TCOM 370
Homework 8 April 17, 1999

This is the last problem set of the semester. It will not be collected for grading, but you should do all problems. Solutions will be posted on April 23.

Problem 1

Monitoring of the performance of a slotted ALOHA scheme reveals that on the average 10% of the slots are empty and 60% of the slots are carrying unusable, multiple frames. Can the Poisson point process assumptions, made for the standard analysis of a slotted ALOHA scheme, be valid for this case?

Problem 2

Consider a network of two workstations A and B and a laser printer L connected to a bus, operated in a slotted manner using the simple ALOHA protocol. A and B each have many frames awaiting access to L. Suppose A and B implement the following strategy: each will attempt to transmit within any particular slot with respective probability p_a and p_b, independently of each other. If both transmit on the same slot, the slot is wasted due to collision and the frames have to be re-transmitted.

(a) Show that the efficiency of the scheme is $\eta = p_a + p_b - 2p_a p_b$

(b) What is the maximum achievable value of η? Would this be a desirable operating point for the network?

(c) A network administrator has required A to use $p_a=0.3$. What is the maximum value of η under this constraint? What is the maximum average number of frames per slot that A can get through with $p_a=0.3$? What is the maximum average number of frames per slot that B can get through, and what happens to A in this case ?

(d) Suppose $p_a=0.5$. Does η depend on p_b? Comment on your answer.

Problem 3

One thousand nodes are connected to a bus that is 1 Km long. Each node needs to send 30 frames, each of 2000 bits, every second, to one host on the bus. The transmission rate on the bus is 100 Mbps. Which of the following MAC protocols can be used: pure ALOHA, slotted ALOHA, Ethernet ?

(Propagation speed is 2.25×10^8 m/s, and the efficiency for an ethernet protocol is $\frac{1}{1+5a}$)

Problem 4

200 PCs are attached to a 10 Mbps Ethernet with a coaxial cable of 1500 m in three segments of 500 m each. The frames have 800 bits. On the average, how many frames can each PC send every second?

Problem 5

A 10 Mbps coaxial-cable Ethernet LAN has a span of 2400 m, uses packets of length 800 bits, and has a propagation speed of 2.25 x 10^8 m/s. An engineer claims that the throughput can be almost doubled by adding a second, identical, parallel cable so that each node is now connected to both cables, with each packet occupying simultaneous half-length slots on each cable. This claim is based on the fact that the effective transmission rate on the bus is now 20 Mbps. Decide if this claim is valid.

Problem 6 ***(from 1997 Final Exam)***

A large number of PCs on a factory floor are networked using a variant of slotted ALOHA. A wireless relay station (on the ceiling) broadcasts to all the PCs on one "downlink" channel, whereas there are ***two*** separate "uplink" frequency bands (channels) available. Each channel allows a transmission rate of 2 Mbps. The transmission slots are synchronized to have the same slot boundaries on the uplink channel pair, and the slot duration is the same as the fixed-length packet duration. When a PC has a packet to send it randomly selects one of the two uplink channels (each equally likely) and puts its packet in the next slot on the selected channel. If the relay station sees a collision-free packet in only one of a pair of uplink slots, it can relay it on the downlink channel. If it sees collision-free packets on both uplink slots simultaneously, not having any buffer, it picks one of the two packets at random and relays it down; the other packet is discarded. If it sees collisions or empty slots only, it does nothing.

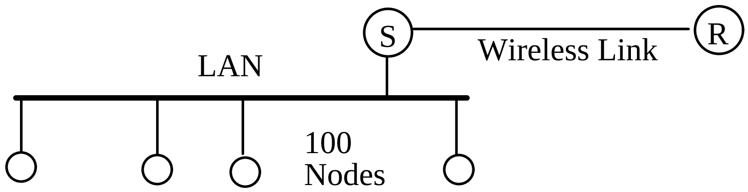
(a) If only one uplink channel is available and all the PCs use that channel, what is the maximum throughput, i.e. the maximum effective transmission rate on the downlink? What fraction of the uplink slots on the channel are empty, and what fraction contain collisions in this situation?

(b) Would your answer to part (a) change if the PCs did not know that one of the uplink receivers at the relay station was dead?

(c) When both uplink channels are available, what is the maximum throughput that can be obtained in this system?

Problem 7 ***(from 1997 Final Exam)***

A 10 Mbps CSMA/CD (IEEE 802.3) LAN has 100 nodes on a cable of length 2250 m on which the propagation speed is 2.25x10^8 m/s. One other node on the LAN is a special node ("S") that functions as one end of a point-to-point wireless link between it and a remote node ("R"). On the wireless link the transmission rate is 10 Mbps in both directions (full-duplex), the propagation speed is $3x10^8$ m/s and the probability of frame error is p=0.1 regardless of the length of the link.



The 100 nodes each produce packets of length 1000 bits which are addressed to S on the LAN and destined for the remote node R, and the LAN is heavily loaded.

(a) How many packets per second, on the average, does S get from the nodes on the LAN?

(b) Suppose that R is 15 Km from S and that Idle RQ is used on the wireless link. Assume that ACK/NACK frames are 500 bits long. Determine if the LAN or the wireless link is the bottleneck for packet transmission between the nodes and R.

(c) Suppose Go-Back-N ARQ is used on the wireless link with a transmit window size of K=3 and ACK/NACK frames of negligible length. How far apart can S and R be without making the wirless link the bottleneck for transmission between the LAN nodes and R ?

(d) If R also had frames to send to nodes on the LAN, would your answer to (c) change?

[Given: For Go-Back-N with transmit window size K, frame error probability P_f, and considering *only* propagation delay T_p and I-frame duration T_{ix}, the utilization factor is

$$\mathbf{U_{with\ error} = U_{no\ error} \frac{1-P_f}{1-P_f + \min\{(1+2a),K\}P_f}} \qquad \text{where } a=\frac{T_p}{T_{ix}}$$]

Problem 8 ***(from 1998 Final Exam)***

(a) The formula for the efficiency of an Ethernet LAN is $\eta=\frac{1}{1+5a}$ where "a" is the ratio {maximum propagation delay T_p between nodes}/{frame duration T_{ix}}.
Explain why in a coaxial cable Ethernet LAN there is a limit on the *shortest frame* length as well as *longest frame* length that can be used, and also on the *maximum length of each cable segment* as well as *number of repeater-connected cable-segments.*

(b) Suppose you have an ethernet LAN with several hundred nodes. You want to add a new cable segment with a 100 nodes to this LAN. Explain the difference between a *bridge* and a *repeater* in connecting the new segment to the existing LAN, stating the advantage and disadvantage of each.

Problem 9 ***(From 1998 Final Exam)***

A number N of PC's and one printer station share a common cable bus. The transmission rate for PC's on the bus is 40 Kbps. The printer station completes printing a page within 2 seconds after getting a complete page of bits from a PC. Each page has 100,000 bits.

A slotted ALOHA multiple-access protocol is used, with a frame length of 100,000 bits. (Short ACKs put by the printer on the bus do not add significant overhead.) If the assumptions for slotted ALOHA analysis remain valid then the probability of a slot carrying a single uncorrupted frame is G_e^{-G}, and the probability of a slot going empty is e^{-G}, where G is the average rate at which all the PC's together are attempting to use each slot.

(a) What is the average number of pages per minute (ppm) printed in the best case, if the assumptions of the ALOHA analysis are valid?
For this case, if N=20, on average how many ppm will each PC be able to print?

(b) An engineer suggests that adding a second printer on this bus will allow each PC to print a larger number of pages per minute. Decide how much improvement, if any, this will produce.

(c) Suppose one rogue PC does not adhere to the ALOHA etiquette, and attempts to transmit a page in every slot with probability 0.5. The other PC's do not know this, and attempt to transmit in any slot with a probability 1/N. How many ppm will the rogue PC be able to print? How many pages per minute will any of the other N-1 PC's be able to print? (Assume that N=20 and that this can be assumed to be large in the analysis).