Assignment 1: Network Overview

1. (2 points) How long does it take a packet of length 2000 bytes to be sent over a link of distance 2500 km, propagation speed 2.5x10^8 m/s, and transmission rate 4 Mbps? More generally, how long does it take a packet of length L to be sent over a link of distance d, propagation speed s, and transmission rate R bps?

   (**Note:** Consider the total of the propagation delay d_{prop} and the transmission delay d_{trans}.)

2. (2 points) Suppose end system A wants to send a large file to end system B. The path from host A to Host B has three links, of rates R_1=1 Mbps, R_2=2 Mbps, and R_3=2.5 Mbps.

   a. Assuming no further traffic in the network, what is the throughput for the file transfer?

   b. Suppose the file is 10 MB. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?

   c. Repeat (a) and (b), but now with R_1 reduced to 500 kbps.

3. (2 points) Equation 1.1 gives a formula for the end-to-end delay of sending ***one packet*** of length *L* over *N* links of transmission rate *R*. Generalize this formula for sending *P* such packets back-to-back over the *N* links.

4. (4 points) This elementary problem begins to explore the propagation delay and transmission delay, two central concepts in data networking. Consider 2 hosts, A and B, connected by a ***single link*** of *R* bps. Suppose that the two hosts are separated by *m* meters, and suppose the propagation speed along the link is *s* meters/sec. Host A is to send ***a packet*** of size *L* bits to host B.

   a. Express the propagation delay, d_{prop}, in terms of *m* and *s*.

   b. Determine the transmission time of the packet, d_{trans}, in terms of *L* and *R*.

   c. Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.

   d. Suppose host A begins to transmit the packet at time *t* = 0. At time *t* = d_{trans}, where is the last bit of the packet?

   e. Suppose that d_{prop} is greater than d_{trans}. At time t = d_{trans}, where is first bit of the packet?

   f. Suppose d_{prop} is less than d_{trans}. At time t = d_{trans}, where is the first bit of the packet?

   g. Suppose *s* = 2.5 x 10^8 m/s, *L* = 1.5 KB and *R* = 4 Mbps. Find the distance *m* so that d_{prop} equals d_{trans}.

Appendix

Table of Units for Data Size.

Unit	Abbreviation	Value
kilobyte	KB	10^3 bytes
megabyte	MB	10^6 bytes
gigabyte	GB	10^9 bytes
terabyte	TB	10^{12} bytes

Table of Units for Data Rate.

Unit	Abbreviation	Value
kilobits/s	kbps, kbit/s	10^3 bits/s
megabits/s	Mbps, Mbit/s	10^6 bits/s
gigabits/s	Gbps, Gbit/s	10^9 bits/s