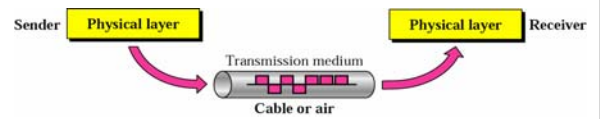


Transmission Media

ผศ. ดร. อนันต์ ผลเพิ่ม
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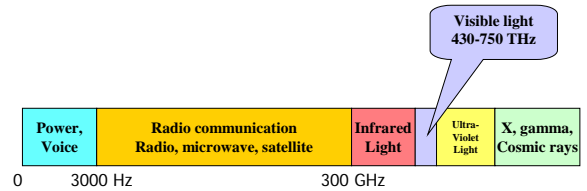
Transmission Media



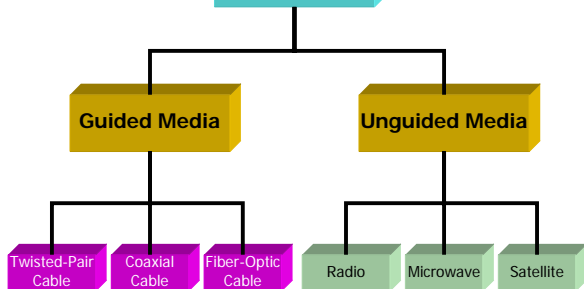
Electromagnetic Energy

- Signals are transmitted in form of electromagnetic energy
- Electromagnetic Energy:
 - a combination of electrical and magnetic fields vibration
 - Travel through a vacuum, air, or other transmission media
 - Some are used for communications

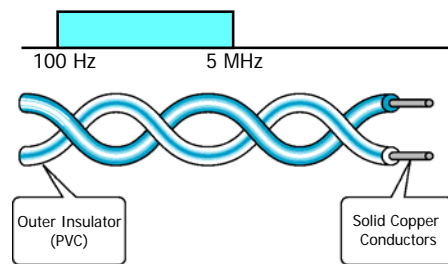
Electromagnetic Spectrum

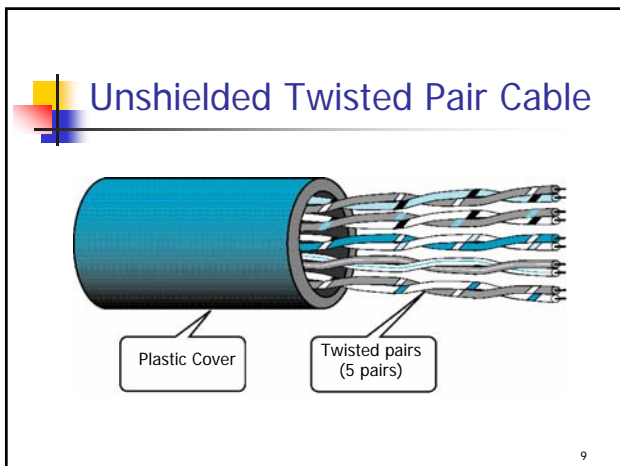
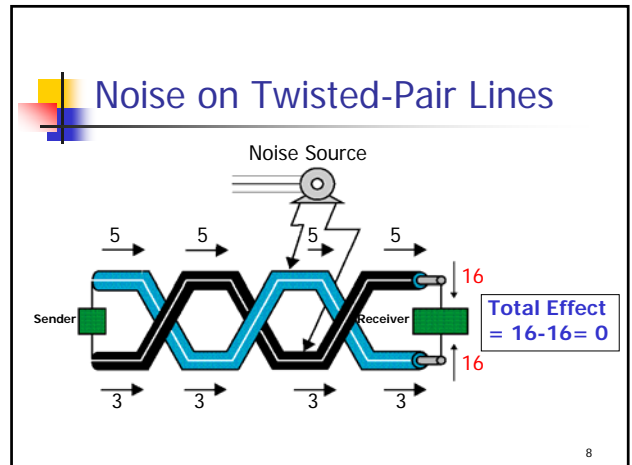
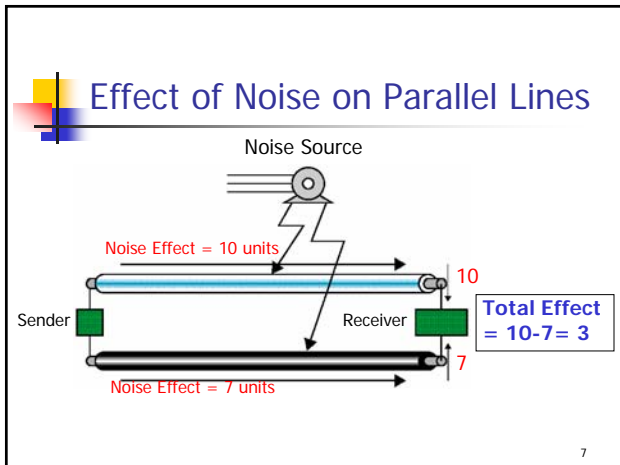


Transmission Media



Twisted Pair Cable



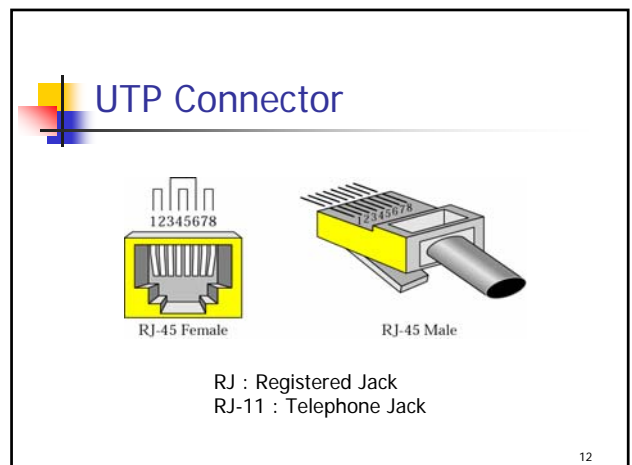


- ### UTP cable standard
- EIA set the cable standards
 - Categorized by the cable quality
 - Category 1: telephone system, voice
 - Category 2: voice & data (4Mbps)
 - Category 3: data (10Mbps), now is the standard for telephone
 - Category 4: 16 Mbps
 - Category 5: 100 Mbps
- 10

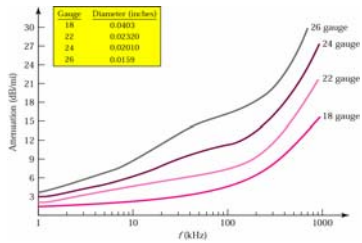
UTP cable standard

Category	Bandwidth	Data Rate	Digital/Analog	Use
1	very low	< 100 kbps	Analog	Telephone
2	< 2 MHz	2 Mbps	Analog/digital	T-1 lines
3	16 MHz	10 Mbps	Digital	LANs
4	20 MHz	20 Mbps	Digital	LANs
5	100 MHz	100 Mbps	Digital	LANs
6 (draft)	200 MHz	200 Mbps	Digital	LANs
7 (draft)	600 MHz	600 Mbps	Digital	LANs

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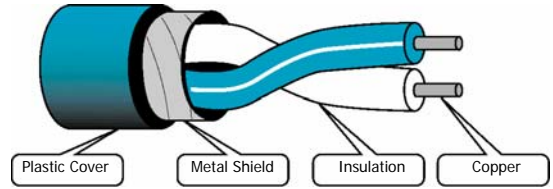
UTP Performance



- Attenuation VS. Freq & Distance
- Unit in decibels/mile (dB/mi)
- Gauge = wire thickness

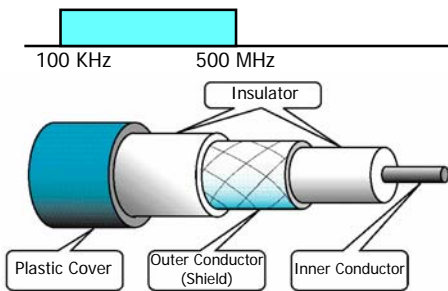
13

Shielded Twisted-Pair Cable



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Coaxial cable



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Coaxial cable standard

- Categorized by radio government (RG)
- Physical specification (wire gauge, conductor,...)
 - RG-8, RG-9, RG-11 : Thick Ethernet
 - RG-58 : Thin Ethernet
 - RG-59 : TV

16

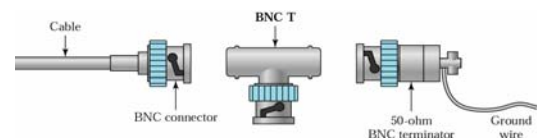
Coaxial cable standard

Category	Impedance	Use
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

17

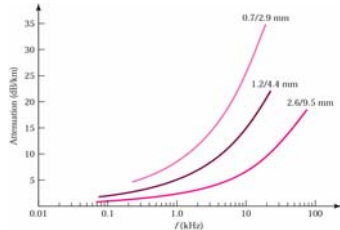
Coaxial cable connector

- Barrel Connectors
 - Bayonet network connector (BNC)
 - T-connector
 - Terminator



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Coaxial cable performance



- Coaxial cable attenuation > UTP attenuation

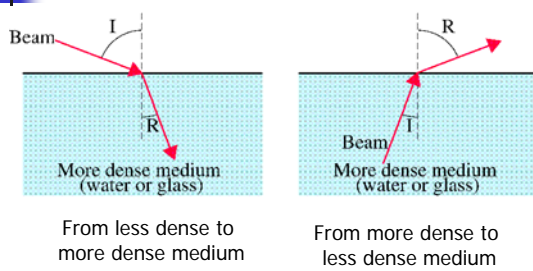
19

Optical Fiber

- Nature of light
 - In vacuum, 3×10^8 m/s
 - Higher density, slower speed
 - Refraction
 - Reflection

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Refraction

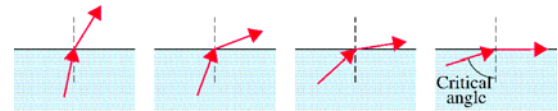


From less dense to more dense medium

From more dense to less dense medium

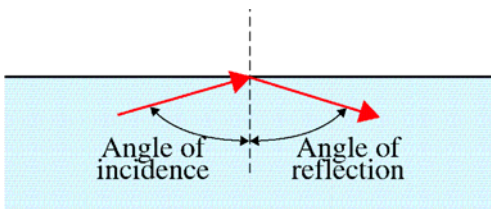
21

Critical Angle

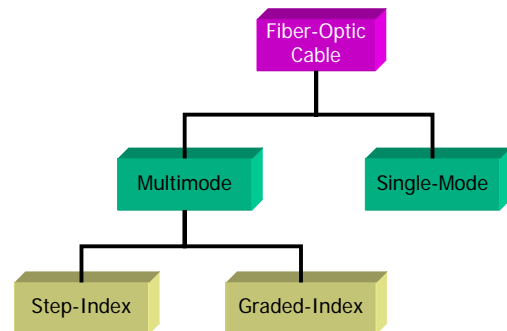


22

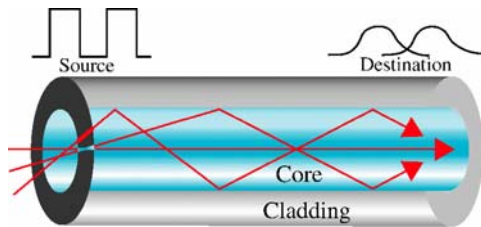
Reflection



23

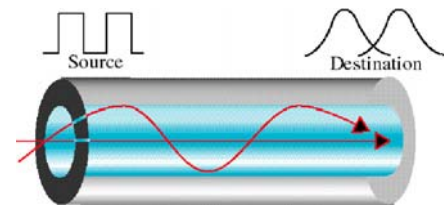


Multimode Step-Index



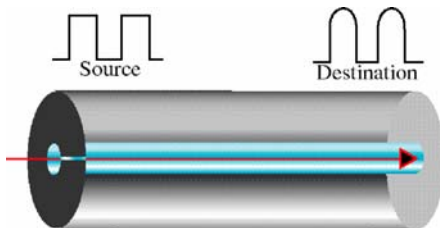
25

Multimode Graded-Index



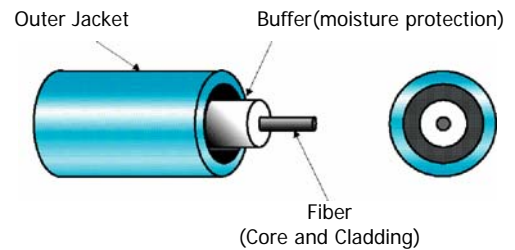
26

Single Mode



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Fiber Cable



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Light source

- Sending device called “light source”
- Receiving device called “photosensitive cell” (photodiode)
- Light source
 - Light-emitting diode (LED)
 - Cheap but unfocused
 - Short distance
 - Injection Laser diode (ILD)
 - Expensive but focused
 - Preserve the signal (long distance)

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Fiber connector

- Size
- Alignment
- Not overly tight (causes changing of reflection angle)
- Barrel shaped connector

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Fiber adv./disadvantages

- Advantages
 - Noise resistance
 - Less signal attenuation
 - Higher bandwidth
- Disadvantages
 - Cost
 - Installation and maintenance
 - Fragility

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LAN (Ethernet cabling)

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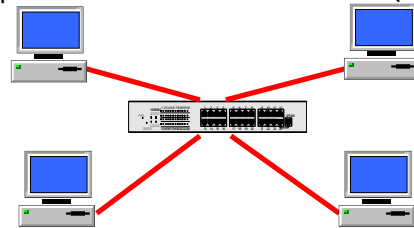
Dominated LAN Architectures

- Ethernet
 - Star
 - Bus
- Token ring
- Token Bus
- FDDI

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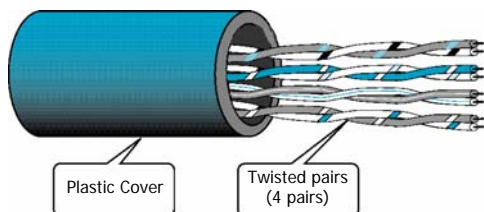
Star Topology

- Each device has a dedicated point-to-point link to a central controller (Hub)



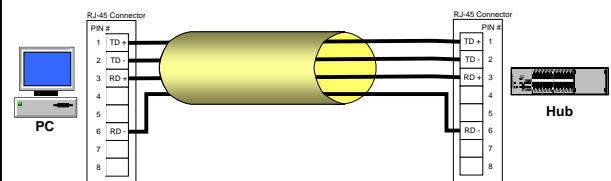
34

Unshielded Twisted Pair Cable

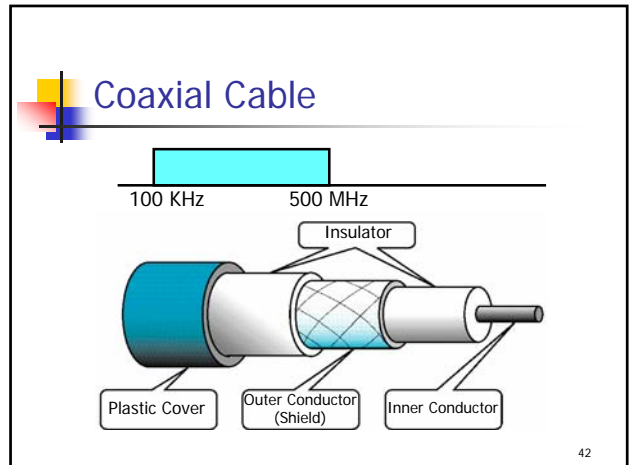
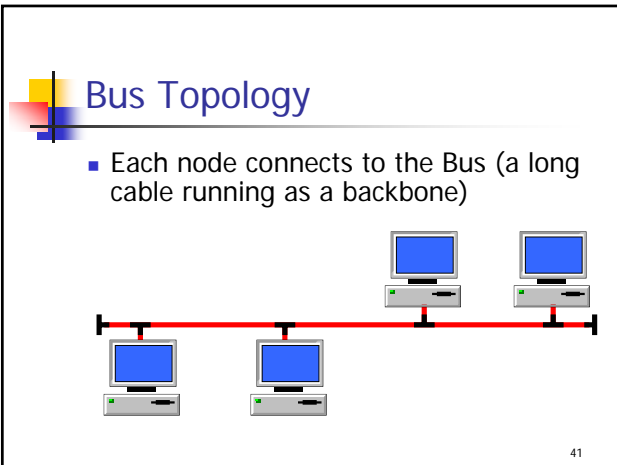
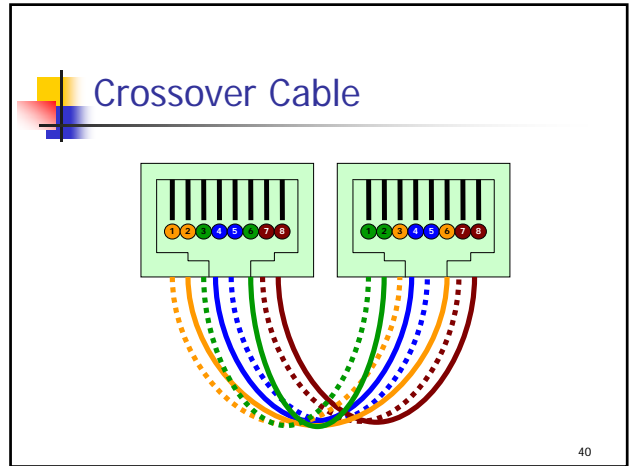
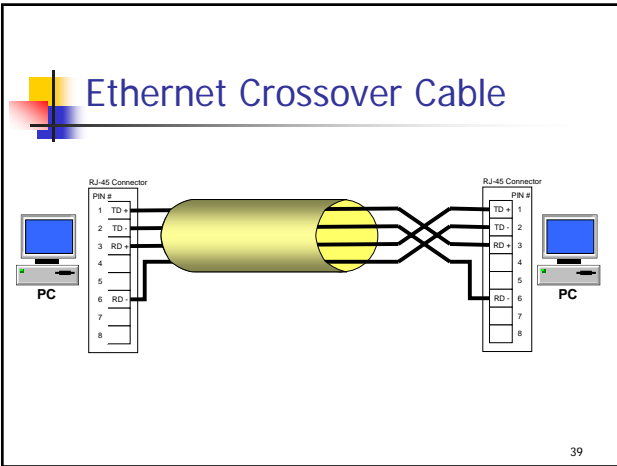
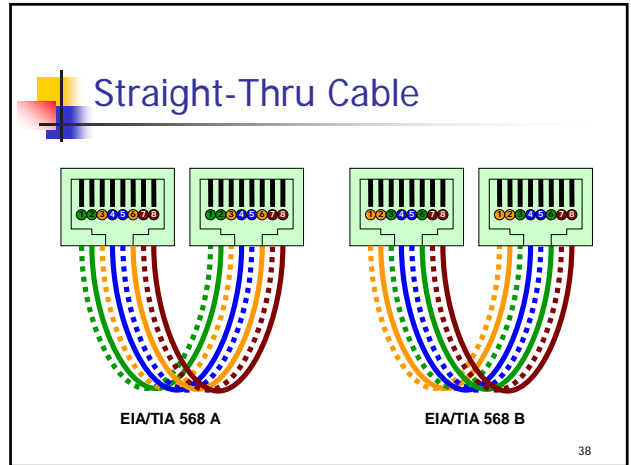
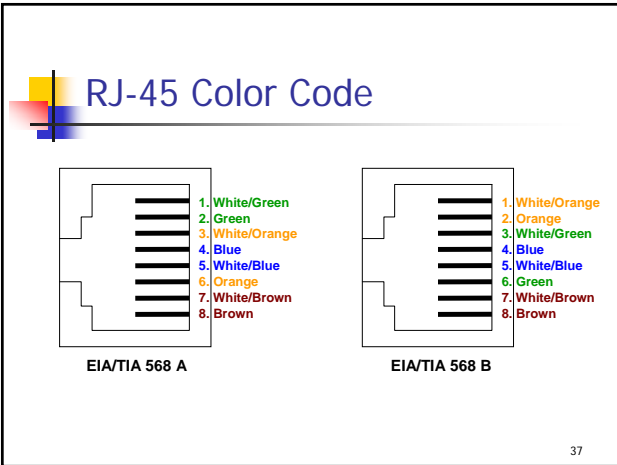


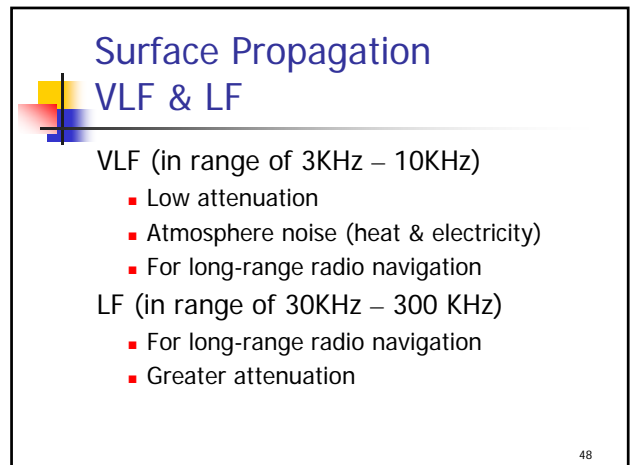
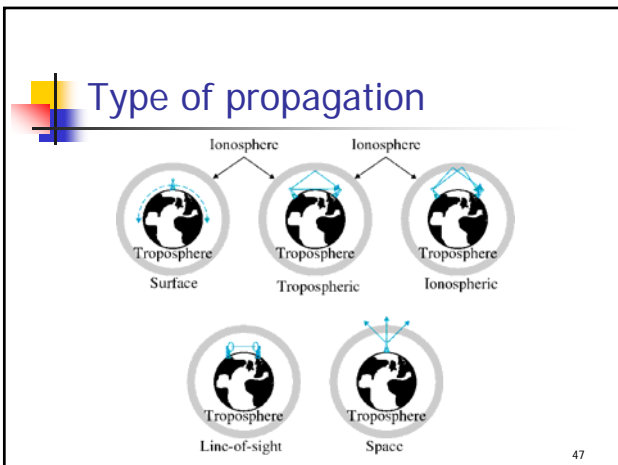
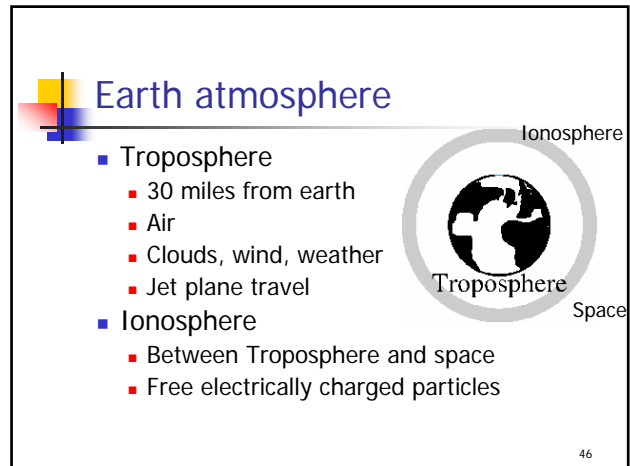
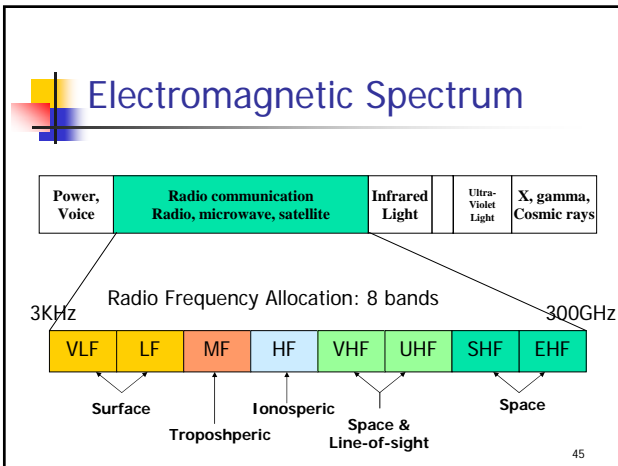
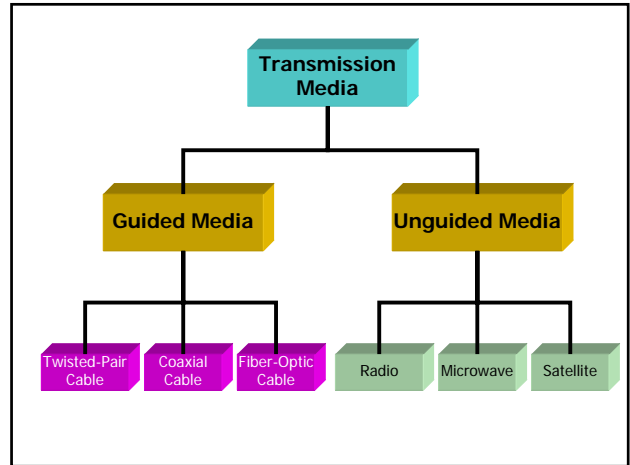
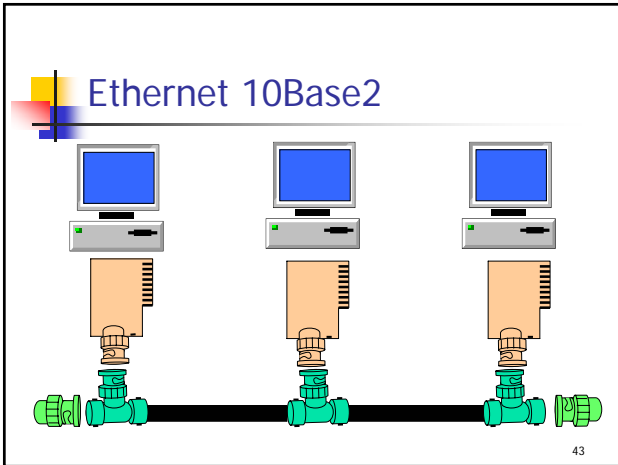
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Ethernet Straight-Thru Cable



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Troposphere Propagation

MF

MF (300KHz – 3MHz)

- Distance is limited by reflected angle
- Rely on line-of-sight antennas
- AM radio (535 KHz – 1605 MHz)

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Ionosphere Propagation

HF

HF (3 MHz – 30 MHz)

- Amateur radio (Ham radio)
- Citizen's band (CB)
- International Broadcasting

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Light-of-sight Propagation

VHF & UHF

VHF (30 MHz – 300 MHz)

- VHF television
- FM radio

UHF (300 MHz – 3 GHz)

- UHF television
- Mobile telephone
- Cellular
- Microwave communication

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Space Propagation

SHF & EHF

SHF (3 GHz – 30 GHz)

- Mostly light-of-sight & space
- Terrestrial & satellite microwave
- Radar communication

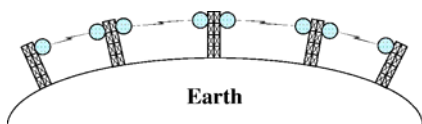
EHF (30 GHz – 300 GHz)

- Radar
- Satellite

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Terrestrial Microwave

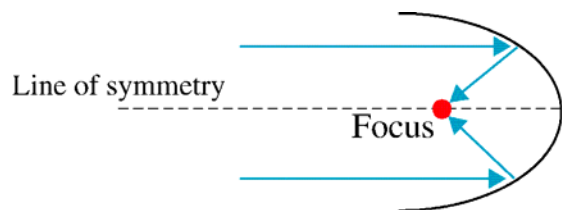
- Need light-of-sight (Do not follow the earth)
- The Taller the antennas, the longer the distance
- Propagate in one direction at a time (2 frequencies for 2-way communication)



53

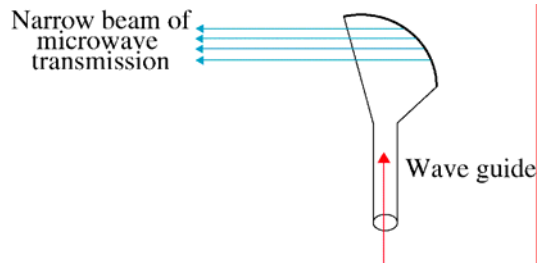
Parabolic dish antenna

(Receiver)



54

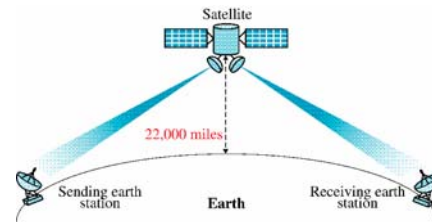
Horn antenna (Transmitter)



55

Satellite Communication

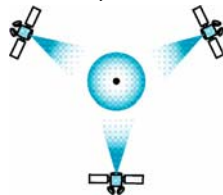
- Like microwave
- Supertall antenna & repeater



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Geosynchronous Satellites

- Stationary antenna
- Satellite moves same speed as earth
- Only one orbit (22,000 miles)



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Frequency Bands for Satellite Communication

- GHz
- 2 different bands
- From the earth → satellite : Uplink
- From satellite → the earth : Downlink

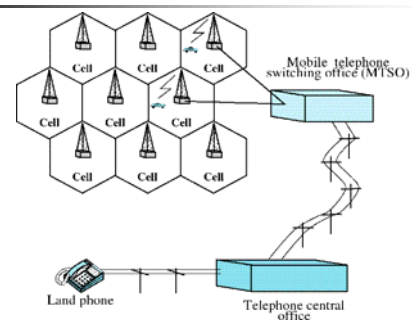
58

Cellular Telephony

- For 2 moving devices / a station
- Be able to locate and track
- Service area is divided into cells
 - Cell office
 - Mobile telephone switching office
- Cell size can be adjusted (by power)

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Cellular system



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Mobile phone places a call

- Key the number and send
- Scan the bands select strong signal channel
- Send phone number to Cell Office
- Cell office relays phone number to MTSO
- MTSO → telephone central office
- If called party available, make connection → MTSO
- MTSO assigns unused channel
- Mobile tuning to the assigned channel

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Land phone places a call

- Telephone central office → MTSO
- MTSO searches for mobile location (call paging)
- If found, MTSO → send ringing
- Assign a voice channel

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Handoff

- Mobile phone moves to another cell
- MTSO monitor signal strength every few seconds
- If low, MTSO seeks for new cell
- MTSO hand the signal to new one
- Transparent to user

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Transmission Impairment

- Attenuation
- Distortion
- Noise

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Attenuation



- Loss of energy
- Decibel (dB) – relative strength
 - $\text{dB} = 10 \log_{10} (P_1/P_2)$
 - Negative value : attenuate
 - Positive value : amplified
- Why dB?
 - dB can added for cascading system

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Distortion



- Signal changes its shape
- Occur in composite signal (different Frequency)
- Each signal component has different propagation delay

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Noise

- Thermal noise (motor, appliances)
 - Random motion of electron in a wire
- Crosstalk
 - Effect of one wire on the other
- Impulse
 - Spike, lightning

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Transmission line performance

- Throughput
 - How fast data can pass (bps)
- Propagation speed
 - The distance a bit can travel in one sec.
 - Ex., light propagation = 3×10^8 m/s (same as twisted-pair)
 - Coaxial cable = 2×10^8 m/s (for MHz to GHz)
- Propagation time
 - Time for a bit to travel = distance / propagation speed (micro sec / km)

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Wavelength

- Depends on both frequency and the medium
- Transmission of light in an optical fiber
- Wavelength = a distance for a signal can travel in one period
- Wavelength = propagation speed * Period
- Wavelength in air > in coaxial cable (or fiber)

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Shannon's Formula

- $C = B \log_2 (1 + S/N)$
- For telephone line
 - BW = 3000
 - S/N = 35 dB (3126)
- So, max. data rate,
 $C = 3000 * \log_2(3127) = 34.8$ Kbps

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Media comparison

- Cost (mat. + install)
- Speed
- Attenuation
- Electromagnetic interference (EMI) :
static(audio) or snow(visual)
- Security (eavesdropping)

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