Final Exam (ECE 333) Introduction to Communication Networks

Prof. Dongning Guo

6-8 pm, June 7, 2006

Requirements

- You have 2 hours to complete the exam. Use your time strategically.
- This is a closed book closed notes exam. Work on your own.
- Use of calculator is NOT allowed.
- Show all your work in the answer book and clearly indicate your answers. Only work in the answer book will be considered. If we cannot read it, we cannot grade it.
- Make sure to provide justification for your answers. A correct numerical answer without justification may be considered wrong.

Some Formulas May or May not Be Useful

Constants:

$e \approx 2.72$. $\ln 2 \approx 0.69$. $\ln 3 \approx 1.10$. $\ln 9 \approx 2.20$. $\ln 10 \approx 2.30$.

The speed of light in vacuum is 3×10^8 m/s.

A Poisson random variable X with its mean value equal to λ has the following probability mass function:

$$\mathsf{P}\{X = n\} = \frac{1}{n!}\lambda^n e^{-\lambda}.$$

Shannon capacity of an additive white Gaussian channel of bandwidth B is

$$C = B \log_2 \left(1 + \frac{P}{BN_0}\right) \text{ bits/s}$$

where P is the received signal power and N_0 is the noise power per unit bandwidth.

Problem 1 (7 points)

Tick the correct answer(s) to each of the following questions.

1. The number of links in a fully connected non-directional network of N nodes is (a) N; (b) N^2; (c) $N^2 - N$; (d) $(N^2 - N)/2$; (e) N^N; (f) 2^N.

2. A dog can carry an 80 Gigabyte hard disk from your dorm to the Tech in 5 minutes. Compare to the internet connection between your dorm and the Tech, which has faster data rate? (a) The dog; (b) the Internet.

3. Suppose a network in the Internet uses an address mask of 255.255.255.0. Assuming each host has a unique IP address, what is the maximum number of hosts on this network? (Choose the closest number.) (a) 2^{32}; (b) 65536; (c) 256; (d) 16; (e) 4; (f) 2.

4. The advantage(s) of the best-effort service model of the Internet Protocol (IP) is/are: (a) It makes the Internet more scalable; (b) It provides quality-of-service guarantees because the best effort is made for all applications; (c) Even User Datagram Protocol (UDP) would work well since the network provides reliable service; (d) It obviates the need for error-control coding in the Physical Layer and Data Link Layer (DLL).

5. Carrier Sense Multiple Access with Collision Detection (CSMA/CD) is used in the 802.3 Ethernet LAN standard. However, in 802.11 standard for Wireless LAN, CSMA with Collision Avoidance (CSMA/CA) is used. This is mainly because (a) Collision detection is infeasible in wireless LANs (b) Collision detection is feasible in wireless LANs but collision avoidance is more efficient (c) IEEE politics (d) CSMA/CA is superior but 802.3 was developed before collision avoidance was a known option.

6. In the Transmission Control Protocol (TCP) the receiver advertises its window size in order to prevent the transmitter from overrunning the receiver's buffer. This is called (a) Medium access control (b) Congestion control (c) Traffic control (d) Flow control (e) Buffer control.

7. TCP corresponds to which layer of the OSI reference model? (a) Physical layer; (b) Data link layer; (c) Network layer; (d) Transport layer; (e) Session layer; (f) Representation layer; (g) Application layer.

Problem 2 (8 points)

Packets of class 1 and class 2 arrive at a switch at the rate of 10 packets/second and 20 packets/second respectively. Packets of class 1 leave the switch exactly 1 second after they arrive. Each packet of class 2 spends in average T seconds in the switch. The average number of total packets in the switch is observed to be 50 packets.

(a) Find the average number of packets of class 2 in the switch.

(b) What is the value of T?

Problem 3 (6 points)

Consider a network of N nodes and L links. A node wishes to flood a packet to the entire network. Each node forwards the packet to all its neighbors except the incoming node after it receives the packet for the first time, and will not forward after it sees the packet for twice or more.

Prove that the total number of transmissions M involved in flooding the packet satisfies
(a) $M \geq L$.
(b) $M < 2L$.
Give adequate justification.

[prove, *verb*: to establish the existence, truth, or validity of (as by evidence or logic).]

Problem 4 (8 points)

Assume that all the data frame transmissions on a dedicated link are error-free. The round trip time is T. The forward link has an efficiency of 0.17 if STOP&WAIT ARQ is used.

(a) What is the transmission time of a single frame?

Suppose from this point on Selective Repeat ARQ with the same window size on both ends is used instead. Find the efficiency of the link if

(b) The maximum window size is 4 and the receiving node acknowledges every frame it receives. Draw a diagram to show the timings of frames including ACKs.

(c) The maximum window size is 8 and the receiving node acknowledges every frame it receives.

(d) The maximum window size is 8 and the receiving node acknowledges every 3 frames it receives.

Problem 5 (8 points)

Consider a slotted Aloha system with an infinite number of users. Assume that the transmission attempts are modelled as a Poisson processes with average rate G transmissions per slot.

(a) What is the probability a transmission is successful on its first attempt?

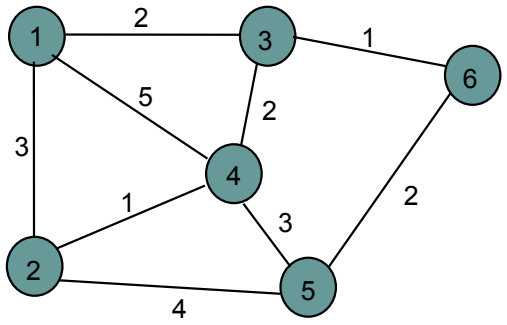
(b) What is the probability that it takes exactly k attempts for a transmission to be successful?

(c) What is the average number of transmission attempts needed for a packet to be successful?

(d) Suppose when a collision occurs, a node retransmits in each slot with probability q. What is the average number of slots from a packet arrives until it is successfully received?

Problem 6 (8 points)

Consider the following network with associated link costs



(a) Use the Dijkstra algorithm to find the set of shortest paths from node 2 to all other nodes. Show your work in the following table.

Iteration	Nodes	D_1	D_3	D_4	D_5	D_6
Initial						
1						
2						
3						
4						
5						
6						

(b) Produce a routing table in the following.

Destination	Next node	Cost
1		
3		
4		
5		
6		