ECE-C357 Lecture 1.2

Ch 1 : Physical Layer (Media)

Units

- In the study of computer networks, one comes across very large units (frequency, bit rate, download size, clock frequency, CPU speed etc) as well as very small units (time, wavelength etc)
- Large Units:
  - Kilo (K) $X10^{3}$
  - Mega (M) $X10^{6}$
  - Giga (G) $X\ 10^{9}$
  - Tera (T) $X\ 10^{12}$
  - Peta (P) $X\ 10^{15}$
  - Exa (E) $X\ 10^{18}$

Units (Contd)

- Caution:

  Memory and disk capacities as well as file size is measured in Bytes (B) = 8 bits (b)

  However,

  1 KB = 2^{10} or 1024 B

  1 MB = 2^{10} KB = 2^{20} B

  1 GB = 2^{10} MB = 2^{30} B and so on

  Whereas,

  1 Kb = 1000 b

  1 Mb = 1000 Kb and so on

Units (Contd)

- Small Units:

  milli (m) $X\ 10^{-3}$

  micro (μ) $X\ 10^{-6}$

  nano (n) $X\ 10^{-9}$

  pico (p) $X\ 10^{-12}$

  femto (f) $X\ 10^{-15}$

Physical Media

- Guided media (“wired” media)
  - Twisted pair copper wire (e.g. DSL)
  - Coaxial cable (e.g. TV Broadband)
  - Fiber optic cable (e.g. FIOS)
- Unguided media (“wireless” media)
  - Terrestrial radio / microwave

    (e.g.: microwave links, wireless standards like 802.11(WiFi),2G,3G,4G, Blue Tooth etc)
  - Satellite microwave (e.g. Satphones)

General Characteristics of Physical Media

- Velocity of Propagation

  $v = c/\sqrt{\varepsilon}$

  where ε is the dielectric constant of the medium (>1) and c is the velocity of light in free space = 3*10^8 meters/sec

  Typical velocities are:

  Copper 2.3*10^8 m/sec

  Optical Fiber 2*10^8 m/sec

General Characteristics of Media (Contd)

- Bit Rate (Digital Bandwidth)

  It is the maximum no of bits per second that can be transmitted on the link

  It is limited by the analog bandwidth in Hz, distance, distortion, attenuation and noise over the link

  Varies widely from Kilobits per second (Kbps) to Gigabits per second (Gbps)

- Error Rate

  It is the rate at which errors are introduced in the transmitted signal when it traverses the link

  varies between 1 in 10^ 5 to 1 in 10^14

Copper Media

- Telephone Cables:

  -CAT 3 Unshielded Twisted Pair (CAT 3 UTP) – lower bandwidth (10 Mbps)

  -CAT 5 UTP – higher bandwidth (100 Mbps)

- Coaxial Cables:
  - “10 Base 5” 0.4 in dia 500m segments
  - “10 Base 2” 0.2 in dia 200 m segments

Fiber Optic Media

- “Multimode” - less expensive
- “Monomode” – more expensive
- “Graded Index”

- Light carried is in the IR region
- Wavelengths used – 850 nm , 1300 nm 1550 nm
- Light Source – LED or Laser

Wireless Media

- Relationship between frequency(f) and wavelength(λ) is

$$v = f \lambda$$

  v being the velocity of light in the medium
- Commonly used velocities:

  Vacuum/Air 3×10^8 meters/sec

  Copper cable 2.3×10^8 meters/sec

  Fiber optic cable 2×10^8 meters/sec

Wireless Media (Contd)

- Electromagnetic spectrum is divided into ranges based on frequencies
- MF 300 KHz - 3 MHz (AM Radio)
- HF 3 MHz – 30 MHz (SW Radio)
- VHF 30 MHz – 300 MHz (FM Radio,TV)
- UHF 300 MHz – 3 GHz (TV, Cell Phones, Wireless LAN,Blue Tooth, GPS)
- SHF 3 GHz – 30 Ghz (Wireless LAN, Satellites)
- EHF 30 GHz – 300 GHz (Radio Astronomy)

Wireless Media (Contd)

- Nomenclature for bands (Letter Bands)
  - P Band (250 – 500 MHz)
  - L Band 1-2 GHz
  - S Band 2-4 Ghz (TV Broadcast satellites)
  - C Band 4-8 GHz (Communication satellites)
  - X Band 8-12 Ghz (Military)
  - K_u Band 12-18 GHz (TV satellites)
  - K Band 18 – 27 Ghz
  - K_a Band 27-40 GHz
  - V band (40 – 75 Ghz)
  - W band (75-110 GHz)

Wireless Media

- Terrestrial Microwave – frequency around 2 GHz – needs repeater stations

- Satellite Microwave – uses higher frequencies like S, C, Ku and Ka bands – covers a much larger region and has broadcast property

Comparison of Physical Media

- The criteria for comparison are the following:

  a. Velocity of Propagation
  b. Bit Rate
  c. Error rate
  d. Electromagnetic Interference (EMI)
  e. Broadband vs Baseband
  f. Cost (both initial and maintenance)
  g. Speed of deployment
  h. Ease of maintenance
  i. Broadcast property

Comparison of 3 types of Mainstream Media

- Copper – least expensive, offers moderate bandwidth over medium distances, susceptible to noise and interference
- Fiber – Highest bandwidth , needs repeater stations every few miles, offers immunity from noise, interference etc
- Satellite – offers large geographic spread and broadcast capability at medium bit rates

Network Access

- Residential access
  - Dial-up
  - Digital Subscriber Line (DSL)
  - Hybrid Fiber Coaxial (HFC) Cable
- Commercial access
  - Through Local Area Networks (LAN)
- Mobile access
  - Wireless LANs (Wifi)
  - Wide area wireless networks (3G/4G/LTE)