

# Physical Layer: Components

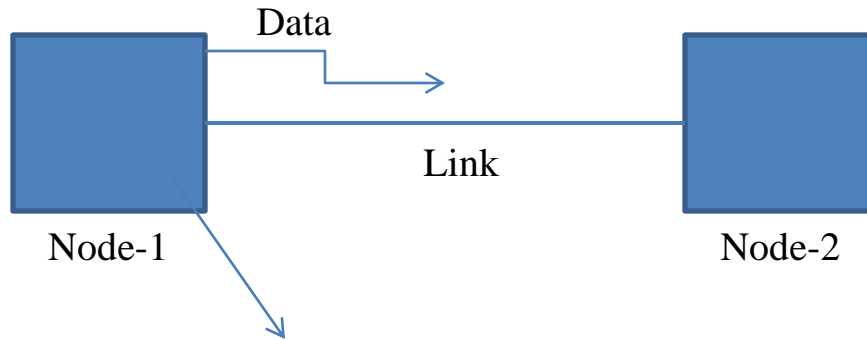
Kameswari Chebrolu

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# Physical Layer

- Bit-by-bit delivery



Nodes: **Hosts, Routers or Switches**

Hosts: General Purpose computers some part implemented in software, some hardware

Routers/Switches: **Specialized hardware (for performance reasons)** but here most is in hardware, for performance

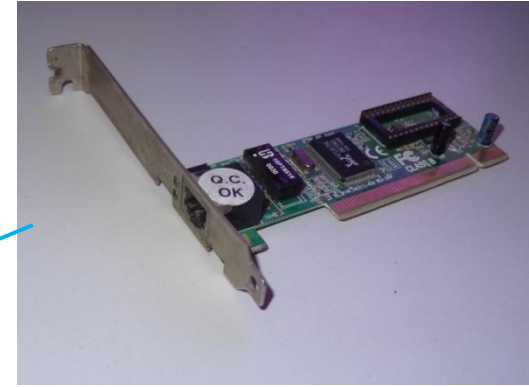
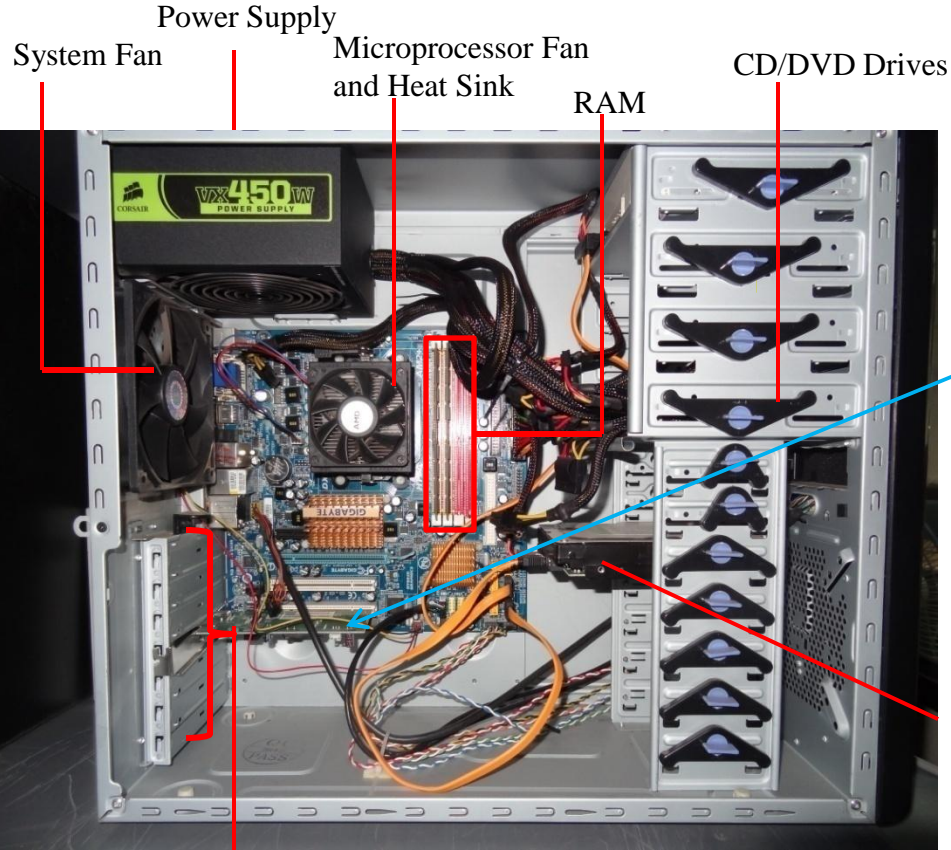
# Bit by Bit Delivery

- Components node, link
- Theory
- Modulation
- Line Codes

# Components: Outline

- Host Internals
- Link Characteristics
- Types of Links

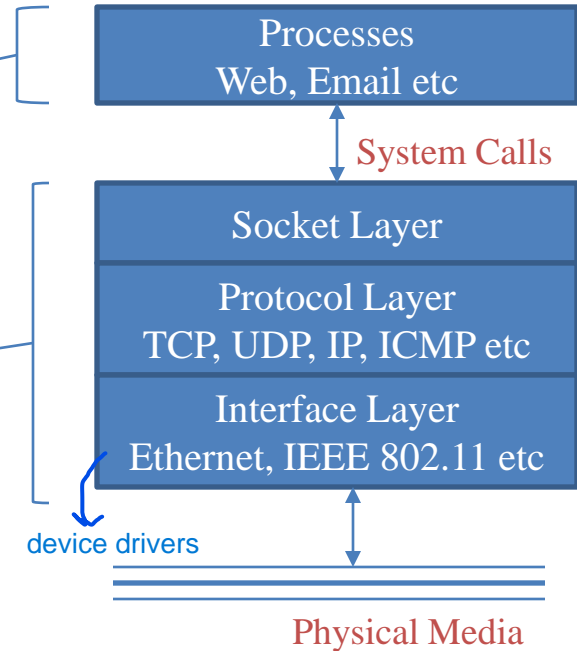
# Inside Computer



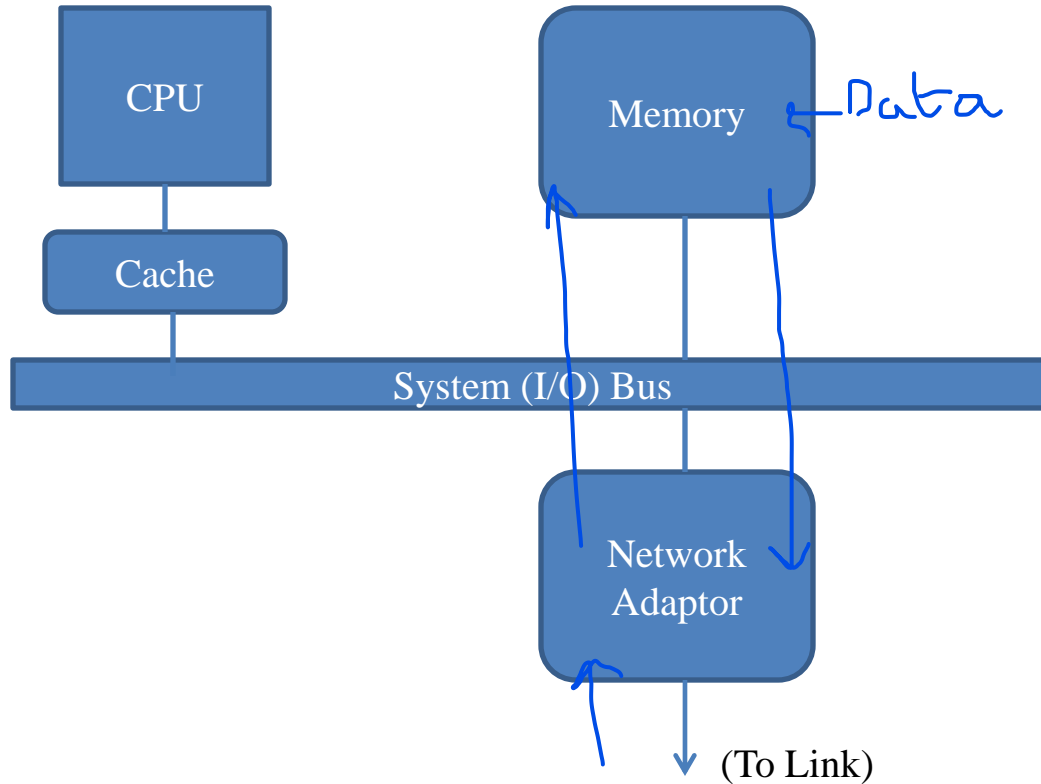
Hard Drive

# Network Code Organization

- Most applications implemented as **user space** processes.
- Protocols are implemented in the **system kernel**.
  - Socket Layer interface b/w application process, protocol.
  - Protocol Layer
  - Interface Layer



# Architecture



# Data Transfer

- Digital Data (bits: 1's and 0's)
- Direct Memory Access (DMA) faster
  - Adaptor directly reads/writes host memory
- Programmed I/O (PIO)
  - CPU responsible for moving data between adaptor and memory



# Links

- Examples: Twisted Pair, Co-axial cable, Wireless  
ethernet cable tv phone
- Physical medium that propagates signals (electromagnetic waves)
- Wave: speed, frequency, wavelength

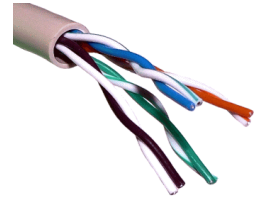
$$c = f * \lambda$$

(c is speed of light in the medium, ranges from  $2*10^8$  to  $3*10^8$  m/s)

# Imperfect Physical Media

- Signal often made up of multiple frequency components
- **Attenuation:** Loss of energy over distance (expressed in dB/km)
  - Different frequencies experience different amount of loss
  - Often some frequencies are fully cutoff leading to link bandwidth
- **Delay Distortion:** Different frequencies propagate at different speeds
- **Noise:** Unwanted energy from other sources
  - **Thermal Noise** due to random motion of electrons
  - **Crosstalk:** Interference from adjacent transmissions

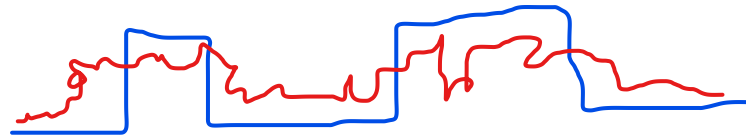
range of freq that suffer little  
attenuation



End Result: Received Signal is distorted

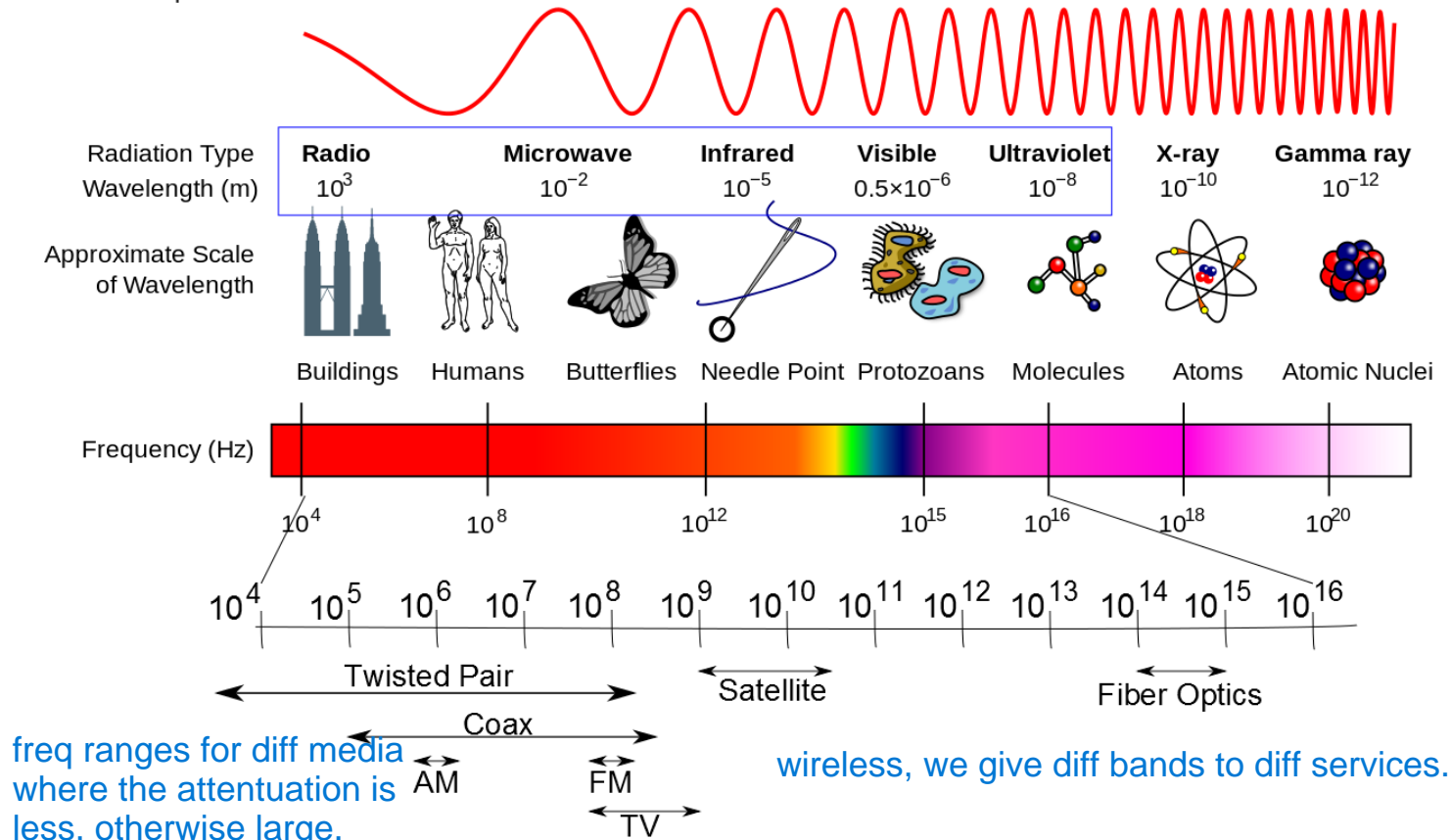
# Decibels

- Ratio between two power quantities expressed in logarithmic scale
  - $10\log_{10} (P1/P2)$
- Example: 3dB/100m attenuation means  $P2 = P1/2$  i.e. power reduced by half after 100m



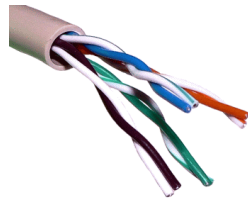
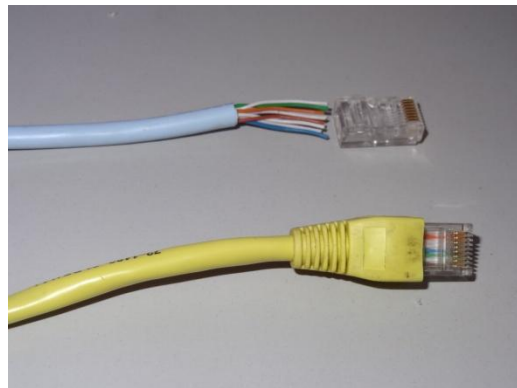
distortion, sent vs recieved

# Electromagnetic Spectrum



# Twisted Pair

- Usage: Ethernet, Telephone Lines
- Different categories: depend on twists/cm
  - Band.Width Attenuation
  - Cat 3: 16Mhz, 3-15dB/100m
  - Cat 5: 100Mhz, 2-24dB/100m
  - Cat 6: 250Mhz, 2-32dB/100mranges bcz of diff freq/. loss prop to freq.
- Typical distances under 100m
- Data rates between 10Mbps-1Gbps



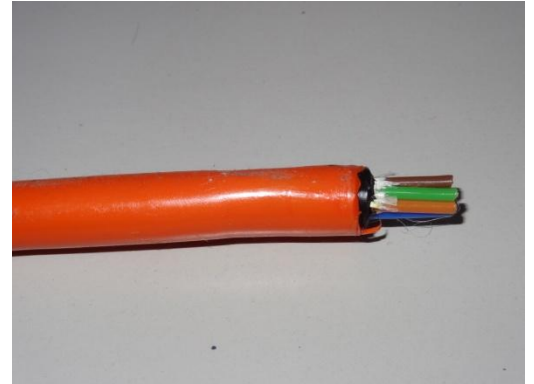
# Coaxial Cable

- Usage: Cable TV
- Provides up to 1Ghz bandwidth
- Attenuation: 1-45dB/100m (for a given frequency its lower than twisted pair)
- Typical distances under 500m
- Data rates between 10-100Mbps



# Fiber Optics

- Usage: Long Haul Transmission (Internet Backbone)
- Supports terahz  $(100 \text{ to } 300) * 10^{12} \text{Hz}$
- Attenuation is 0.2dB/km
- Typical distances: tens of kms
- Data rates: 100 to 10Gpbs



# Wireless

- Usage: TV, Satellite, Cellular, WiFi, WiMax
- Spectrum ranges from Khz to few hundred Ghz
  - Actual allocated spectrum varies with technology
  - E.g. Max channel bandwidth for WiFi: 40Mhz, LTE(cellular): 20Mhz, WiMax: 20Mhz
- Attenuation (free-space):  $32.45 + 20\log(d) + 20\log(f)$  **dB** (where d is in km and f is in MHz)
  - E.g: At 1km and 100Mhz, loss:74dB; at 1Ghz, loss: 94dB
- Typical distances: few meters to few kms
- Data rates: few kbps to hundreds of Mbps





# Types of Links

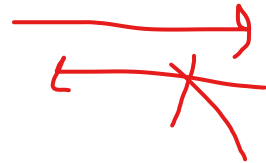
- Full-duplex: Support data flow in either direction

2 pairs of wires



- Half-duplex: Support data flow in only one direction at a time (e.g. walkie-talkie)

- Simplex: Support permanent uni-direction communication (e.g. one way street)



# Summary

- Looked inside a computer (node)
  - Hardware, network code organization and data transfer mechanisms
- Studied about links (which carry electromagnetic waves)
  - Imperfections, spectrum (bandwidth of links), types of links
- Going Ahead: Data to signal transformation