CS4450 Problem Set #2

1 CSMA/CD: Random Access

Let A and B be two stations attempting to transmit on an Ethernet. Each has a steady queue of frames ready to send; A's frames are denoted A_1, A_2, ..., and B's are defined similarly.

Recall the random access protocol discussed in class. In case of a collision, A and B back off for $d \times T$ time where T is the back off unit time and $d \in D = \{0, ..., 2^k - 1\}$, where k is the number of collisions so far. You can think of selecting a d from D as choosing a time slot to transmit the packet from 2^k future slots.

Suppose A and B simultaneously attempt to send their first frame, collide, and happen to choose back off times of $0 \times T$ and $1 \times T$, respectively, meaning A wins the race and transmits A_1 while B waits.

a) At the end of the first transmission, B will attempt to retransmit B_1 while A will attempt to transmit A_2. These attempts will collide. Now A will choose a waiting time in $\{0 \times T, 1 \times T\}$, while B will choose a waiting time in $\{0 \times T, ..., 3 \times T\}$. What is the probability that A wins this second back off race?

b) Suppose A wins the second back off race in (a). A transmits A_2, and when it is finished, A and B collide again as A tries to transmit A_3 and B tries once more to transmit B_1. What is the probability that A wins this third back off race?

c) Given that A wins the first three back off races, what is a lower bound for the probability that A wins all of the remaining back off races?

d) In the case that (c) holds, what happens to the frame B_1?

2 CSMA/CD: Random Access

Let A and B be two stations attempting to transmit a single packet on an Ethernet.

Recall that in case of the kth collision, A and B choose a $d \in D = \{0, ..., 2^k - 1\}$ and wait for $d \times T$ time. Here, d is chosen randomly from the set D, where the probability of selecting any element in D is distributed uniformly.

a) Let P_k be the probability of success after the k^{th} collision in the $(k+1)^{th}$ attempt. Write P_k in terms of k.

b) Let S_k be the probability of success in $(k+1)$ attempts given there is a collision to start with. Write S_k in terms of k.

c) Let S be the probability of success after k collisions, at some point in the future. Calculate S.

Now, we will consider when the probability of selecting elements from D, i.e. selecting a time slot, is not distributed uniformly.

Specifically, let

$$D = \{0, 1, 2, ..., d_{2^k - 1}\} \text{ and } P = \{p, 2p, 3p, ..., 2^k p\}$$

where p is the solution to

$$p + 2p + 3p + ... + 2^k p = 1.$$

Let p_i, the i^{th} element of P, be the probability of choosing d_i, the i^{th} element of D. Let P_k and S_k be defined as before.

d) Given the probability distribution above, calculate the probability of success in the second attempt, i.e. P_1.

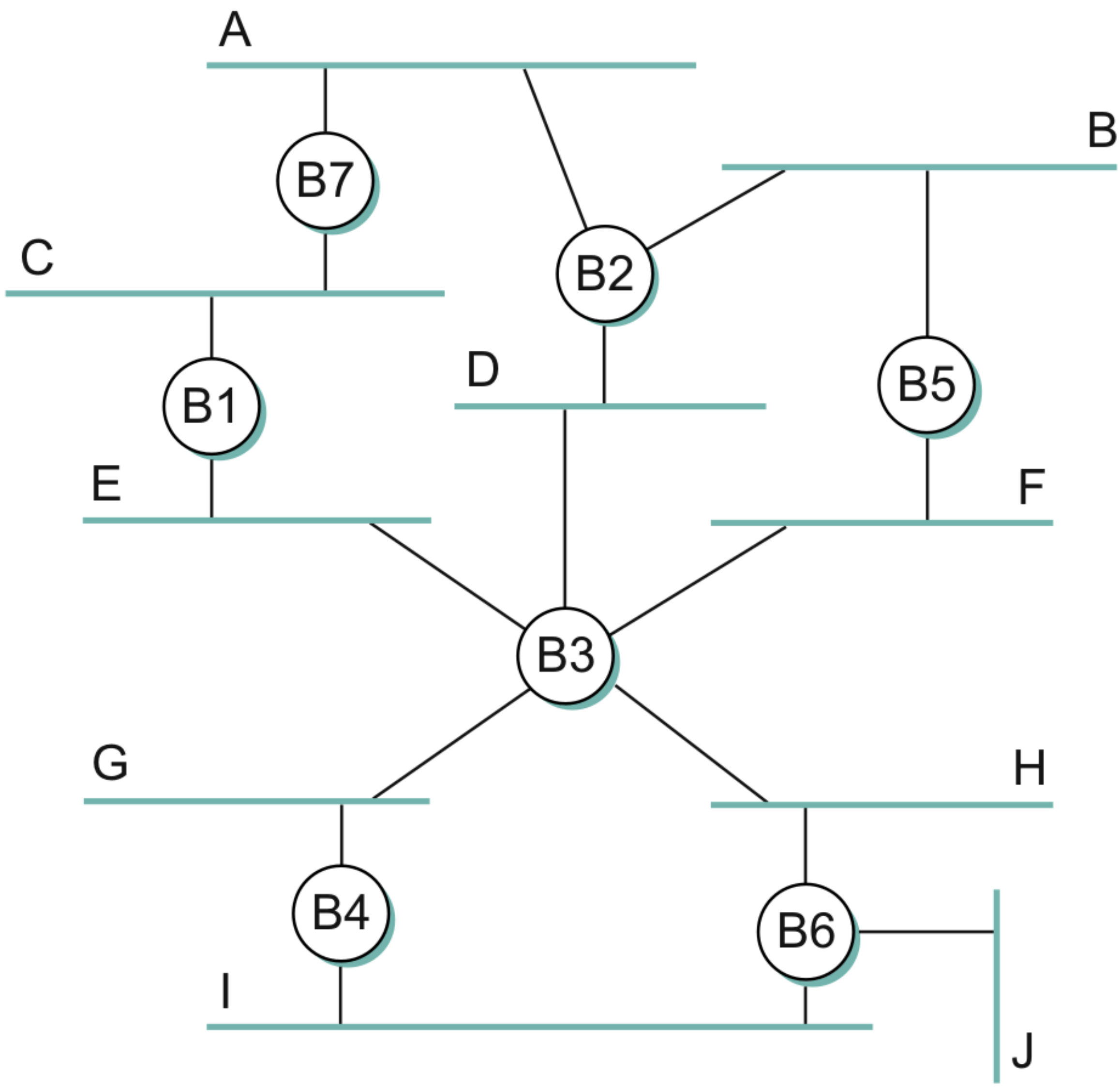
e) Calculate the probability of success in the third attempt, i.e. P_2. Calculate S_2.

f) Write P_k and S_k in terms of k.

Now, assume there are 3 stations, A, B & C, and a uniform probability distribution in choosing slots.

g) Can we use the same method as we used in (a) & (b) to calculate P_k and Q_k? Why/why not?

3 The Spanning Tree Algorithm



Above an extended LAN and its corresponding network graph is given.

a) Which ports are selected by the spanning tree algorithm?

b) Assume that the bridge $B1$ fails. Which ports are selected by the spanning tree algorithm after the recovery process and a new tree has been formed?

4 Programming

Suppose N stations are waiting for another packet to finish on an Ethernet. All transmit at once when the packet is finished and collide.

Write a program to implement the simulation of this case up until the point when one of the N waiting stations succeeds. Model time as an integer, T, in units of slot times and treat collisions as taking one slot time (e.g. a collision at time T followed by a backoff of k = 0 should result in a retransmission attempt at time T + 1).

a) Find the average delay before one station transmits successfully, for N=5, N=10, N = 20, N = 40, and N = 100.

b) Plot the average delay against the number of stations. How is delay related to the number of stations?