CSE 461 26wi Section 2 – Physical Layer

Latency, Bandwidth & Theoretical Limits

Terms	Description
Latency	Total time for a message to arrive on a network. = Propagation + Transmit + Queue
Round Trip Time (RTT)	Latency for travel from source to destination to source
Propagation	How long it takes for information to travel a distance from source to destination (varies by medium). = Distance / "Speed of Light"
Transmit	How long it takes for information to be put onto the wire before travelling. = Size / Bandwidth
Queue Time	How long data must wait until it's their turn to be transmitted
Bandwidth (Data Rate)	The number of bits that can be transmitted over a period of time
Throughput	The measured performance of a system
Nyquist Limit	Maximum bit rate $R = 2B$ bits/sec (binary) or $R = 2B \log_2 V$ bits/sec (multi-level)
Shannon Capacity	Maximum lossless information carrying rate of a channel $C = Blog_2(1 + \frac{S}{N})$ bits/sec

Exercises

1) Suppose we have a network link with a **bandwidth of 10 Mbps**. We want to send a **100 KB file** to a friend somewhere else in the network. The RTT from us to our friend is **20 ms**. How long does it take for the entire file to be delivered?

2) Consider a point to point link **50 km in length**. Suppose the **propagation speed is 2 * 10^8 m/s**. At what bandwidth in Mbps would the propagation delay equal the transmit delay for **100 B packets**? What about for 512 byte packets?

3) Suppose you (S) are sending a packet of size M = 150 KB to a host (D). There are N = 8 routers connected between S and D**.** Given that the bandwidth of each router = 4Mbps and the propagation delay between routers = 50ms, **what is the total time required for the packet to arrive at D?**

4) Suppose a **128-kbps** point-to-point link is set up between Earth and a SpaceX colony on Mars. The distance from Earth to Mars (at their closest) is approximately **55 Gm**, and data travels over the link at the speed of light **(3 * 10^8 m/s)**

   a) Calculate the minimum RTT for the link.

   b) Calculate the delay x bandwidth product for the link.

   c) Say your aunt Betty takes a selfie on Olympus Mons, and sends a 5 MB picture to you on Earth. How quickly after the picture is taken can you receive the image from Betty?

5) Read the following statements, and state whether they are TRUE or FALSE

   a) The protocol stack of the Internet has an hourglass shape with a “narrow waist”. At the waist is the transport layer.
   b) Packets traverse from the “topmost” layers to the “bottom-most” layers at the transmitter.
   c) Alice has a noise-free channel and can transmit a single-tone to Bob. Since she can send only a single tone, i.e. Bandwidth = 0, her Shannon capacity is also zero
   d) The Internet mandates that if Apple Inc. makes the physical and datalink layer, Apple must implement the corresponding network layer as well.
   e) If we inspect at a packet inside a wire, the PHY header will be the outermost header.

6) Find the Shannon channel capacity for a Wi-Fi channel with W_c = 80 MHz and SNR = 40 dB.