Homework 1 (EECS 333) Introduction to Communication Networks

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Due in class on March 31, 2007 (Friday)

Reading Assignment

• Chapter 1, Sections 2.1-2.2 and Sections 3.1-3.3 in Leon-Garcia/Widjaja.


Note

When doing the homework, always state clearly the assumptions you make and explain clearly the reasoning behind your answers. A correct answer with no justification may be considered wrong. Also, make sure your solutions are neatly written up—if a solution is unreadable it will be considered incorrect.

Each problem is worth 10 points unless otherwise noted. You can use all resources that help you solve the problems. But directly obtaining answers from the Internet is prohibited.

Problem 1  A Brief History of the Internet

Read the 1997 article “The past and future history of the Internet,” by Leiner and et al. (See the Reading Assignment in above)

Answer the following questions:
1. Who was J. Licklider, and what was his “galactic network” concept?
2. Who coined the term packet?
3. What (who?) is an IMP?
4. Did the ARPANET use NCP or TCP/IP?
5. Was packet voice proposed as an early application for Internet?
6. How many networks did the initial IP address provide for?

Problem 2  Fault Tolerant Network Topologies

Consider a network with \( N \) nodes. Give the minimum number of links necessary in order for each pair of nodes to be able to communicate through two independent routes, namely, the two routes involve two disjoint subsets of links. Describe a topology that achieves this minimum.

[Hint: If you find it hard to obtain a general solution to the \( N \)-node network, it may help to first visit the special case of a network with 2 nodes, 3 nodes, 4 nodes ... This methodology is often useful.]

Problem 3  How long is “a bit” long?

The IEEE 802.3 standard defines on 10Base-T ethernet a transmission speed of 10 Mbps (\( 10^7 \) bits per second) over a segment of unshielded twisted pair cable of length up to 100 meters. Assume the propagation speed in coax is 2/3 the speed of light in vacuum, which is \( 3 \times 10^8 \) m/s. Find how long a bit is in meters.

[Hint: Imagine bits flow through the cable next to each other. Let time freeze so that you see the bits stand still in the cable and use a ruler to measure the length of each bit.]
Problem 4  Link Failure

Suppose each link in a 6-node network fails independently with a probability $p < 1$. Give the probability that a pair of nodes cannot communicate to each other if the network takes

- a) the star topology where neither one of the two nodes of interest is the hub;
- b) the ring topology where the two nodes are randomly picked out of all nodes;
- c) the fully connected topology. Compare it with the results in (a) and (b). [Note: This last question is harder. It is fine if you cannot get an exact solution; then you need to give it in terms of the order of $p$ assuming that $p$ is very small.]

Problem 5  Binomial Distribution

Consider a single point-to-point link that connects two nodes. Due to channel impairment, each packet arrives at the destination node correctly with probability $p$ ($0 < p < 1$). The event that a packet is received correctly or not is independent of one another.

(a) Assume $n$ packets are received in total. Write an expression that gives the probability that $k$ packets will be received correctly.

(b) What is the expected number of packets that will all be received correctly in a row?

(c) Suppose each packet takes $T$ seconds to send, and packets are continually sent, one after the other. Given that an error just occurred, what is the expected length of time until the next error occurs.

Problem 6  Geometric Packet Size

The length of a packet in a packet switched network may have a variable size. In this case packet lengths may be modeled probabilistically. Suppose that the length of a packet, $L$, is modeled as a geometric random variable with mean $L$ bits. Assume that packets are to be transmitted at rate $R$ bits per second over a link in a network.

(a) What is the probability it takes less than $T$ seconds to transmit a packet?

(b) What is the average time needed to transmit a packet?

(c) In some networks all packets are required to have the same size. Can you think of one advantage and disadvantage for such a requirement.