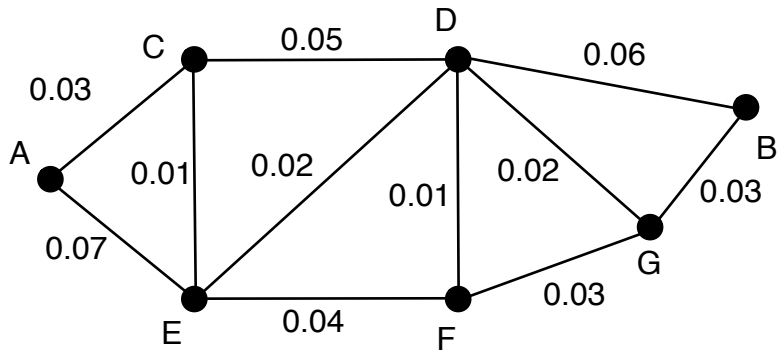
American University of Beirut
Department of Electrical and Computer Engineering
EECE 350/450 – Computer Networks
Spring 2013
Midterm – March 28, 2013
Closed Book / Notes – No Programmable Calculators – 90 minutes

NAME:_____ ID Number: _____

- All questions are equally graded
- **PENALTY** is four-to-one (four wrong answers cancel one correct answer, one to three wrong answers have no effect)
- Grading is based on the answers marked on the SCANTRON sheet only.
- There are **36** questions and **7** pages in this exam.

The number shown next to each link of the network shown below is the probability of the link failing during the lifetime of a virtual circuit *from node A to node B*. It is assumed that links fail independently of each other. Find the most reliable path from A to B; that is, the path for which the probability that all of its links stay intact during the virtual circuit's lifetime is maximal. This problem is equivalent to finding the path with minimum cost, for which we can use Dijkstra's algorithm, as shown in the table below the graph.



Step	N'	D(B), p(B)	D(C), p(C)	D(D), p(D)	D(E), p(E)	D(F), p(F)	D(G), p(G)
0	{A}	∞, -	..., A	∞, -	0.07, A	∞, -	∞, -
1	{A,C}	..., ...	..., ...	0.08, C	..., ...	..., ...	..., ...
2	{A,C,..}	..., ...	..., ...	***Z***, ...	..., ...	..., ...	..., ...
3	{A,C,..,..}	..., ...	..., ...	..., ...	..., ...	..., ***Y***	..., ...
4	{A,C,..,..,..}	..., ...	..., ...	..., ...	..., ...	..., ...	..., ...
5	{A,C,..,..,..,..}	..., ...	..., ...	..., ...	..., ...	..., ...	..., ...
6	{A,C,..,..,..,..,..}	..., ...	..., ...	..., ...	..., ...	..., ...	..., ...

1. Find the value of ***Z*** in the table.
a) 0.08 b) 0.04 c) 0.05 d) 0.06 e) 0.07

2. Find the value of ***Y*** in the table.
a) C b) D c) E d) F e) G

3. At Step 4, the set **N'** includes, in addition to A and C:
a) B,D,E b) B,E,F c) B,F,G d) D,E,F e) E,F,G

4. After finding the most reliable path from A to B, what is the probability of failure of this path? Note that for the path to be intact, *all* the links on the path must be intact.
a) 11.5% b) 12.4% c) 8.7% d) 9.6% e) 10.5%

Suppose users share a 2.4 Mbps link. Also suppose each user requires 200 kbps when transmitting.

5. When circuit switching is used, how many simultaneous users can be supported over the 2.4 Mbps link?
a) 5 b) 6 c) 24 d) 12 e) 10

6. Suppose now that packet switching is used over the 2.4 Mbps link, that each user requires 600 kbps when transmitting, and that there are 21 users in total. Each user transmits with a 10% probability. Find the probability that at any given time instant, 5 or more users are transmitting simultaneously.
a) 5.2% b) 4.3% c) 3.5% d) 2.8% e) 2.2%

Station A wants to send 1100-Byte data frames (neglect header) to station B over an 802.11 wireless LAN. Assume that the distance from A to B is 70 meters, the bitrate is 24 Mbps, DIFS is 50 μs, SIFS is 10 μs, and that the RTS and CTS frames are 20 Bytes and 16 Bytes, respectively, and that ACK frames are 64 Bytes. The propagation speed is 3×10^8 m/sec.

7. Find the propagation delay from A to B (in microseconds).
a) 0.300 b) 0.267 c) 0.333 d) 0.233 e) 0.200

8. Station A starts its DIFS timer at time $t = 0$. Estimate the time at which the *data* frame transmission from A to B *starts* (in microseconds).
a) 57.2 b) 82.5 c) 32.5 d) 72.5 e) 62.5

9. How long does it take station A to transmit all bits of the data frame (in microseconds)?
a) 466.7 b) 433.3 c) 400.0 d) 366.7 e) 333.3

10. What is the cycle time (in microseconds), defined as time $t = T$ at which station A starts its DIFS timer ***again*** to transmit a new frame?
a) 547.9 b) 514.4 c) 581.3 d) 447.5 e) 480.9

11. What is the effective useful throughput of the network (in Mbps)? The useful bits are those of the data frames only.
a) 19.3 b) 17.9 c) 18.3 d) 18.7 e) 19.0

Consider a symmetrical full-duplex 512 kbps wireless link with a 120-millisecond one-way propagation delay between two hosts. The data frames carry a useful *payload* of size 6000 bits. Assume that both ACK and data frames have 320 bits of header information, and that ACK frames carry no data. The propagation speed is 3×10^8 m/sec.

12. What is the effective useful data throughput (excluding headers), in kbps, when using Stop-and-Wait? Assume that the wireless link is error-free.
a) 23.7 b) 27.4 c) 12.1 d) 16.1 e) 19.9

13. If the bit-error-rate (BER) of the wireless link is 10^{-5}, what is the frame error rate for data frames (including header)?
a) 0.033 b) 0.042 c) 0.052 d) 0.061 e) 0.071

14. If the frame error rate is 0.03, and assuming ACK frames are error-free, what is the expected number of frame transmissions when the source has 1000 frames to transmit and uses Stop-and-Wait?
a) 1031 b) 1064 c) 1053 d) 1042 e) 1075

15. What is the minimum number of bits needed to *detect* single-bit errors in the data frames (including header)?
a) 1 b) 2 c) 3 d) 4 e) 5

16. What is the minimum number of bits needed to *correct* single-bit errors in the data frames (including header)?
a) 13 b) 11 c) 12 d) 10 e) 14

Assume now that the link is error-free and uses Go-Back-N sliding windows:

17. What is the maximum *useful data* throughput possible (excluding headers), in kbps?
a) 474.1 b) 486.1 c) 462.6 d) 489.6 e) 481.2

18. What minimum value of window size W gives the maximum throughput possible?
a) 39 b) 30 c) 25 d) 21 e) 18

19. How many bits in the frame header are needed to encode the frame sequence number?
a) 3 b) 4 c) 5 d) 6 e) 7

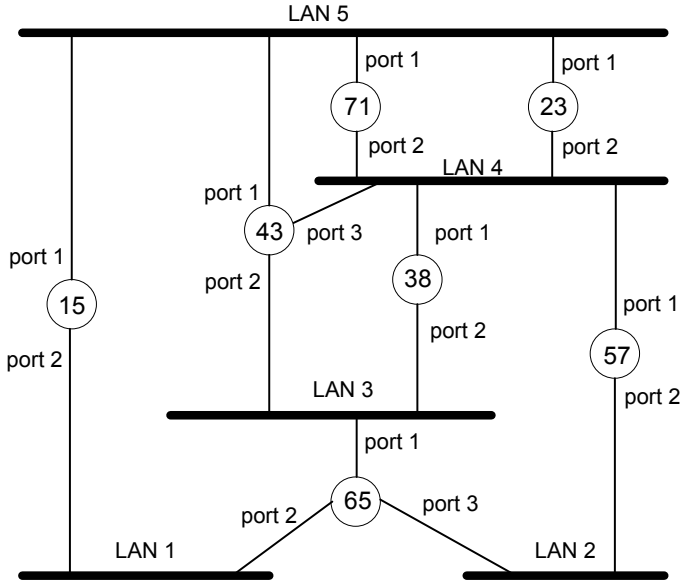
Given two stations A and B connected to one 10 Mbps Ethernet network cable, with *no other* stations on the network. The two stations are 200 meters apart. Each station wants to send a frame of 4000 bits. The propagation speed on the cable is 2×10^8 m/sec. Assume that processing delays at stations A and B are negligible.
Both stations attempt to transmit at time $t = 0$. As a result, a collision occurs. Assume that the collision is detected as soon as the wavefront of the collision signal arrives at a station. After the collision and for the sake of retransmission, A draws $K = 0$ and B draws $K = 1$. Note that Ethernet uses CSMA/CD with backoff intervals of multiples of 512 bit-times, i.e. with backoff intervals of $K\times51.2$ microseconds. Ignore the transmission of jam signals after collision detection.

20. At what time t (in microseconds) does station A detect the collision?
a) 2.5 b) 1.5 c) 2.0 d) 1.0 e) 0.5

21. At what time t (in microseconds) is station A's frame *completely* delivered to B?
a) 503 b) 705 c) 604 d) 301 e) 402

22. Suppose that two Ethernet switches are now inserted between A and B. Each switch has a 5 microsecond processing delay and applies Store-and-Forward as part of its forwarding procedure. At what time t (in microseconds) is station A's frame completely delivered to B?
a) 1211 b) 1812 c) 910.5 d) 1511.5 e) 2112.5

The circles in the network diagram below depict LAN bridges. The bridge ID is the number inside the circle. The thick lines depict LAN segments (LAN 1 to LAN 5).



23. For the Spanning Tree, the root bridge is bridge number:
a) 57 b) 43 c) 65 d) 23 e) 15

24. Assume that the Spanning Tree is formed. A station on LAN 2 transmits a frame to another station on LAN 3. Which bridge will *not* forward the frame?
a) 65 b) 38 c) 15 d) 43 e) 23

25. Assume that the Spanning Tree is formed. A station on LAN 5 transmits a broadcast frame. How many frame transmissions occur (including the initial transmission by the station on LAN 5)?
a) 7 b) 9 c) 5 d) 8 e) 6

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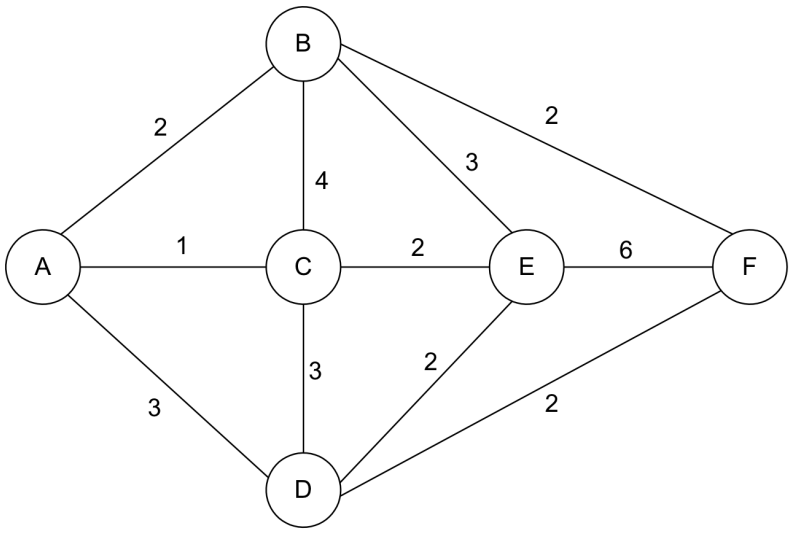
26. In the wired network shown below, flooding is used for packet delivery. How many packet transmissions are seen when node B sends a packet to node D? Packet switches remember packets that they have seen and do not forward them again. The destination does not forward the packet.
a) 18 b) 19 c) 22 d) 25 e) 14



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27. Consider a 4-layer protocol architecture with the following layers: link, network, transport, and application. The link layer uses FLAG Bytes to delimit a frame at its start and at its end. The network layer uses a 12-Byte header. The transport layer uses a 10-Byte header. Moreover, the transport layer limits the size of its *payload* to 100 Bytes. For a 450-Byte message from an application, what is the overhead (in **%** of total) in the transmission of the message (overhead_Bytes / total_Bytes)?
a) 13 b) 21 c) 24 d) 17 e) 19

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28. Compute the checksum of the words
1011 0100 1110 1000,
0110 1110 1100 0111, and
1110 0111 0011 1010
using the internet checksum algorithm.
a) 1111 0101 0001 0000
b) 1111 0101 0001 0110
c) 1111 0101 0001 0100
d) 1111 0101 0001 0010
e) 1111 0101 0001 1010

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29. Consider a network with two LAN segments connected by a bridge. On segment 1, four stations: A, B, C, D are present. On segment 2, three stations: X, Y, Z are present. Consider the following sequence of events (in chronological order):
A sends to B ; C sends to X ; X broadcasts ; Z sends to C ; Y sends to D ; D sends to Y.
Which of the following events, that occurs next, will result in a forwarding decision at the bridge (i.e. from segment 1 to segment 2, or vice versa)
a) A sends to C
b) A sends to B
c) Z sends to Y
d) D sends to A
e) B sends to A

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30. Find the CRC when sending the following message bits 110010101110 using the generator polynomial $x^3 + x^2 + 1$
a) 011 b) 001 c) 010 d) 111 e) 101

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31. What is the maximum bitrate (in Mbps) that can be achieved over a channel with a 1.1 MHz bandwidth, and a signal to noise ratio of 30 dB?
a) 15 b) 12 c) 13 d) 14 e) 11

32. How many levels are required for the data transmission in the previous question?
a) 4 b) 32 c) 16 d) 8 e) 64

Suppose you attach a network monitor to observe the sequence of frames that travel over a link from sender A to receiver B. The problem is to deduce what protocols, if any, could have generated the observed sequence. The following diagrams depict a flow of frames, with their corresponding sequence numbers, from the sender (A). There may be traffic from B to A, which is not depicted in the diagram. A gap between adjacent frames implies passage of time with no transmission from the sender.
Note that the *x*-axis is time, and not space.

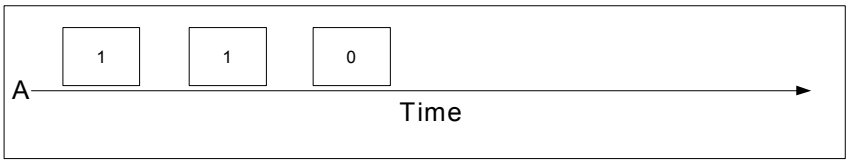

Diagram 1

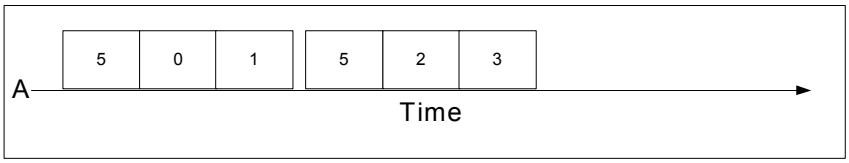

Diagram 2

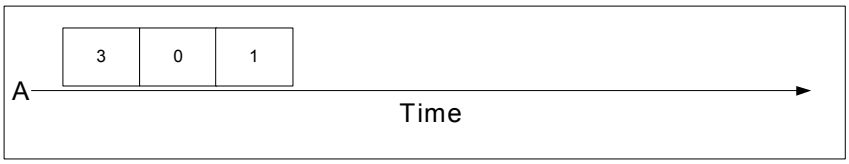

Diagram 3

33. For Diagram 1, the *most likely* protocol being used is:
a) Stop-and-Wait
b) Go-Back-N
c) Selective Repeat
d) Ethernet
e) Spanning Tree

34. For Diagram 2, the *most likely* protocol being used is:
a) Stop-and-Wait
b) Go-Back-N
c) Selective Repeat
d) Ethernet
e) Internet

35. For Diagram 2, the sender window size *seems to be*:
a) 1 b) 2 c) 3 d) $\pi/2$ e) e

36. For Diagram 3, the protocol is *not*:
a) Stop-and-Wait
b) Go-Back-N
c) Selective Repeat
d) Sliding Windows
e) Reliable