# Assignment 1: Network Overview[1]

<u>Please submit your answers with the title page in a single PDF file.</u>

1. (2 points) What are the five layers in the Internet protocol stack? Which layers does a router process?

2. (2 points) How long does it take a packet of length 2300 bytes to be sent over a link of distance 2500 km, propagation speed 2.5×10^8 m/s, and transmission rate 100 Mbps? Consider the total of the propagation delay d_{prop} and the transmission delay d_{trans}. 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?

3. (3 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=10 Mbps, R_2=25 Mbps, and R_3=20 Mbps.

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

    b. Suppose the file is 200 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 5 Mbps.

4. (4 points) Assume processing delay and propagation delay are very small and negligible. An end-to-end path in the following figure are *only* used by a pair of hosts A and B. Suppose A is sending 100 packets to B over this path. Each packet contains 2000 bytes. Suppose the data rate of each link is R = 100 Mbps. Calculate the total **end-to-end delay** (d_{e2e}) for sending all the packets from Host A to Host B.
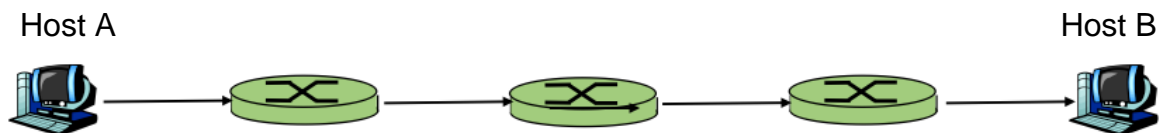
5. (4 points) Consider 2 hosts, A and B, connected by a ***single link*** of R bps. Suppose that the two hosts are separated by m meters, and the propagation speed along the link is s meters/sec. Host A is sending a number of packets ***sequentially*** to Host B. Each packet contains L bits. Consider only the transmission delay d_{trans} and the propagation delay d_{prop}.

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a. Suppose host A begins to transmit the first packet at time $t = 0$. At time $t = d_{trans}$, where is the last bit of the packet: still at host A (including just sent out); in the middle of the link between A and B; or have arrived at host B?

b. Suppose that d_{prop} is greater than d_{trans}. At time $t = d_{trans}$, where is first bit of the first packet: still at host A (including just sent out); in the middle of the link between A and B; or have arrived at host B?

c. Suppose $s = 2.5 \times 10^8$ m/s, $m = 500$ meters, $L = 2$ kB, and $R = 10$ Mbps. When will the first bit of the second packet arrive at Host B? (Hint: Host A only begins to send the second packet after the first packet has been transmitted onto the link.)

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