PROBLEMS

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.

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?

3. Ten thousand airline reservation stations are competing for the use of a single slotted ALOHA channel. The average station makes 18 requests/hour. A slot is 125 μsec. What is the approximate total channel load?

4. Measurements of a slotted ALOHA channel with an infinite number of users show that 10% of the slots are idle.
   (a) What is the channel load, G?
   (b) What is the throughput?
   (c) Is the channel underloaded or overloaded?

5. Figure 4-4 illustrates that the maximum throughput ranges from pure ALOHA (lowest) to 0.01-persistent CSMA (highest). To achieve higher maximum throughput, a protocol makes some trade-offs, for example, extra hardware support or increased wait time. For the protocols plotted in this figure, explain what trade-off each protocol makes to achieve higher throughput.

6. 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)?, and (b) a 40-km multimode fiber optic cable (signal propagation speed is 65% of the signal propagation speed in vacuum)?

7. How long does a station, s, have to wait in the worst case before it can start transmitting its frame over a LAN that uses the basic bit-map protocol?

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

9. See Fig. 4-10. 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?

10. A group of friends gets together to play highly interactive CPU- and network-intensive video games. The friends play together using a high-bandwidth wireless network. The wireless signal cannot propagate through walls, but the friends are all in the same room. In such a setup, would it be best to use nonpersistent CSMA or the token ring protocol? Please explain you answer.

11. A collection of 2^n stations uses the adaptive tree walk protocol to arbitrate access to a shared cable. At a certain instant, two of them become ready. What are the minimum, maximum, and mean number of slots to walk the tree if $2^n \gg 1$?

12. The wireless LANs that we studied used protocols such as CSMA/CA and RTS/CTS instead of using CSMA/CD. Under what conditions, if any, would it be possible to use CSMA/CD instead?

13. Six stations, A through F, communicate using the MACA protocol. Is it possible for two transmissions to take place simultaneously? Explain your answer.

14. 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?

15. What is the baud rate of classic 10-Mbps Ethernet?

16. Sketch the Manchester encoding on a classic Ethernet for the bit stream 0001110101.

17. 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?

18. Consider building a CSMA/CD network running at 1 Gbps over a 1-km cable with no repeaters. The signal speed in the cable is 200,000 km/sec. What is the minimum frame size?

19. 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?

20. 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?

21. The 1000Base-SX specification states that the clock shall run at 1250 MHz, even though gigabit Ethernet is only supposed to deliver a maximum data rate of 1 Gbps. Is this higher speed to provide for an extra margin of safety? If not, what is going on here?

22. How many frames per second can gigabit Ethernet handle? Think carefully and take into account all the relevant cases. *Hint*: the fact that it is *gigabit* Ethernet matters.

23. Name a network that allow frames to be packed back-to-back. Why is this feature worth having?

24. In Fig. 4-27, four stations, A, B, C, and D, are shown. Which of the last two stations do you think is closest to A and why?

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

26. See Fig. 4-33(b). 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 tc F, which pairs of stations are hidden or exposed terminals?

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

(a) TXOP is not used?
(b) TXOP is used?

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

29. Two devices connected to the same 802.11 network are both downloading a large fi from the Internet. Explain how one device could obtain a higher data rate than t other by (ab)using a 802.11 mechanism intended to provide quality of service.

30. Fig. 4-28 shows different wait times in 802.11 for frames with different priorities. Th approach prevents high-priority traffic, such as frames carrying real-time data, fro getting stuck behind regular traffic. What is a disadvantage of this approach?

31. Give two reasons why networks might use an error-correcting code instead of error d tection and retransmission.

32. Why are solutions such as PCF (Point Coordination Function) better suited for v sions of 802.11 that operate at higher frequencies?

33. A disadvantage of Bluetooth's profiles is that they add significant complexity to protocol. How can these profiles be an advantage from the perspective of the appl tions?

34. Imagine a network where stations communicate using laser beams, similar to the se shown in Fig. 2-11. Explain how this setup is similar to, and different from, both E ernet and 802.11, and how that would affect the design of its data link layer and M protocols.

35. From Fig. 4-30, we see that a Bluetooth device can be in two piconets at the same ti Is there any reason why one device cannot be the controller in both of them at the sa time?

36. What is the maximum size of the data field for a 3-slot Bluetooth frame at basic r Explain your answer.

37. Bluetooth supports two types of links between a controller and a worker. What they and what is each one used for?

38. It is mentioned in the text that the efficiency of a 1-slot frame with repetition enco is about 13% at basic data rate. What will the efficiency be if a 5-slot frame with r tition encoding is used at basic data rate instead?

39. Beacon frames in the frequency hopping spread spectrum variant of 802.11 contai dwell time. Do you think the analogous beacon frames in Bluetooth also contai dwell time? Discuss your answer.

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

41. Consider the extended LAN connected using bridges *B*1 and *B*2 in Fig. 4-33(b). pose the hash tables in the two bridges are empty. What does *B*2's hash table lool 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.

42. Consider the extended LAN connected using bridges *B*1 and *B*2 in Fig. 4-33(b) pose the hash tables in the two bridges are empty. Which of these data transmi 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.

43. Consider the extended LAN connected using bridges *B1* and *B*2 in Fig. 4-33(b pose the hash tables in the two bridges are empty. List all ports on which a pac 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.

44. See Fig. 4-36. Imagine an additional bridge, $B0$, is connected to bridges $B4$ and $B5$. Sketch the new spanning tree for this topology.

45. Consider the network of Fig. 4-39. If a machine connected to bridge $B1$ were to suddenly become white, would any changes be needed to the labeling? If so, what?

46. 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.

47. Consider two Ethernet networks. In network (a), stations are connected to a hub via full-duplex cables. In network (b), stations are connected to a switch using half-duplex cables. For each of these networks, why is CSMA/CD (not) needed?

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

49. 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.

50. To make VLANs work, configuration tables are needed in the bridges. What if the VLANs of Fig. 4-39 used hubs rather than switches? Do the hubs need configuration tables, too? Why or why not?

51. In Fig. 4-40, the switch in the legacy end domain on the right is a VLAN-aware switch. Would it be possible to use a legacy switch there? If so, how would that work? If not, why not?

52. 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.

53. 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.

54. Download the wireshark program from *www.wireshark.org*. It is a free open-source program to monitor networks and report on what is going on there. Learn about it by watching one of the many tutorials on YouTube. There are many Web pages discussing experiments you can do with it. It is a good way to get a hands-on feeling for what goes on on a network.