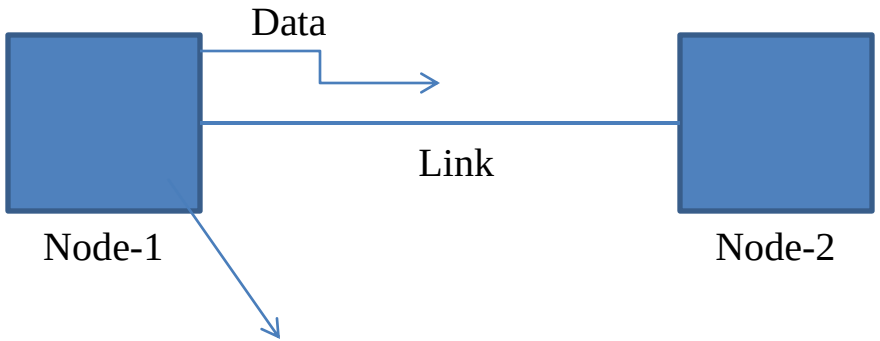
Physical Layer: Components

Kameswari Chebrolu

Physical Layer

- Bit-by-bit delivery



Nodes: Hosts, Routers or Switches
Hosts: General Purpose computers
Routers/Switches: Specialized hardware (for performance reasons)

Bit by Bit Delivery

- Components
- Theory
- Data Transformation
- Encoding

Components: Outline

- Host Internals
- Link Characteristics
- Types of Links

Inside Computer

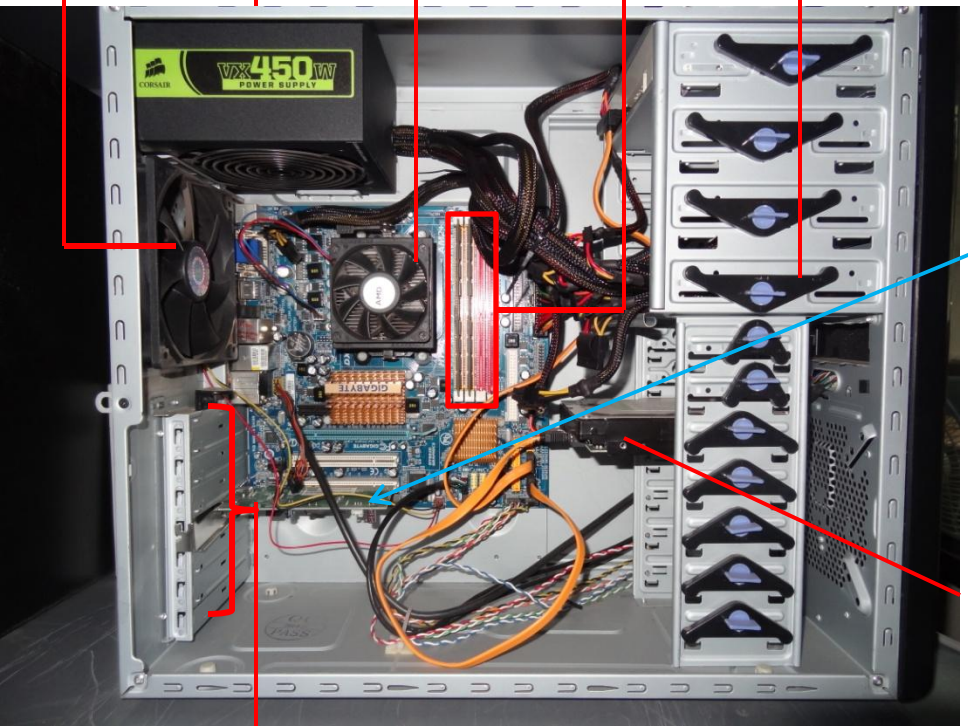
Power Supply

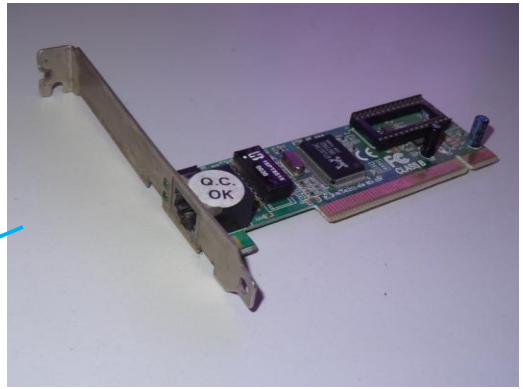
System Fan

Microprocessor Fan and Heat Sink

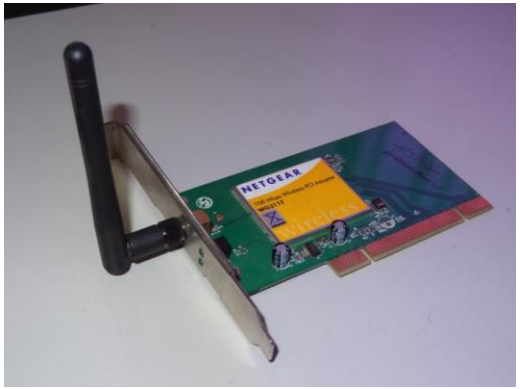
RAM

CD/DVD Drives





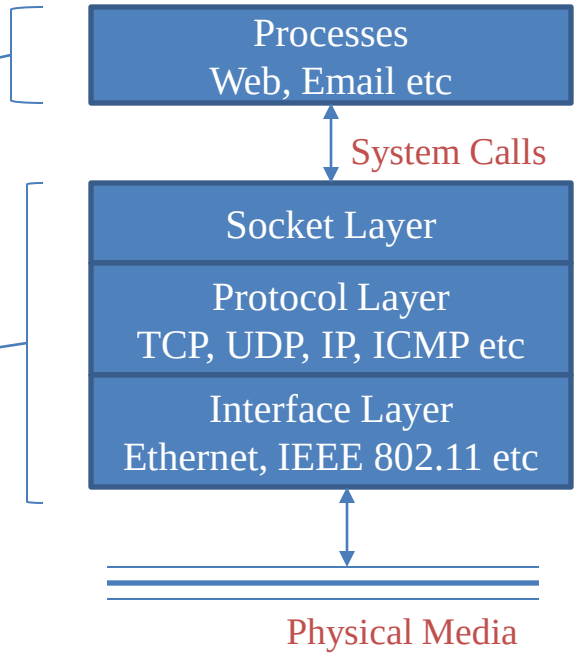
Hard Drive



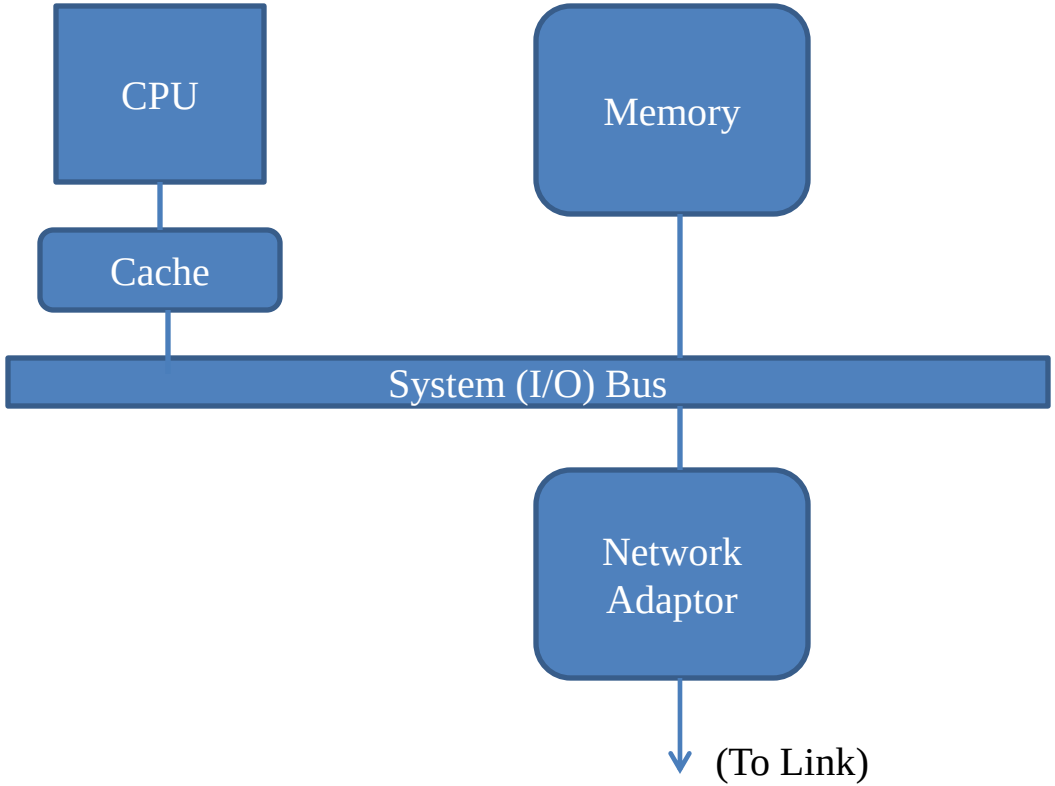
Expansion Slots (network adaptor, graphics card etc)

Network Code Organization

- Most applications implemented as user space processes.
- Protocols are implemented in the system kernel.
  - Socket Layer
  - Protocol Layer
  - Interface Layer



Architecture



Data Transfer

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

Links

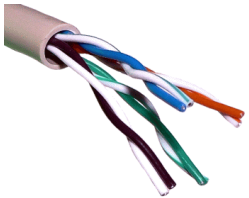
- Examples: Twisted Pair, Co-axial cable, Wireless
- Physical medium that propagates signals (electromagnetic waves)
- Wave: speed, frequency, wavelength

$$c = f * \lambda$$

(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

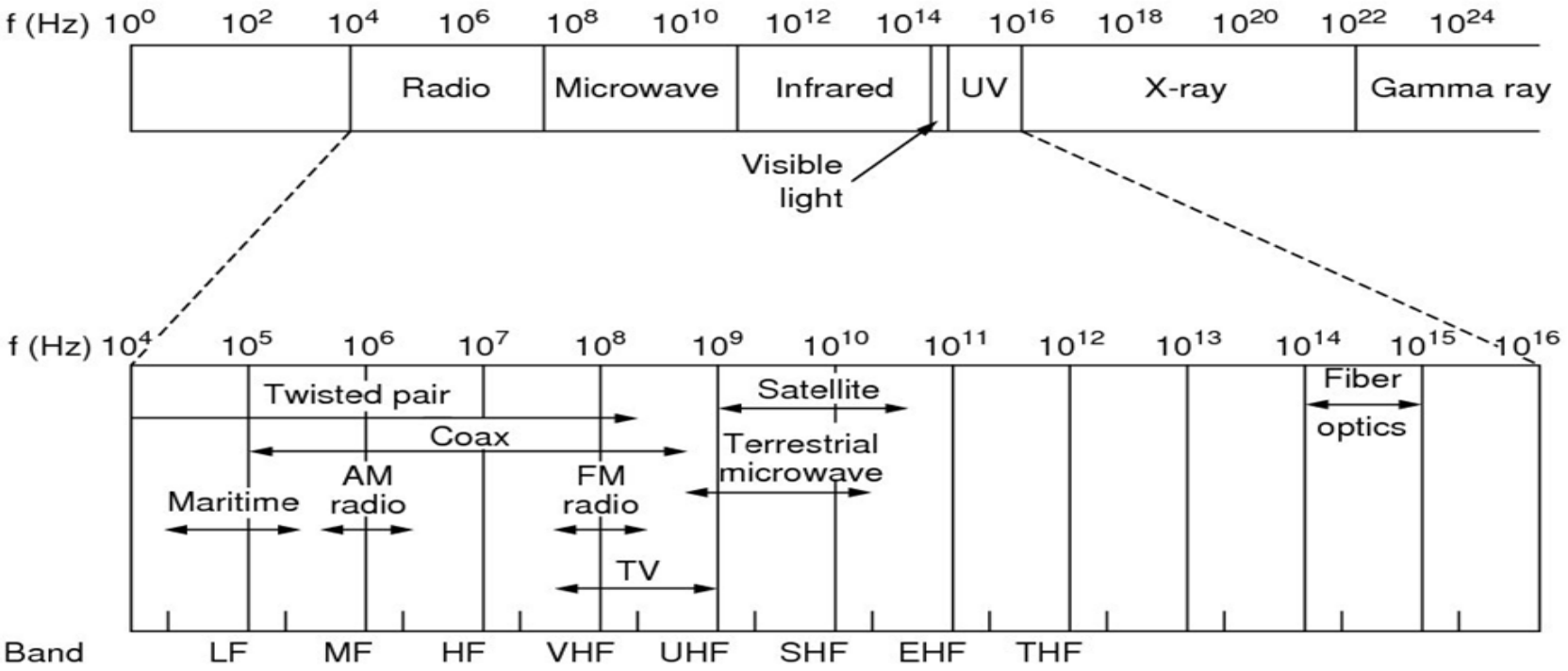


End Result: Received Signal is distorted

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

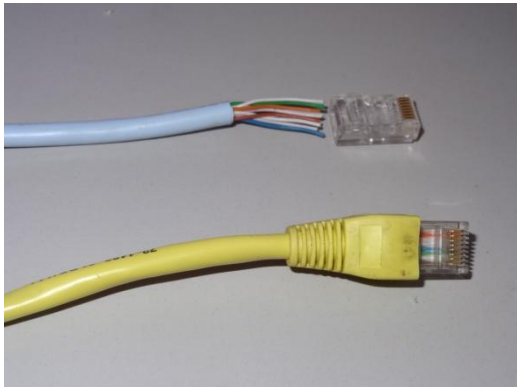
Electromagnetic Spectrum

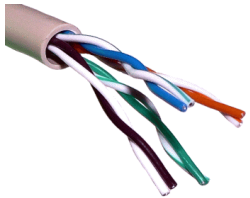


Picture Source: Computer Networks by Andrew S. Tanenbaum

Twisted Pair

- Usage: Ethernet, Telephone Lines
- Different categories:
  - Cat 3: 16Mhz, 3-15dB/100m
  - Cat 5: 100Mhz, 2-24dB/100m
  - Cat 6: 250Mhz, 2-32dB/100m
- 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

Fig from made-in-china.com

Fiber Optics

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

Fig from made-in-china.com

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 + 20log(d) + 20log(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
- 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