

EECS 122: Introduction to Communication Networks

Homework 1

(11 points)

Due: 1999-Sep-10-Fri (start of class)

Problem 1. (1 point) How long does it take to transmit 15 kbytes ($15 \cdot 2^{10}$ bytes) over a link with rate 1.5 Mbps ($1.5 \cdot 10^6$ bits per second)?

Problem 2. (2 points) Suppose you usually send e-mail from your school account, but today you dial in to the school's computer from your home computer using a 9.6 kbps modem, log in to your school account, and then proceed to compose and send e-mail from your school account as usual. You are a fast typist, so you can type 400 characters per minute on average. What fraction of the *capacity* (bit-rate) of the modem connection are you using? (Assume the modem transmits 8 bits per character.) How could you do things differently to exploit the full capacity of the modem connection?

Problem 3. (2 points) In a packet-switched network, the transmission line is shared by many users. Suppose there are several users on machines directly attached to a shared 38.4 kbps line, all of whom are composing and sending email. How many users can the line accommodate? Assume that on average $\frac{1}{6}$ of an email message is typed manually, while the rest is copied from existing files or generated automatically. Again assume a typing speed of 400 characters per minute, and 8 bits per character.

Problem 4. Consider two hosts A and B connected via n hops ($n \geq 2$):

$$A \longleftrightarrow R_1 \longleftrightarrow R_2 \longleftrightarrow \cdots \longleftrightarrow R_{n-1} \longleftrightarrow B$$

That is, R_1, \dots, R_{n-1} are routers, and A is connected to R_1 by a point-to-point link, R_1 is connected to R_2 by a point-to-point link, and so on. Assume all links have the same capacity C (in bps). Also assume the propagation delay of the links to be negligible and that no packets from other hosts exist on the path from A to B (this is a very unrealistic assumption). Consider a packet of size $S + H$ (in bits) to be transmitted from A to B . S is the amount of actual data, while H is the size of the header and trailer.

- a) **(2 points)** How much time does it take to transmit the packet from A to B ?
- b) **(4 points)** The optimal way to break up the packet into smaller packets, in order to minimize the total delay, is to divide it into a number of equal-sized packets. (Food-for-thought: why equal-sized?) How many packets? (Notice that when the packet is split into smaller packets, separate headers/trailers are added to each of the smaller packets. Assume the size of headers/trailers to be H for packets of any size.)

Problem 5. (food-for-thought) Compare and contrast a packet-switched network and a circuit-switched network. What are the relative advantages and disadvantages of each?

Problem 6. (food-for-thought) Discuss the limitations of building a packet-switched network on top of the existing cable TV network. What technical challenges must be addressed to make such a network a reality?

Problem 7. (hands-on) Check the man-page of the Unix utility `ping`. Use `ping` to find the *round-trip time* (RTT) to various Internet hosts in countries all over the world. The RTT is the delay from the time a host *A* starts transmitting a packet to a host *B*, till the time *A* receives an *acknowledgment* packet from *B* (that is, it encompasses transmission time, propagation time, and queuing delays both ways; notice that the RTT depends on the current state of the network). Then use `traceroute` (enter `traceroute` to see its usage) to find the routes followed by packets sent to these hosts. (The `whereis` command can be used to locate commands not in your search path. The `traceroute` command is not installed on all Unix systems.)

Grading policy:

- Show your work. Every answer gets all points if correct and arrived at validly, half the points if “mostly right”, and no points if “mostly wrong”. For the sake of the readers, no finer granularity is provided. The final homework score will be total points earned over total points possible.
- “Food-for-thought” and “hands-on” problems will not be graded. You are, nevertheless, strongly encouraged to work on them.