# CS 428/528
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## Homework 1: Introduction to Networking

**Problem 1 (50 points)**

This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking. Consider two hosts, A and B, connected by a single link of rate 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, dprop, in terms of m and s.

**Answer)** d_prop = m/s

b. Determine the transmission time of the packet, dtrans, in terms of L and R.

**Answer)** d_trans = L/R

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

**Answer)** d_nodal = d_prop + d_trans = m/s + L/R

d. Suppose Host A begins to transmit the packet at time t=0. At time t=dtrans, where is the last bit of the packet?

**Answer)** The last bit will just have started to propagate to host B. It will just have been transmitted onto the wire

e. Suppose dprop is greater than dtrans. At time t=dtrans, where is the first bit of the packet?

**Answer)** The first bit will be on the wire being sent to host B but will not have arrived yet

f. Suppose dprop is less than dtrans. At time t = dtrans, where is the first bit of the packet?

**Answer)** The first bit will have already arrived at host B.

g. Suppose $s = 2.5 \cdot 108$, L = 120 bits, and R = 56 kbps. Find the distance m so that dprop equals dtrans.

**Answer)** m = (0.12*(2.5*10^8))/56 = 535714m

**Problem 2 (50 points)**

Consider the network scenario in the figure below. K sources are connected to the Internet via links of capacity RS, and within the network fairly share a common link of capacity R, to K destinations. Each destination is connected to the network by a link of capacity RD. You can assume that there are no other links or source-destination pairs in the network. Suppose that source Si has an infinitely large file it wants to send to destination Di (i.e., each sources sends to a different destination).

a) Suppose that K=10, RS = 100 Mbps, RD= 54 Mbps, and R = 50 Gbps. What is the throughput between each source-destination pair? Where are the bottleneck links?

**Answer)**
$S_n$ -> $D_n$ = min(Rs, Rd, R/K) = min(100Mbps, 54 Mbps, 50/10 Gbps) = 54Mbps
The bottleneck is the throughput of $R_d$

b) Suppose now that K=10, Rs = 100 Mbps, Rd= 1 Mbps, and R = 0.75 Gbps. What are the throughputs between each source-destination pair? Where are the bottleneck links?

**Answer)**
$S_n$ -> $D_n$ = min(Rs, Rd, R/K) = min(100 Mbps, 1 Mbps, 750/10 Mbps) = 1Mbps
The bottleneck is the throughput of $R_d$

c) In the scenario above, suppose we increase the capacity of the destination links to 100 Mbps. Will this increase the throughput between sources and destinations? Explain you answer.

**Answer)**
Yes, this would increase throughput because the total throughput is limited to the slowest link which in this case is the destination link so if we increase the slowest link to 100Mbps, the total throughput will increase as well

Before: total_throughput = min(100Mbps, 1 Mbps, 750/10 Mbps) = 1 Mbps
After: total_throughput = min(100 Mbps, 100 Mbps, 750/10 Mbps) = 75 Mbps

d) Now repeat 'a' above, but assume that the link connecting S1 to the network has a capacity of 1 Mbps, and that all other values are unchanged.

**Answer)**

S1->Sn = min (Rs, Rd, R/K) = (1Mbps, 54Mbps, 5Gbps) = 1Mbps
Sn1->Sn2 = min (Rs, Rd, R/K) = (100Mbps, 54Mbps, 5Gbps) = 54Mbps