CSC 524

Computer Networks
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Lecture 3
11-12/02/2013

Agenda

Introduction

- Last week we discussed Layers
  - Bottom layer is physical layer
- Why when you download a big file it takes so long ?
  - Why not 1 second ?
  - Why is Fiber > DSL > mobile
  - Why doesn't everyone have Fiber ?
- We will answer all these questions !

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- Transmission media Characteristics
  - Bandwidth
  - Delay
  - Cost
  - Ease of Maintenance
- Categorized by
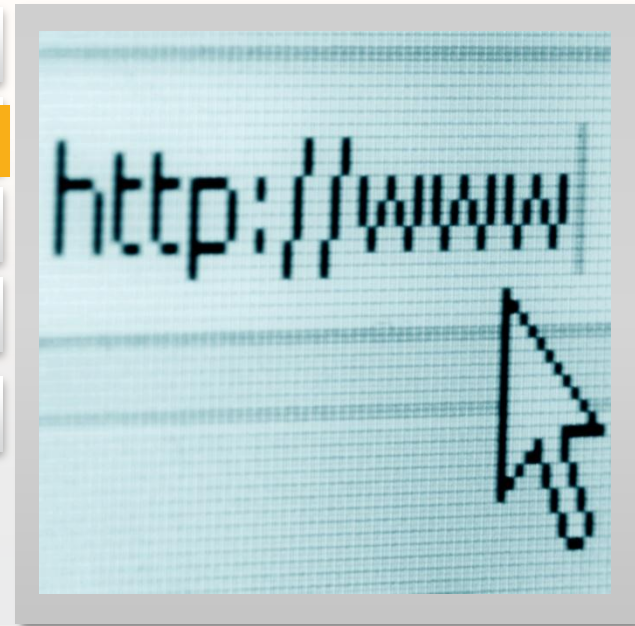 - Guided (copper wire, fiber..etc)
  - Unguided (Wireless)

- # Mother nature has limitations
  - – Noise
  - – Material
  - – Spectrum limitation

Agenda

Guided Transmission

- Magnetic Media
  - Sneakernet ☺
    http://en.wikipedia.org/wiki/Sneakernet
  - Google used it ! 120TB
    http://news.bbc.co.uk/2/hi/technology/6425975.stm
  - Sometimes it is faster
  - Delay: High, Bandwidth: usually High (depends)
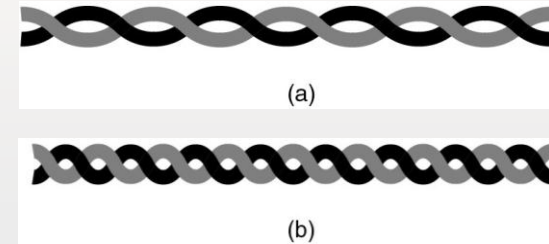
Guided Transmission (Cont'd)

- Twister Pair (TP)
  - Two insulated copper wires
  - Twisted to prevent it from being an antenna
  - Run several Kilometers without problem
    - After that repeaters are needed
  - Used mainly for telephone systems
  - TP transmits Digital/analog data
  - Bandwidth: depends on thickness of the wire
  - Cost: Cheap. Maintenance: Easy

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Guided Transmission (Cont'd)

- Twister Pair (TP) comes in many categories
- CAT3: 4 pairs
- CAT5: same, but more twists
- CAT6, CAT6a ..etc

(a) Category 3 UTP.
(b) Category 5 UTP.

- http://en.wikipedia.org/wiki/Twisted_pair

Guided Transmission (Cont'd)
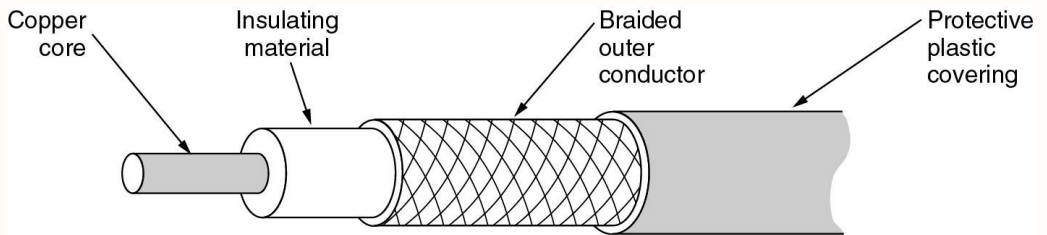
Most common cable categories

Category	Type	Frequency Bandwidth	Applications
Cat1		0.4 MHz	Telephone and modem lines
Cat2		4 MHz	Older terminal systems, e.g. IBM 3270
Cat3	UTP[6]	16 MHz[6]	10BASE-T and 100BASE-T4 Ethernet[6]
Cat4	UTP[6]	20 MHz[6]	16 Mbit/s[6] Token Ring
Cat5	UTP[6]	100 MHz[6]	100BASE-TX & 1000BASE-T Ethernet[6]
Cat5e	UTP[6]	100 MHz[6]	100BASE-TX & 1000BASE-T Ethernet[6]
Cat6	UTP[6]	250 MHz[6]	1000BASE-T Ethernet
Cat6e		250 MHz (500 MHz according to some)[who?]	
Cat6a		500 MHz	10GBASE-T Ethernet
Cat7	S/FTP[6]	600 MHz[6]	Telephone, CCTV, 1000BASE-TX in the same cable. 10GBASE-T Ethernet.
Cat7a		1000 MHz	Telephone, CATV, 1000BASE-TX in the same cable. 10GBASE-T Ethernet.
Cat8		1200 MHz	Under development, no applications yet.

Guided Transmission (Cont'd)

- Coaxial Cable (coax)
- Two popular types 50-ohm, 75-ohm
- Bandwidth: depends on material
- Cost: cheap
- Maintenance: easy
- Still used for cable + MAN

Copper core   Insulating material   Braided outer conductor   Protective plastic covering

Guided Transmission (Cont'd)

Year	Organization	Effective speed
2009	Alcatel-Lucent[7]	15 Tbit/s
2011	KIT[8]	26 Tbit/s
2010	NTT[9]	69.1 Tbit/s
2011	NEC[10]	101 Tbit/s
2012	NEC, Corning[11]	1.05 Petabit/s

- Fiber optics

- Limit is 50,000 Gbps = 50 Tbps

- Why can't we get all of this
  - Conversion optical-2-electrical isn't fast enough
  - Moore's law ☹
  - Computation vs. communications.. Communications won!
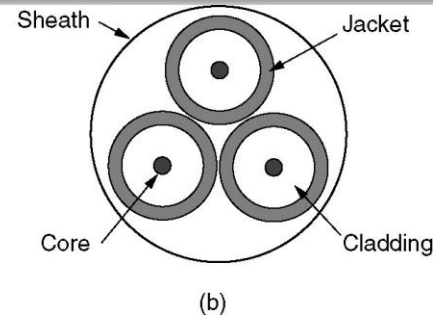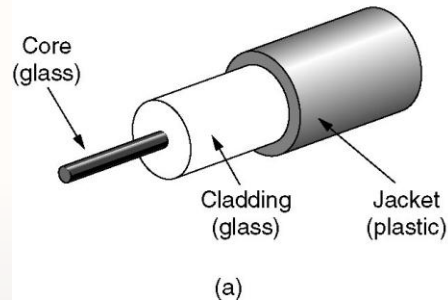
Guided Transmission (Cont'd)

- Fiber optics
  - Cheap, Fast, short delay, and cheap!
- Components
  - Light source: light =1, no light =0
  - Transmission medium: thin fiber of glass
  - Detector
- Convert electrical signal to light and backwards

Core (glass)
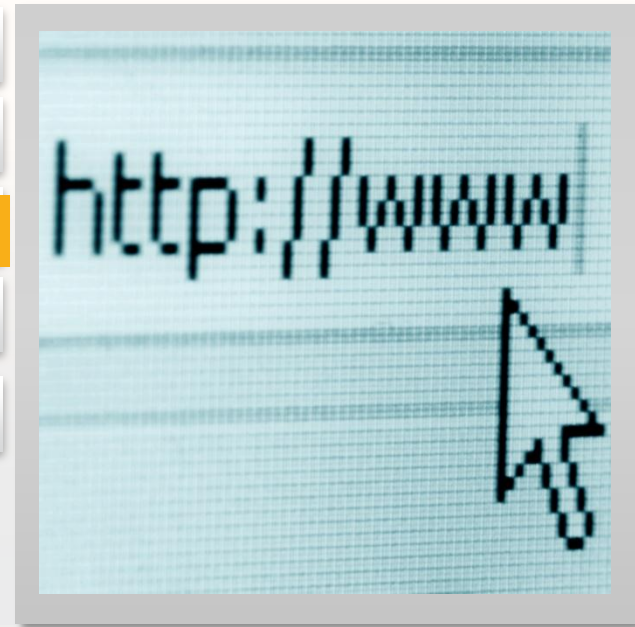Cladding (glass)
Jacket (plastic)
(a)

Sheath
Jacket
Core
Cladding
(b)

- Fiber optics

- Two kind of light sources
  - LED (Light Emitting Diodes)
  - Laser
- Usually Fiber is used in backbones for high-bandwidth .. UTP is used internally
- Secure: Very difficult to tap !

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Unguided Transmission

- Can you carry a UTP around ?

- Wireless travel through air + Vacuum

- Frequency (Hz) (German physicist Heinrich Hertz in 1887) (number of oscillations/second)

- Wavelength

- Freq (MHz) x Wavelength (Meters) = 300!
  - 100Mhz =3 meters
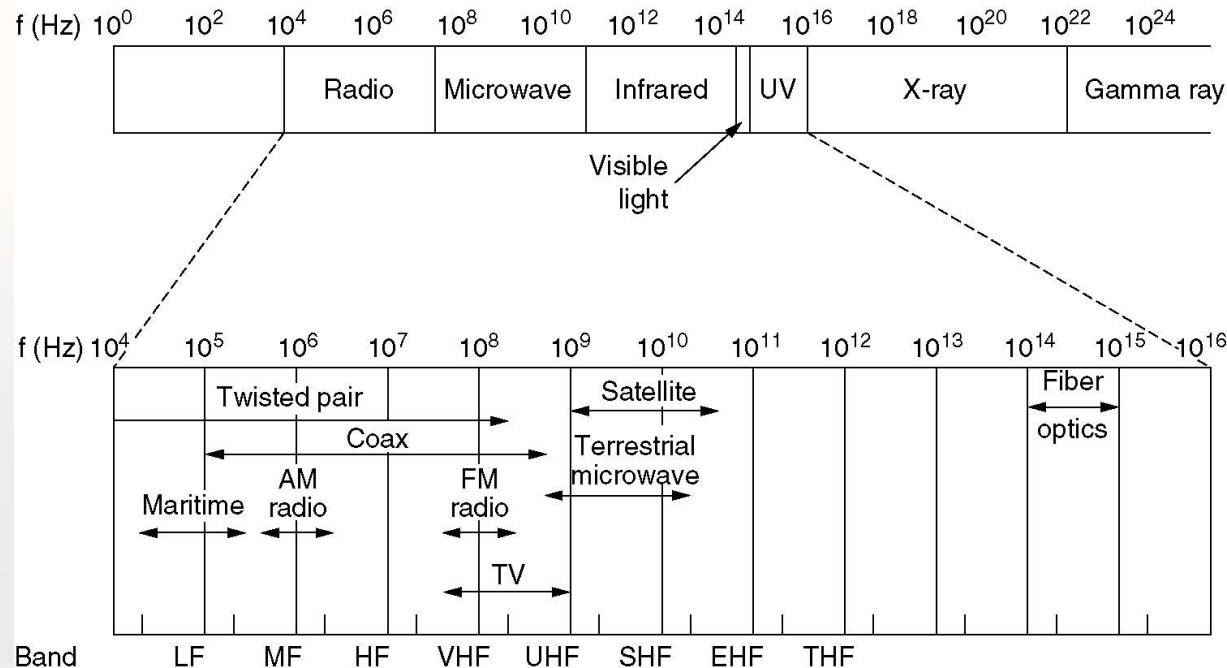 - 1000Mhz = 0.3 meters
  - etc

$$\lambda f = c$$

Unguided Transmission (Cont'd)

- LF = Low
- MF= Medium
- LF= High
- VHF= Very
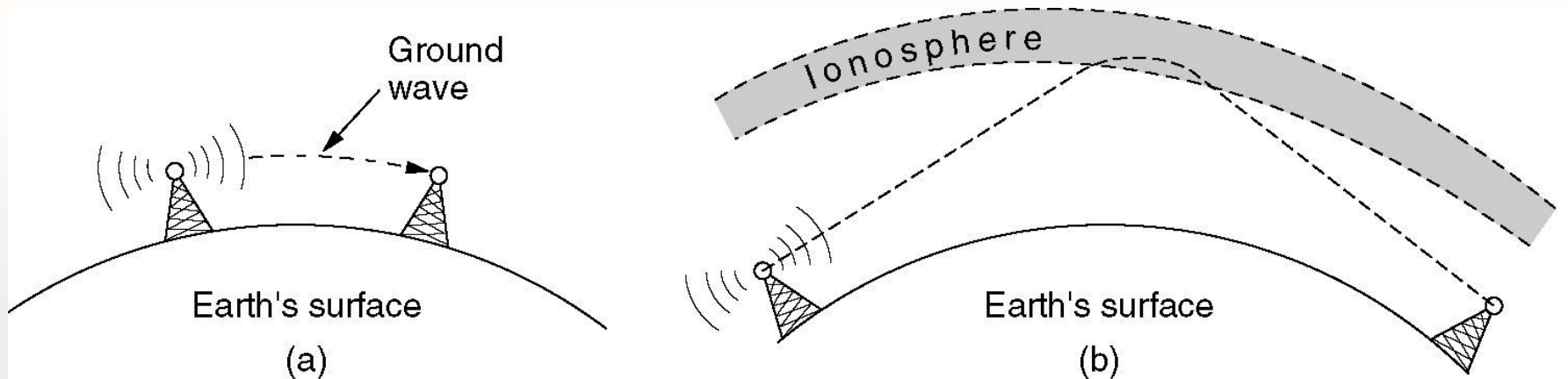- SHF= Super
- EHF = Extremely
- THF = Tremendously !

- Radio Transmission
  - Easy to generate
  - travel long distances
  - Indoor/ outdoor
  - Omnidirectional (no alignment needed)
    - Story of Highway patrol and Cadillac
    - Since it travels long distances, it causes interference
    - governments license the spectrum !

Unguided Transmission (Cont'd)

(a) In the VLF, LF, and MF bands, radio waves follow the curvature of the earth.

(b) In the HF band, they bounce off the ionosphere.

Unguided Transmission (Cont'd)

- ## Microwave Transmission
  - – Higher frequencies
  - – Almost straight line
  - – Sender/receiver must be aligned
  - – It was used for Telephone companies
    - • MCI (Microwave Comm. Inc) competitor for AT&T
  - – Alfaisaliah Tower ?!

- ## Long distance ?→ repeaters
  - – 100m tall tower covers up to 80 km

Unguided Transmission (Cont'd)

- Radio → lower frequencies
  - Can penetrate walls
- Microwave → Higher frequencies
  - Very high it could roast birds
  - Requires line-of-sight !
- Microwave is easy to install, no digging, no laying wires !
  - They are CHEAP too !

Unguided Transmission (Cont'd)

- Politics
  - ITU (itu.int)
  - USA → FCC
  - How to allocate ?
    - Beauty contest ..who is better ?
    - Remember.. Google was bidding on the old spectrum? 2008!
    - http://en.wikipedia.org/wiki/United_States_2008_wireless_spectrum_auction
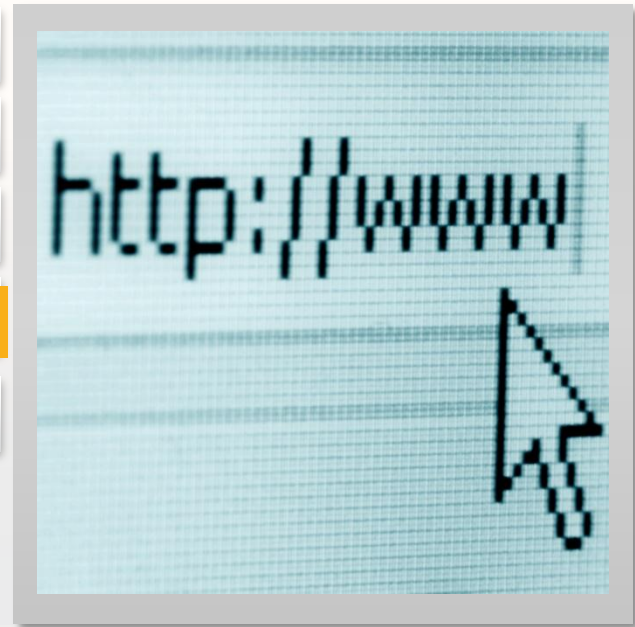
Unguided Transmission (Cont'd)

- Satellite
  - Geostationary Satellites
  - Medium-Earth Orbit Satellites
  - Low-Earth Orbit Satellites
- Alwaleed + bill gates and others were planning Teledesic network using satellites
- http://en.wikipedia.org/wiki/Teledesic
- Failure of Iriduim + GlobalStar made them re-think .. It was stopped 2002 !

Agenda

- # Public Switched Telephone Networks
  - ## – Structure

Telephone   End office   Toll office   Intermediate switching office(s)   Toll office   End office   Telephone

Local loop   Toll connecting trunk   Very high bandwidth intertoll trunks   Toll connecting trunk   Local loop
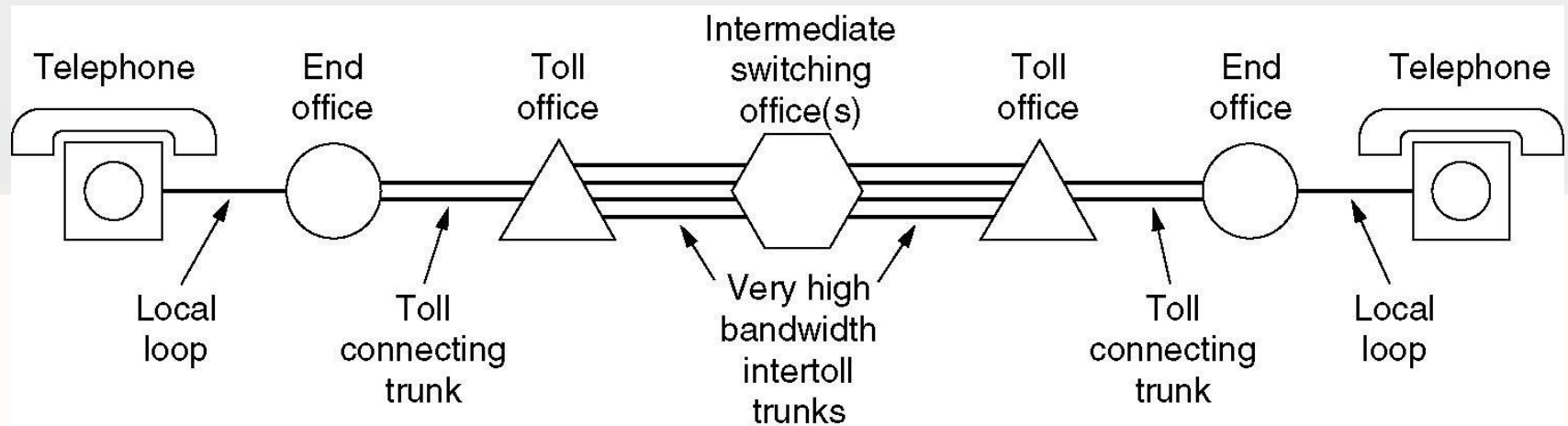
- Public Switched Telephone Networks
- Three major components:
    - Local loops (analog twisted pairs going into houses and businesses).
    - Trunks (digital fiber optics connecting the switching offices).
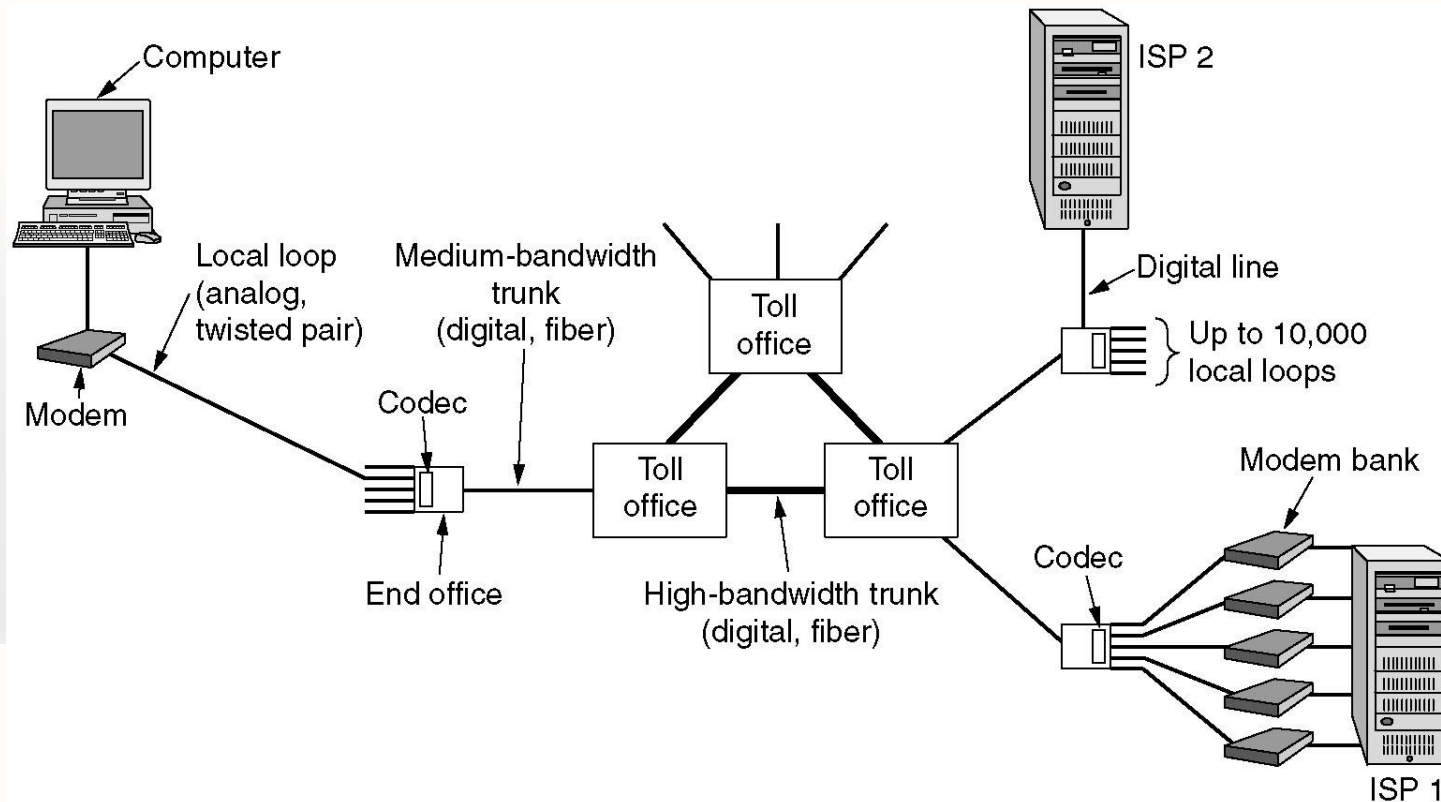   - Switching offices (where calls are moved from one trunk to another).

PSTN (Cont'd)

- Politics !
  - AT&T was monopolizing the telecom in the US!
  - In 1984 it was broken into several companies
  - It is history !!
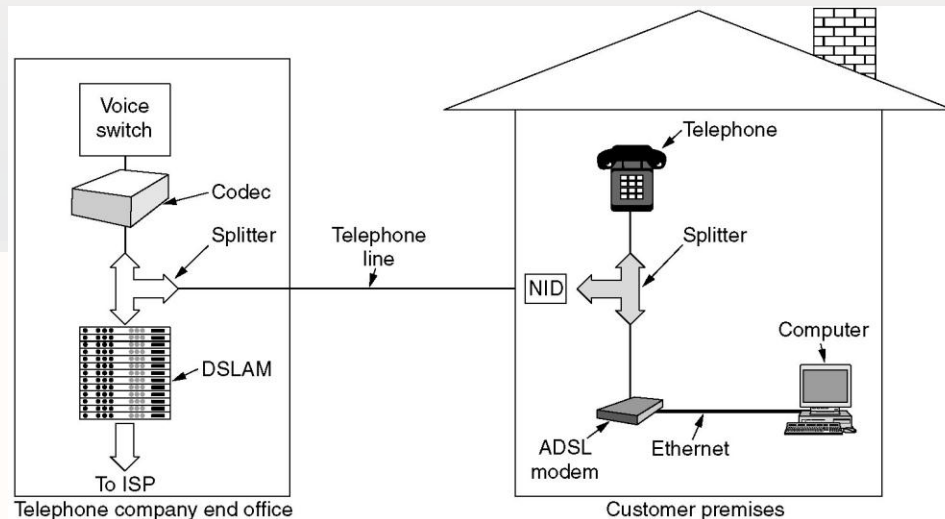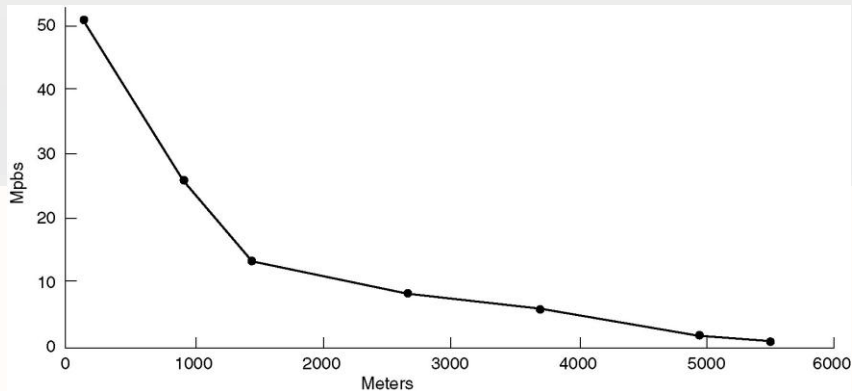
The use of both analog and digital transmissions for a computer to computer call. Conversion is done by the modems and codecs.
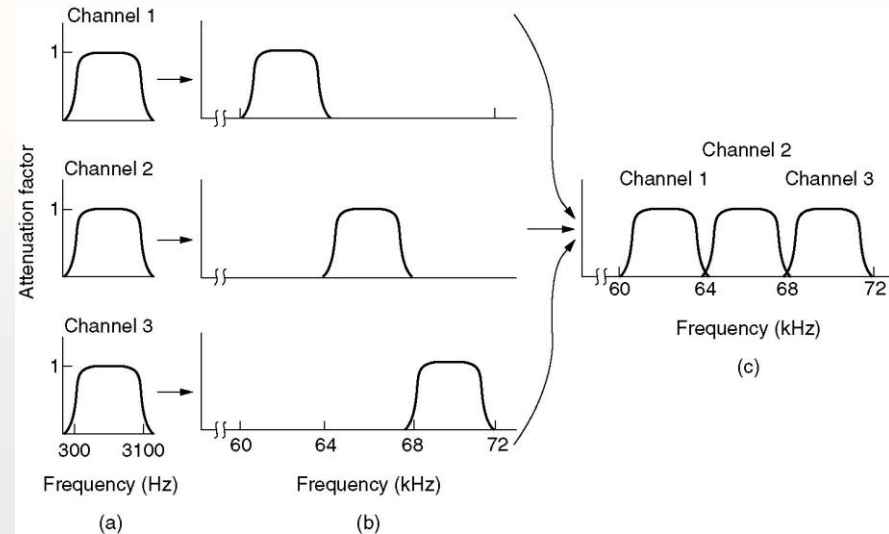
- # Modem
  - ## – Modulator/DeModulator
- # DSL (Digital Subscriber Lines)

- ## Multiplexing ?!
  - – FDM/ WDM
  - – TDM

THANK YOU!