Computer Networks
Problem Set 4

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Chapter 4. The Medium Access Control Sublayer

4.1 For this problem, use a formula from this chapter, but first state the formula. Frames arrive randomly at a 100-Mbps channel for transmission. If the channel is busy when a frame arrives, it waits its turn in a queue. Frame length is exponentially distributed with a mean of 10,000 bits/frame. For each of the following frame arrival rates, give the delay experienced by the average frame, including both queueing time and transmission time.

- **a**. 90 frames/sec.
- **b**. 900 frames/sec.
- **c**. 9000 frames/sec.

4.2 A group of N stations share a 56-kbps pure ALOHA channel. Each station outputs a 1000-bit frame on average once every 100 sec, even if the previous one has not yet been sent (e.g., the stations can buffer outgoing frames). What is the maximum value of N?

4.3 A large population of ALOHA users manages to generate 50 requests/sec, including both originals and retransmissions. Time is slotted in units of 40 msec.

- **a**. What is the chance of success on the first attempt?
- **b**. What is the probability of exactly k collisions and then a success?
- **c**. What is the expected number of transmission attempts needed?

4.4 In an infinite-population slotted ALOHA system, the mean number of slots a station waits between a collision and a retransmission is 4. Plot the delay versus throughput curve for this system.

4.5 What is the length of a contention slot in CSMA/CD for

- **a**. a 2-km twin-lead cable (where signal propagation speed is 82% of the signal propagation speed in vacuum)?
- **b**. a 40-km multimode fiber optic cable (signal propagation speed is 65% of the signal propagation speed in vacuum)?

4.6 In the binary countdown protocol, explain how a lower-numbered station may be starved from sending a packet.

4.7 See Figure 1(which is Fig. 4-10 in textbook). Assume that the stations know that there are four ready stations: B, D, G, and H. How does the adaptive tree walk protocol traverse the tree to let all four stations send their frame? How many additional collisions occur if the search starts from the root?

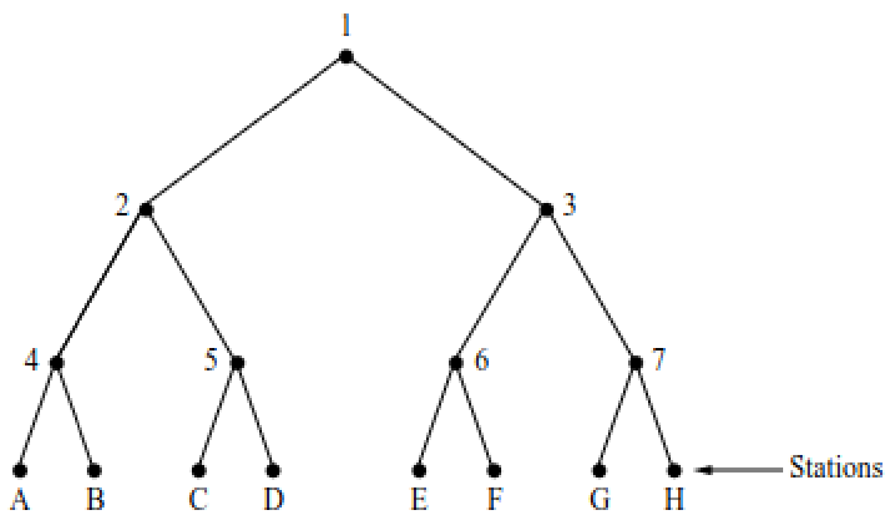

Figure 1: Exercise 4.7

4.8 Sixteen stations, numbered 1 through 16, are contending for the use of a shared channel by using the adaptive tree-walk protocol. If all the stations whose addresses are prime numbers suddenly become ready at once, how many bit slots are needed to resolve the contention?

4.9 Consider five wireless stations, A, B, C, D, and E. Station A can communicate with all other stations. B can communicate with A, C and E. C can communicate with A, B and D. D can communicate with A, C and E. E can communicate A, D and B.

a. When A is sending to B, what other communications are possible?

b. When B is sending to A, what other communications are possible?

c. When B is sending to C, what other communications are possible?

4.10 A seven-story office building has 15 adjacent offices per floor. Each office contains a wall socket for a terminal in the front wall, so the sockets form a rectangular grid in the vertical plane, with a separation of 4 m between sockets, both horizontally and vertically. Assuming that it is feasible to run a straight cable between any pair of sockets, horizontally, vertically, or diagonally, how many meters of cable are needed to connect all sockets using:

a. A star configuration with a single router in the middle?

b. A classic 802.3 LAN?

4.11 A 1-km-long, 10-Mbps CSMA/CD LAN (not 802.3) has a propagation speed of 200 m/μsec. Repeaters are not allowed in this system. Data frames are 256 bits long, including 32 bits of header, checksum, and other overhead. The first bit slot after a successful transmission is reserved for the receiver to capture the channel in order to send a 32-bit acknowledgement frame. What is the effective data rate, excluding overhead, assuming that there are no collisions?

4.12 Two CSMA/CD stations are each trying to transmit a frame. They both contend for the channel, using the binary exponential backoff algorithm after a collision. What is the probability that the contention ends on round k, and what is the mean number of rounds per contention period?

4.13 An IP packet to be transmitted by Ethernet is 60 bytes long, including all its headers. If LLC is not in use, is padding needed in the Ethernet frame, and if so, how many bytes?

4.14 Ethernet frames must be at least 64 bytes long to ensure that the transmitter is still going in the event of a collision at the far end of the cable. Fast Ethernet has the same 64-byte minimum frame size but can get the bits out ten times faster. How is it possible to maintain the same minimum frame size?

4.15 In Figure 2(which is Fig. 4-27 in textbook), four stations, A, B, C, and D, are shown. Which of the last two stations do you think is closest to A and why?

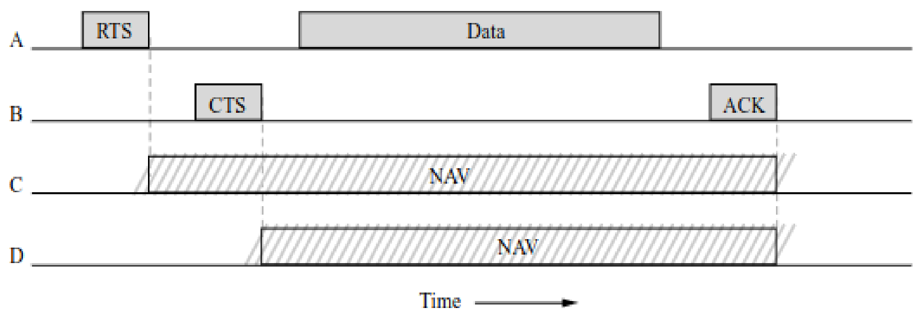

Figure 2: Exercise 4.15

4.16 Give an example to show that the RTS/CTS in the 802.11 protocol is a little different than in the MACA protocol.

4.17 See Figure 3(which is Fig. 4-33(b) in textbook). Imagine that all stations, bridges, and hubs shown in the figure are wireless stations, and the links indicate that two stations are within range of each other. If B2 is transmitting to D when B1 wants to transmit to A and H1 wants to transmit to F, which pairs of stations are hidden or exposed terminals?

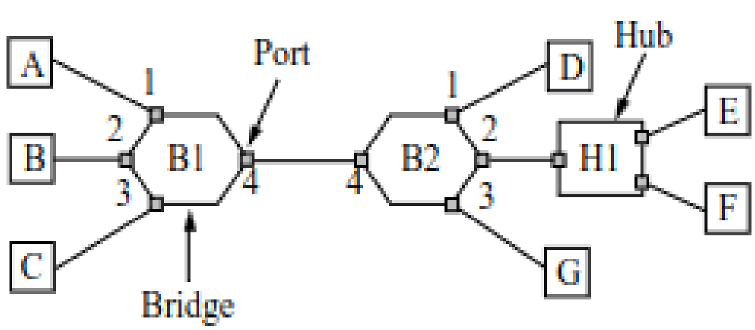

Figure 3: Exercise 4.17

4.18 A wireless LAN with one AP has 10 client stations. Four of these stations have data rates of 6 Mbps, four stations have data rates of 18 Mbps, and the last two stations have data rates of 54 Mbps. What is the data rate experienced by each station when all ten stations are sending data together, and

a. TXOP is not used?

b. TXOP is used?

4.19 Suppose that an 11-Mbps 802.11b LAN is transmitting 64-byte frames back-to-back over a radio channel with a bit error rate of 10^{-7}. How many frames per second will be damaged on average?

4.20 Give two reasons why networks might use an error-correcting code instead of error detection and retransmission.

4.21 Why are solutions such as PCF (Point Coordination Function) better suited for versions of 802.11 that operate at higher frequencies?

4.22 A switch designed for use with fast Ethernet has a backplane that can move 10 Gbps. How many frames/sec can it handle in the worst case?

4.23 Consider the extended LAN connected using bridges B1 and B2 in Figure 3(which is Fig. 4-33(b) in textbook). Suppose the hash tables in the two bridges are empty. What does B2's hash table look like after the following sequence of data transmissions:

a. B sends a frame to E.

b. F sends a frame to A.

c. A sends a frame to B.

d. G sends a frame to E.

e. D sends a frame to C.

f. C sends a frame to A.

Assume that every frame is sent after the previous frame has been received.

4.24 Consider the extended LAN connected using bridges B1 and B2 in Figure 3(which is Fig. 4-33(b) in textbook). Suppose the hash tables in the two bridges are empty. Which of these data transmissions leads to a broadcast:

a. A sends a frame to C.

b. B sends a frame to E.

c. C sends a frame to B.

d. G sends a frame to C.

e. E sends a frame to F.

f. D sends a packet to C.

Assume that every frame is sent after the previous frame has been received.

4.25 Consider the extended LAN connected using bridges B1 and B2 in Figure 3(which is Fig. 4-33(b) in textbook). Suppose the hash tables in the two bridges are empty. List all ports on which a packet will be forwarded for the following sequence of data transmissions:

- **a**. A sends a packet to C.
- **b**. E sends a packet to F.
- **c**. F sends a packet to E.
- **d**. G sends a packet to E.
- **e**. D sends a packet to A.
- **f**. B sends a packet to F.

4.26 Consider an Ethernet LAN with seven bridges. Bridge 0 is connected to 1 and 2. Bridges 3, 4, 5, and 6 are connected to both 1 and 2. Assume the vast majority of frames is addressed to stations connected to bridge 2. First sketch the spanning tree constructed by the Ethernet protocol, then sketch an alternative spanning tree that reduces the average frame latency.

4.27 Store-and-forward switches have an advantage over cut-through switches with respect to damaged frames. Explain what it is.

4.28 It is mentioned in Section 4.8.3 that some bridges may not even be present in the spanning tree. Outline a scenario where a bridge may not be present in the spanning tree.

4.29 Write a program to simulate pure ALOHA. Assume that packet lengths follow a Gaussian distribution with the mean and standard deviation as parameters. The number of stations is also a parameter. Run the clock in steps of ΔT, also a parameter. At each step, each station has some probability of transmitting, regardless of whether any other transmissions are going on. Study the behavior of the system under different conditions of load.

4.30 Capture message traces sent by your own computer using promiscuous mode for a few minutes several times. Build a simulator for a single communication channel and implement the CSMA/CD protocols. Evaluate the efficiency of these protocols using your own traces to represent different stations competing for the channel. Discuss the representativeness of these traces as link layer workloads.

4.31 Write a program to simulate the behavior of the CSMA/CD protocol over Ethernet when there are N stations ready to transmit while a frame is being transmitted. Your program should report the times when each station successfully starts sending its frame. Assume that a clock tick occurs once every slot time (51.2 μsec) and a collision detection and sending of a jamming sequence takes one slot time. All frames are the maximum length allowed.