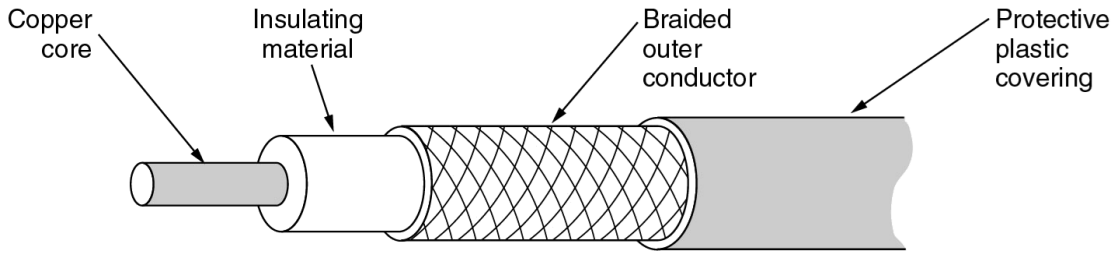
    Need repeater for long distances
  - Category 3 and 5 - with 5 having more twists and better insulation.
  - Popular by UTP (Unshielded Twisted Pair)

Cat3

Cat 5

Transmission Media (3)

- Baseband Coaxial cable
  - **Used for digital transmissions (called baseband.)**
  - **Good noise immunity.**
  - **Data rates as high as 2 Gbps for 1 Km distance.**
  - **Now being replaced by fiber.**
- Broadband Coaxial cable
  - **Used for analog transmissions (called broadband.)**
  - **Can run 300 MHz for long distances.**
  - **Analog signaling has better S/N than digital signaling.**
  - **Interfaces must convert digital signals to analog and vice versa.**
  - **Designed for long distances - can use amplifiers.**

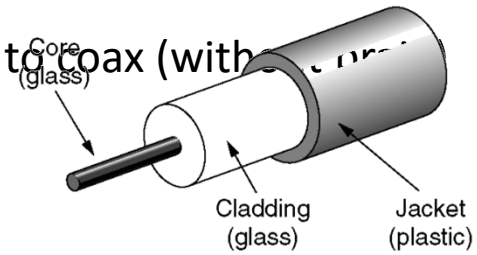


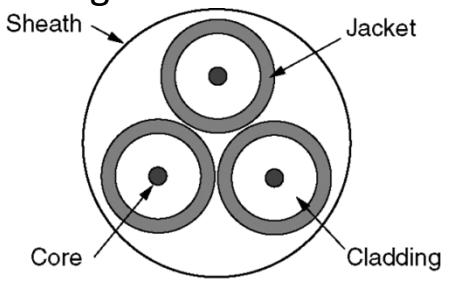
Transmission Media (4)

- Fiber Optic (1)
  - Transmission of light through fiber
  - Bandwidth more than 50,000 Gbps !

    But now restricted to 1Gbps!

    Reason: Electrical and optical signal conversion
  - Including 3 components:
    1. Light source: Pulse of light=1, absence of light=0
    2. Transition medium: an ultra-thin fiber of glass
    3. detector: generate an electrical pulse when light falls on it
  - Similar to coax (with [illegible])





Transmission Media (5)

- Fiber Optic (2)
  - Thickness of core: 8~10 microns or 50 microns
  - Two typically light sources:
    1. LED (Light Emitting Diode)

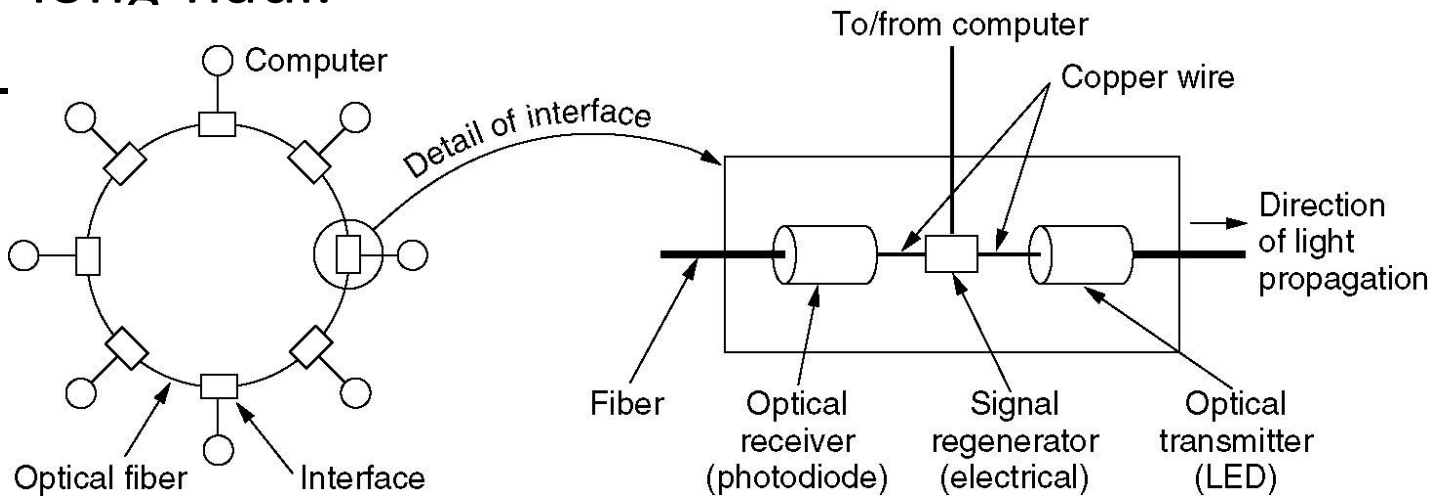
       response time=1ns → data rate = 1Gbps

    2

Item	LED	Semiconductor laser
Data rate	Low	High
Fiber type	Multimode	Multimode or single mode
Distance	Short	Long
Lifetime	Long life	Short life
Temperature sensitivity	Minor	Substantial
Cost	Low cost	Expensive

Transmission Media (6)

- Fiber Optic (3)
  - Properties include total internal reflection and attenuation of particular frequencies.
  - Fiber Optic Networks - can be used for LANs and long-haul.
  -

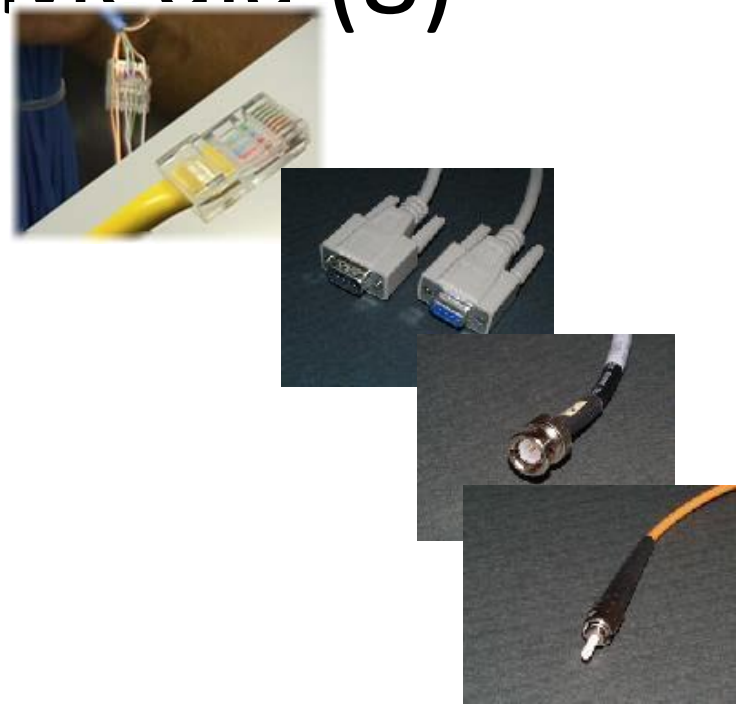


Transmission Media (7)

- Comparison of fiber optic and copper wire

	Fiber	Copper
Bandwidth	Higher	Lower
Distance between repeaters	30 KM	5 Km
Interference	Low	High
Physical	Smaller/Lighter	-
Flow	Uni-directional	Bi-directional

Transmission Media (8)



- Connector
- Repeater
  - Signal Regeneration
  - Clean up
  - Amplify
  - Distance Extension
- Hub
  - Repeater functionality, plus...
    - Concentration Point
    - Signal Distribution Device
    - Management Functions

Wireless transmission

- Radio transmission
- Microwave Transmission
- Lightwave Transmission
- Satellites

Public Switched Telephone System (PSTN) (1)

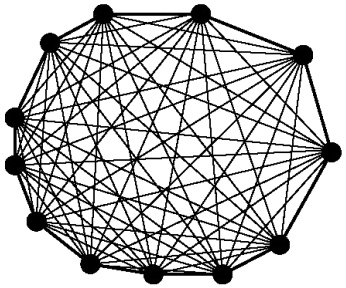
- For connecting computers in near distances (in a company) run a cable between them=LAN
- For long distances and more computers use existing telecommunication facilities = PSTN
  - A cable running ➔ faster than 10^9 bps
  - A dial-up line has max. 56 Kpds

    Difference factor = 20,000 !!
- Transmission of voice and data on system

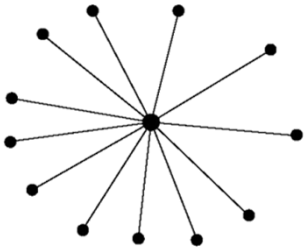
- Computer system designer try to figure out how to use PSTN efficiently

PSTN (2)

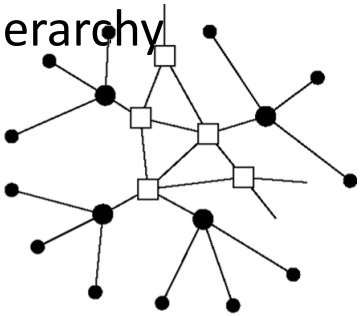
- Telephone structures
  - Fully interconnected



  - Centralized switch

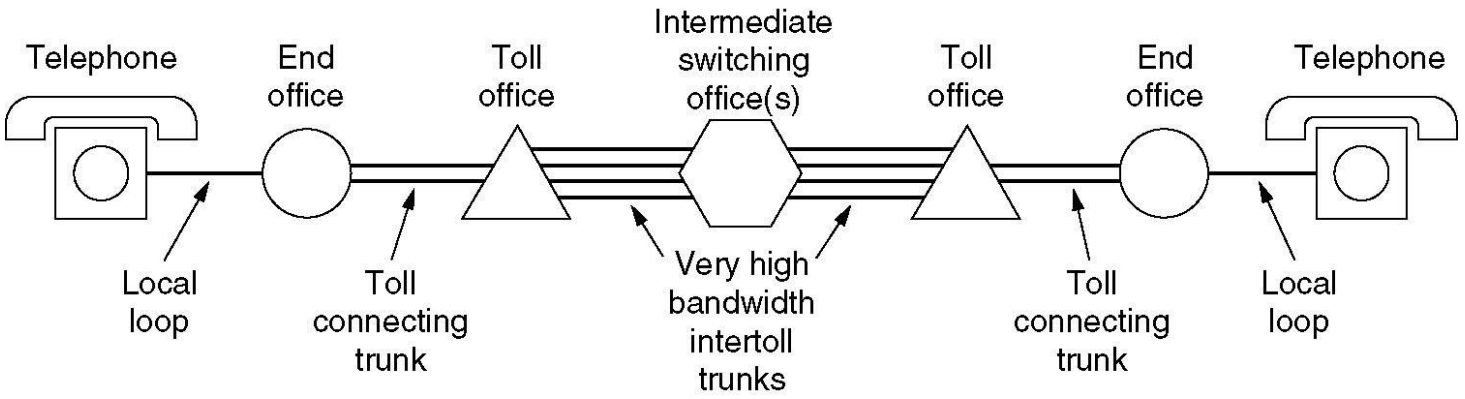


  - Two-level hierarchy



PSTN (3)

- A typical circuit route for a medium-distance call



- Major Components of the Telephone System
  - Local loops: Analog twisted pairs going to houses and businesses
  - Trunks: Digital fiber optics connecting the switching offices
  - Switching offices: Where calls are moved from one trunk to another

PSTN (4)

- The use of analog and digital signals has pros and cons

	Analog	Digital
Signals	Originally	Increasingly
Attenuation/Noise	Low	High
Amplification/Regeneration	Hard	Easy
Information loss	Some	Little
Maintain	-	Easier/cheaper

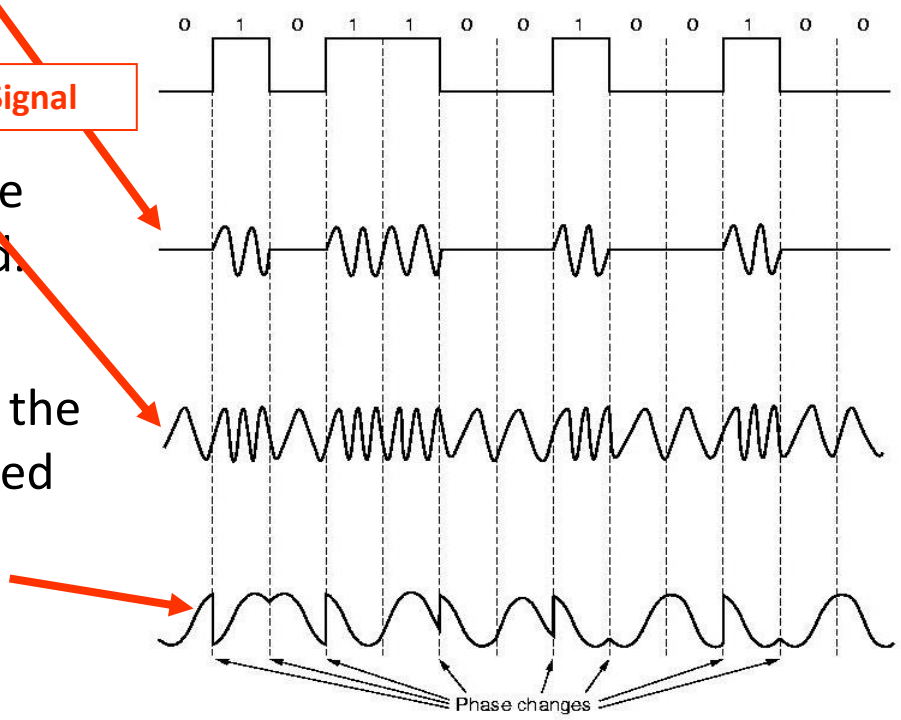
PSTN (5)

- Transmission Impairments:
  - Attenuation - the loss of energy as the signal propagates
  - Delay Distortion - different frequencies travel at different speeds so the wave form spreads out.
  - Noise - unwanted energy that combines with the signal - difficult to tell the signal from the noise.

- Modem
  - A device that converts digital data to and from an analog signal for transmission over phone lines.

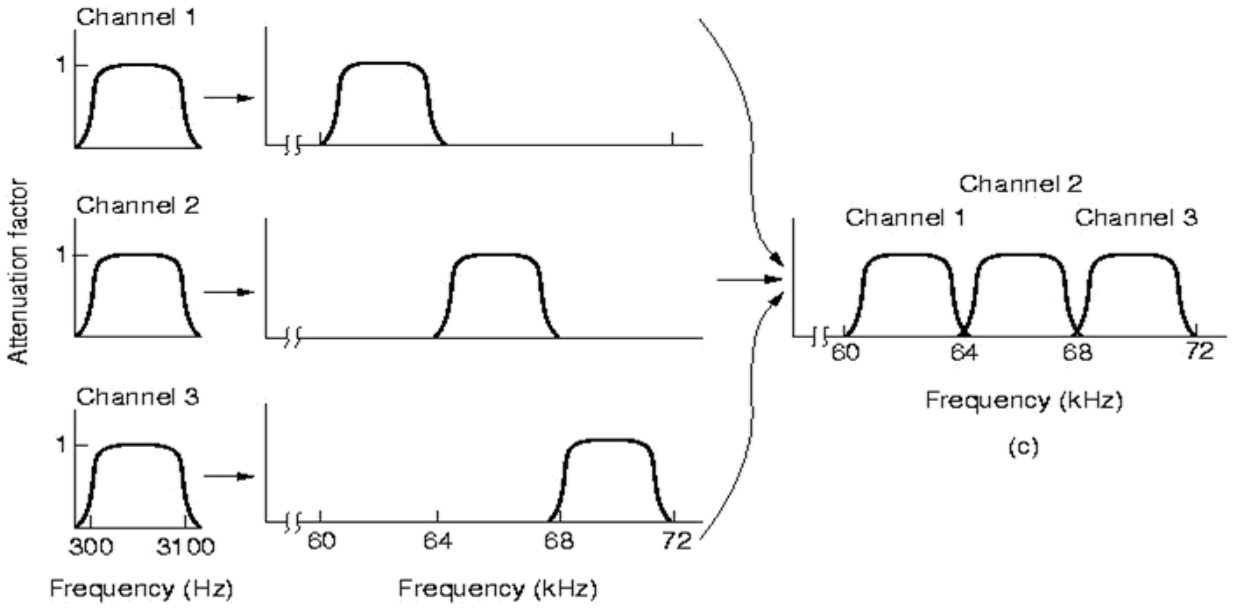
PSTN (6)

- Modem
  - **Amplitude modulation:** Two different amplitudes of sine wave are used to represent 1's and 0's.
  - **Frequency modulation:** Two (or more) different frequencies, close to the carrier frequency, are used.
  - **Phase modulation:** The phase of the sine wave is changed by some fixed amount.



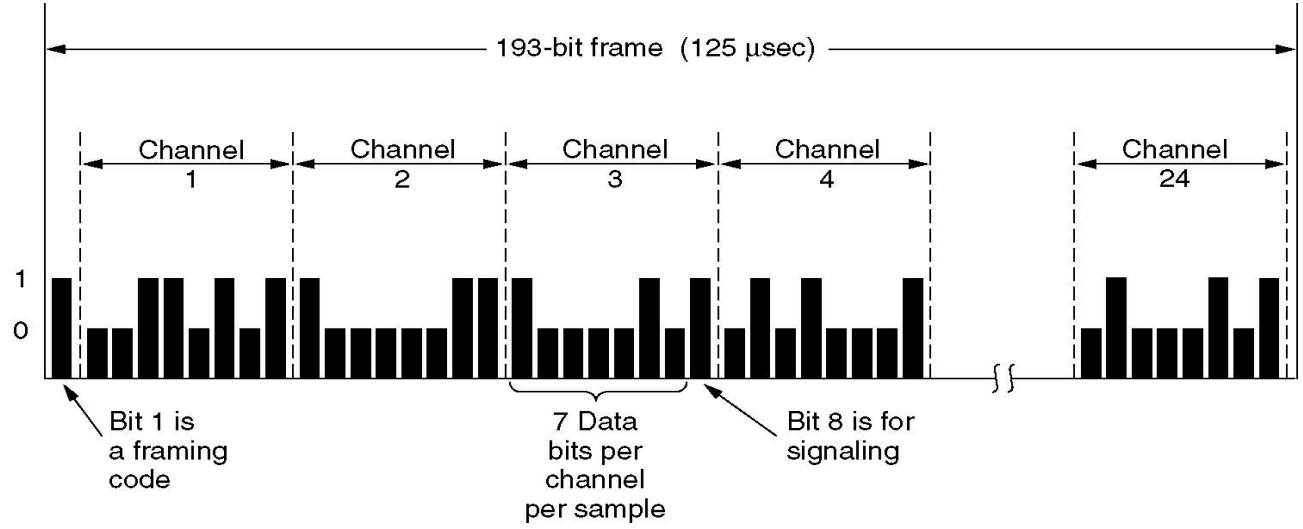
PSTN (7)

- The cost of a wire is independent of the bandwidth of that wire - costs come from installation and maintenance of the physical space (digging)
- **Frequency Division Multiplexing (FDM):**
  - The frequency spectrum is divided up among the logical channels - each user hangs on to a particular frequency. Note that this is analog stuff.



PSTN (8)

- **Wavelength Division Multiplexing (WDM):**
  - The same as FDM, but applied to fibers. There's great potential for fibers since the bandwidth is so huge (25,000 GHz).
- **Time Division Multiplexing (TDM):**
  - In TDM, the users take turns, each one having exclusive use of the medium in a round robin fashion. TDM can be all digital.
  - Ex. T1=24 channels, each 8 bits =192 bits +1 ➔ 1.544 Mbps



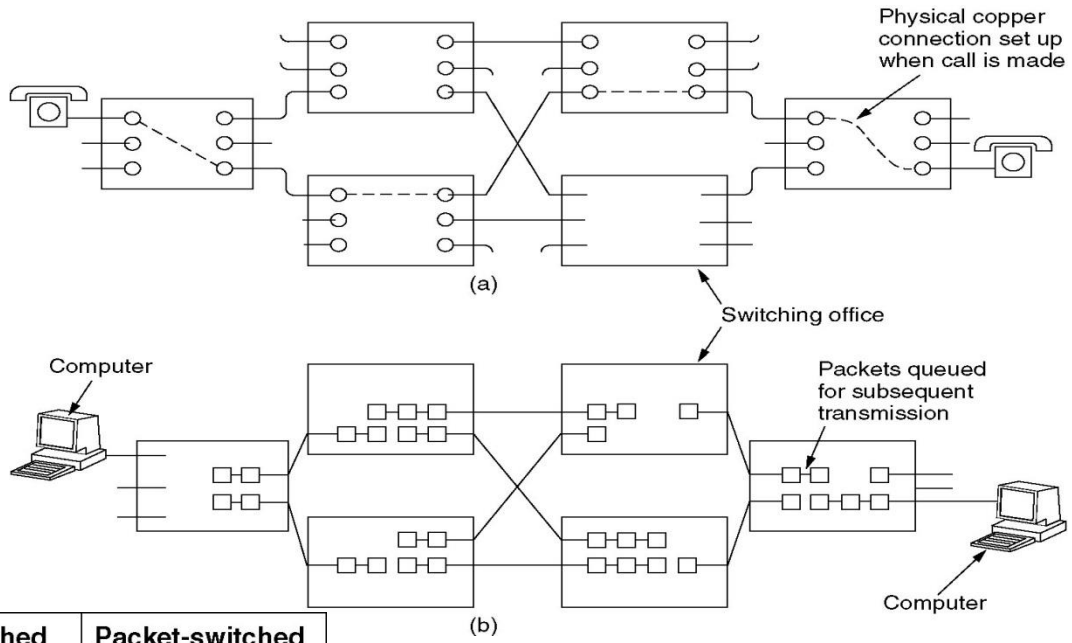
PSTN (9)

- Switching
  - **Circuit Switching:** A physical connection (electrical, optical, radio) is established from the caller phone to the calle phone. This happens BEFORE any data is sent.
  - **Message Switching:** The connection is determined only when there is actual data (a message) ready to be sent. The whole message is re-collected at each switch and then forwarded on to the next switch. This method is called store-and-forward. This method may tie up routers for long periods of time - not good for interactive traffic.
  - **Packet Switching**: Divides the message up into blocks (packets). Therefore packets use the transmission lines for only a short time period - allows for interactive traffic.

PSTN (10)

(a) Circuit switching.

(b) Packet switching.



Item	Circuit-switched	Packet-switched
Call setup	Required	Not needed
Dedicated physical path	Yes	No
Each packet follows the same route	Yes	No
Packets arrive in order	Yes	No
Is a switch crash fatal	Yes	No
Bandwidth available	Fixed	Dynamic
When can congestion occur	At setup time	On every packet
Potentially wasted bandwidth	Yes	No
Store-and-forward transmission	No	Yes
Transparency	Yes	No
Charging	Per minute	Per packet