ECE 358 (Computer Networking)
Project #2 (CSMA/CD)

Description

The learning objective of this project is to design and implement a ***discrete event simulator*** to evaluate the performance of local area networks (LAN) constructed using CSMA and CSMA/CD protocols. The network parameters are as follows:

- N: the number of computers connected to the LAN (variable)
- A: Data packets arrive at the MAC layer following a Poisson process with an average arrival rate of A packets/second (variable)
- W: the speed of the LAN (fixed)
- L: packet length (fixed)
- P: Persistence parameter for P-persistent CSMA protocols.

CSMA/CD:

This protocol, known as CSMA/CD (CSMA with Collision Detection), is the basis of the classic Ethernet LAN. It is important to realize that collision detection is an analog process. The station's hardware must listen to the channel while it is transmitting. If the signal it reads back is different from the signal it is putting out, it knows that a collision is occurring. The implications are that a received signal must not be tiny compared to the transmitted signal (which is difficult for wireless, as received signals may be 1,000,000 times weaker than transmitted signals) and that the modulation must be chosen to allow collisions to be detected (e.g., a collision of two 0-volt signals may well be impossible to detect).

At the time t, a station has finished transmitting its frame. Any other station having a frame to send may now attempt to do so. If two or more stations decide to transmit simultaneously, there will be a collision. If a station detects a collision, it aborts its transmission, waits a random period of time, and then tries again (assuming that no other station has started transmitting in the meantime). Therefore, our model for CSMA/CD will consist of alternating contention and transmission periods, with idle periods occurring when all stations are quiet (e.g., for lack of work).

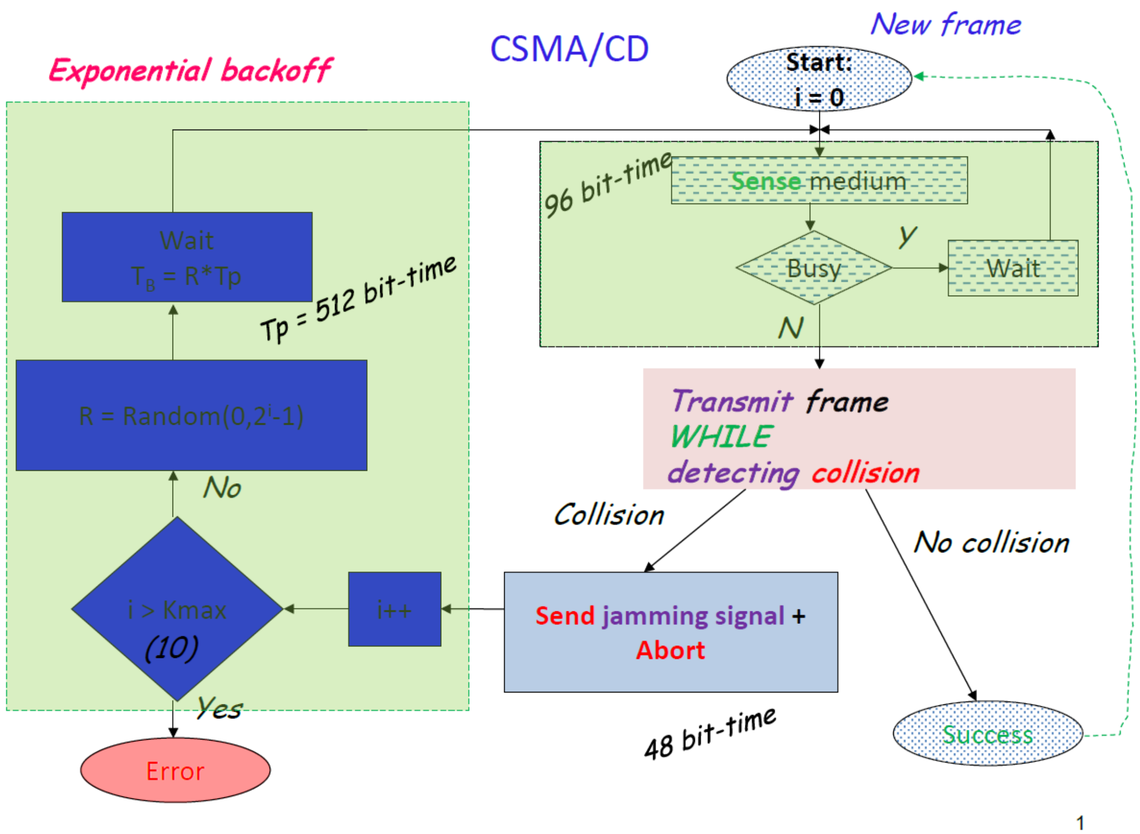

Figure 4: Flow diagram of CSMA/CD (The "Wait" time after "Busy" is equal to the "Wait" time in BEB.)

Next, we will study persistent, non-persistent and P-persistent CSMA/CD protocols. The difference between these protocols is the implementation of the green box in the top left of Figure 1.

Persistent (1-persistent) CSMA/CD:

When a station has data to send, it first listens to the channel to see if anyone else is transmitting at that moment. If the channel is idle, the station sends its data. Otherwise, if the channel is busy, the station just waits until it becomes idle. Then the station transmits a frame. If a collision occurs, the station waits a random amount of time and starts all over again. The protocol is called 1-persistent because the station transmits with a probability of 1 when it finds the channel idle. The green box in the top left of Figure 1 is implemented as follows.

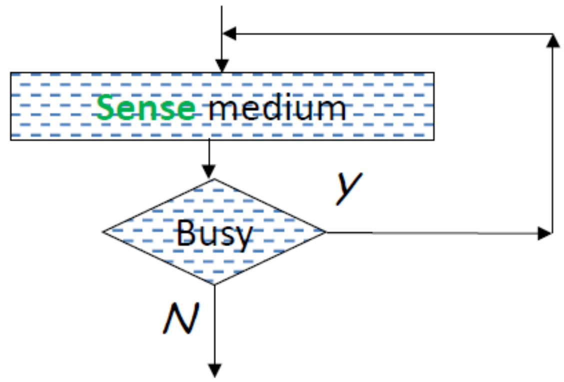

Figure 1: Flow diagram of 1-persistent CSMA/CD

Non-Persistent CSMA/CD:

In this protocol, a conscious attempt is made to be less greedy than in the previous one. As before, a station senses the channel when it wants to send a frame, and if no one else is sending, the station begins doing so itself. However, if the channel is already in use, the station does not continually sense it for the purpose of seizing it immediately upon detecting the end of the previous transmission. Instead, it waits a random period of time and then repeats the algorithm.

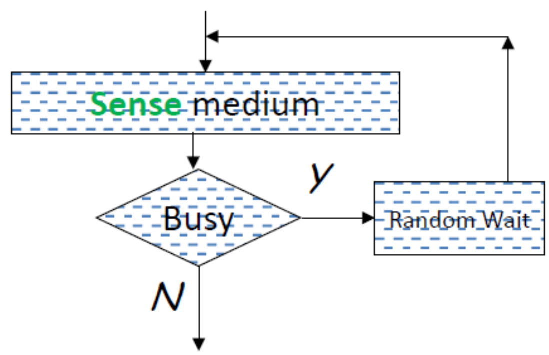

Figure 2: Flow diagram of non-persistent CSMA/CD

P-persistent CSMA/CD:

In this protocol works as follows. When a station becomes ready to send, it senses the channel. If it is idle, it transmits with a probability p. With a probability q = 1 − p, it defers until the next slot. If that slot is also idle, it either transmits or defers again, with probabilities p and q. This process is repeated until either the frame has been transmitted or another station has begun transmitting. In the latter case, the unlucky station acts as if there had been a collision (i.e., it waits a random time and starts again). If the station initially senses that the channel is busy, it waits until the next slot and applies the above algorithm.

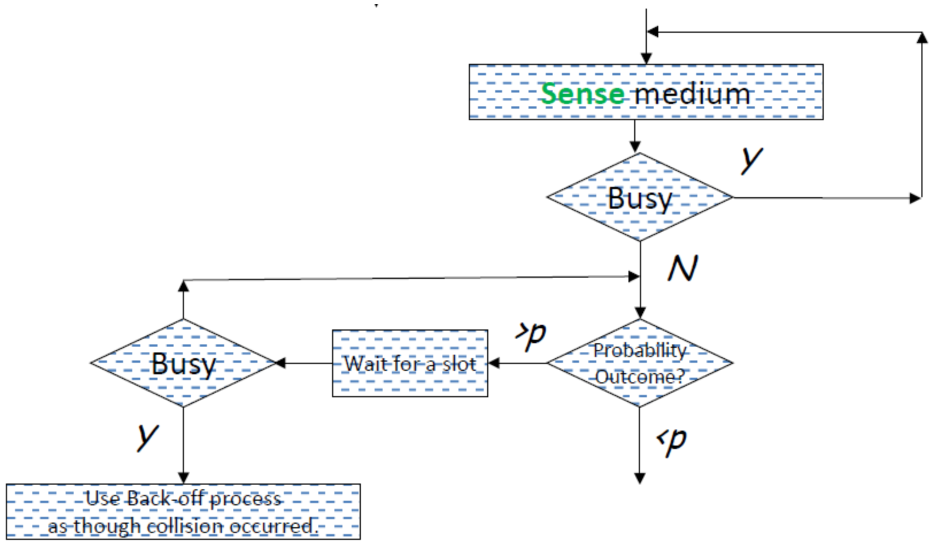

Figure 3: Flow diagram of P-persistent CSMA/CD

Note that the random waiting times in P-persistent and non-persistent protocols are equal to the current value of BEB.

Problems

In all questions, distance between two neighboring nodes is 10 meters. Thus, the total length of the cable is 10*(N-1) meters.

In problems 1 to 4, you are dealing with a CSMA/CD protocol.

1) Show the throughput of the LAN as a function of N (20, 40, 60, 80, and 100) for A = 5, 6, and 7 Packet/sec, W = 1 Mbps, and L = 1500 bytes. (You have to provide three different graphs. One for each value of A)
   Also, comment on the behavior of each graph. (Comments are worth more than 25% of the mark.)

2) Show the throughput of the LAN as a function of A (4, 8, 12, 16 and 20) for N = 20, 30, and 40, W = 1 Mbps, and L = 1500 bytes. (You have to provide three different graphs. One for each value of N)
   Also, comment on the behavior of each graph. (Comments are worth more than 25% of the mark.)

3) Show the average delay in transmitting a packet as a function of N (20, 40, 60, 80, and 100) for A = 5, 6, and 7 Packet/sec, W = 1 Mbps, and L = 1500 bytes. Delay is defined as the gap between the time a packet is generated and the time it is

successfully transmitted. (You have to provide three different graphs. One for each value of A)
Also, comment on the behavior of each graph. (Comments are worth more than 25% of the mark.)

4) Show the average delay in transmitting a packet as a function of A (4, 8, 12, 16 and 20) for N = 20, 30, and 40, W = 1 Mbps, and L = 1500 bytes. (You have to provide three different graphs. One for each value of N)
Also, comment on the behavior of each graph. (Comments are worth more than 25% of the mark.)

In the remaining problems, you will be asked to compare the performance of different CSMA protocols. (Without a switch)

5) Show the throughput and delay of non-persistent and P-persistent (P = 0.01, 0.1, 0.3, 0.6, and 1) CSMA protocols as a function of A (up to 10 packets/sec) for N = 30, W = 1 Mbps, and L = 1500 bytes.
Also, comment on the behavior of each graph and compare them. (Comments and comparisons are worth more than 25% of the mark.)

Assumption

Make any other assumptions as needed.

Make the following submission in printed form:

Your report, which must include the description of the design of your simulator, all the assumptions, performance graphs, and comments on the graphs.