6

Name: Christopher Bennett

ECE 4380/6380: Computer Communications **Spring 2018**

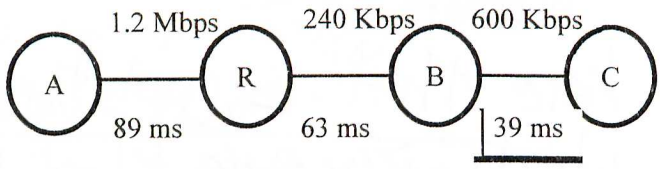
Exam 1 **Friday, February 23**

1. Reliable retransmission protocols. 25 points

22

22
25
25
25
97

Consider three full-duplex point-to-point links connecting nodes *A*, *R*, *B*, and *C* as shown in the figure. The nodes use store-and-forward switching. Ignore any switching or processing delays and assume that there are no errors. The link bandwidths and propagation delays are shown in the figure. For example, the link between *A* and *R* has a data rate of 1.2 Mbps, and the propagation delay on this link is 89 ms. Node *A* has a large number of frames to send to node *C*. All of *A*'s data frames are 1,500 bytes. For any of the ARQ protocols in this problem, an acknowledgement frame is 150 bytes.



✓ 1.1. Suppose *A* sends one frame and when the frame reaches *C*, node *C* immediately sends an acknowledgement frame. What is the round trip time?

✓ 1.2. Consider a sliding window ARQ protocol that operates between nodes *A* and *C*. What is the smallest window size that maximizes the throughput?

1500 bytes = 12000 bits

1.1) $A \to R = \frac{12000 \text{ bits}}{1} \cdot \frac{1 \text{ s}}{1.2 \cdot 10^6 \text{ bits}} = 10 \text{ ms}$

$R \to B = \frac{12000 \text{ bits}}{1} \cdot \frac{1 \text{ s}}{240 \cdot 10^3 \text{ bits}} = 50 \text{ ms}$

$B \to C = \frac{12000 \text{ bits}}{1} \cdot \frac{1 \text{ s}}{600 \cdot 10^3 \text{ bits}} = 20 \text{ ms}$

$C \to B = 1 \text{ ms}$

$B \to R = 5 \text{ ms}$

$R \to A = 2 \text{ ms}$

$RTT = 2(89\text{ms}) + 2(63\text{ms}) + 2(39\text{ms}) + 10\text{ms} + 50\text{ms} + 20\text{ms} + 1\text{ms} + 5\text{ms} + 2\text{ms}$

$\boxed{RTT = 470 \text{ ms}}$ ✓

12) Max throughput of sliding window is $\frac{\text{data}}{\text{packet size}} \cdot$ smallest bandwidth.

Here that is just the smallest bandwidth, which is 240 Kbps

$$240 \text{ Kbps} = \frac{(\text{Window Size})(12000)}{470 \text{ ms}}$$

$\Rightarrow$ Window Size of 9.4 which gives a min window max throughput to be SWS = 10

1.3. Instead of an end-to-end ARQ protocol, consider two ARQ protocols. One operates between nodes *A* and *B* and a second that is independent of the first and operates between nodes *B* and *C*. For the link between nodes *B* and *C*, assume stop-and-wait is used. What is the maximum throughput that can be achieved on the link between *B* and *C*?

$B \xrightarrow[39ms]{600Kbps} C$

$20ms + 2ms + 2(39ms)$

B→C packet C→B Ack propagation time

$\Rightarrow$ Delay = 100ms

$$\boxed{\text{Max throughput} = \frac{12000 \text{ bits}}{100 \text{ ms}} = 120 \text{ Kbps}}$$

1.4. Assume the current-logical channels ARQ protocol is used and that it operates between nodes *A* and *B* (i.e., node *R* is just a store-and-forward switch and does not participate in the ARQ protocol). What is the largest number of channels that can be configured for this ARQ protocol so that none of the nodes experience buffer overflow? (Hint: consider the performance over a very long period. Each node has sufficient buffer space to handle any short-term burst of packets. However, if the rate frames arrive at a node exceeds the rate they depart, eventually buffers will overflow.)

You need throughput to be the same to be able to handle all incoming frames as quickly as they arrive.

RTT between A + B is 10ms + 10ms + 5ms + 2ms + 2(89ms) + 2(63ms)

$\Rightarrow$ RTT(A→B) = ~~371~~ 370 ms

~~Throughput is 32.345 Kbps between A + B~~

Do this the same as you would do sliding window.

$\Rightarrow$ 240 Kbps $\geq \frac{(\text{CLCs})(12000)}{(371 \text{ ms})}$

off by a factor of 2

$\Rightarrow$ CLC # = 7.42

$\boxed{\text{round up to need 8 CLCs}}$

wrong rounding direction

-3

need to limit rate into node B to less that 120 Kbps (by part 1.3)

CLC# ≤ 7.42 $\Rightarrow$ 7

2. CSMA/CD. 25 points

25

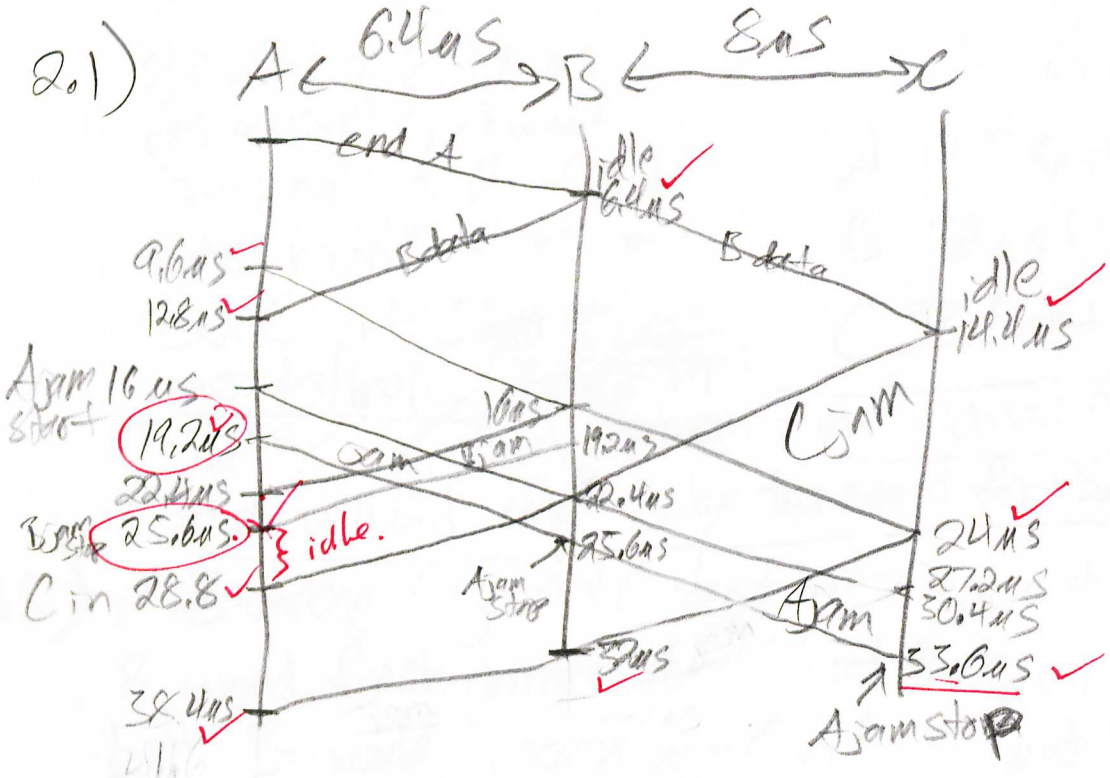
Assume that the Ethernet collision protocol operates as follows. If a host detects a transmission while it is transmitting a frame, then: (i) if the host has already transmitted the 64 bit preamble, the host stops transmitting the frame and sends a 32 bit jamming sequence; (ii) else the host finishes transmitting the 64 bit preamble and then sends a 32 bit jamming sequence. For simplicity, assume a collision is detected as soon as an interfering signal first begins to reach a host. If a host that is transmitting detects a collision, the instant it again detects the channel idle it begin the binary exponential backoff algorithm (recall the duration of a slot is 51.2 μsecs, and a retransmission attempt is made after waiting for x slots, where x is a non-negative integer that is randomly selected). Suppose all frames are 512 bits long, that is, a node transmits a 64-bit preamble followed by the 512-bit frame and followed by a 8-bit postamble.

Three hosts, A, B, and C, are the only active hosts on a 10 Mbps Ethernet. The propagation time between A and B is 6.4 μsec and between B and C is 8 μsec, and host B is located between hosts A and C. Suppose A has been sending its frame and it transmits the last bit of the postamble at time t=0. Host A has another frame to transmit, but it must wait for the 9.6 μsec waiting period before it can attempt its next transmission. Hosts B and C have not been involved in a collision, so the instant each detects the channel idle they will begin their transmissions. Because both hosts B and C transmit there will be a collision.

2.1. Host B detects a collision and sends a jamming signal. After host B is done transmitting its jamming signal, when does host B next detect the channel is idle?

2.2. Repeat question 2.1 for host C.

2.1)



2.1) B next detects channel idle when C finishes its jamming signal to B at 32μs

2.2) C next detects channel idle when A finishes its jamming signal at 33.6μs

2.3. For this problem, host *A* also transmits its next frame, and is involved in a collision. When does host *A first* detect the channel idle after is has finished its jamming signal?

Based on prev. diagram A sees channel first idle at 25.6us when B's jam stops

Because all three hosts experience a collision, the binary exponential backoff algorithm is used. Consider three cases. Assume one of the hosts chooses slot 0 and the other two hosts choose slot 1. For each case: is the host able to transmit successfully? If not, how long does it transmit before it detects a collision?

2.4. Case 1: host *A* chooses slot 0.

2.5. Case 2: host *B* chooses slot 0.

2.6. Case 3: host *C* chooses slot 0.

A takes 64.8us to transmit successfully to B + 72.8us from A→C

B to A is also 64.8us
B to C is 66.4us
C→A is 72.8us
C to B is 66.4us

A 25.6us+51.2us = 76.8us
B 32us+51.2us = 83.2us
C 33.6us+51.2us = 84.8us

2.4) if A chooses 0, B + C start at 83.2us + 84.8us respectively, A would succeed as its first bits would arrive at B + C at 52us + 40us respectively, EXCEPT that Cs original transmission comes in at 28.8us so A will fail and only transmit for 3.2us before colliding

2.5) if B choose 0, A + C start at 76.8us + 84.8us respectively, B would finish correctly at A + C at 96.8us + 98.4us respectively, but B would reach A + C at 38.4us + 40us meaning it would block A + C + transmit correctly

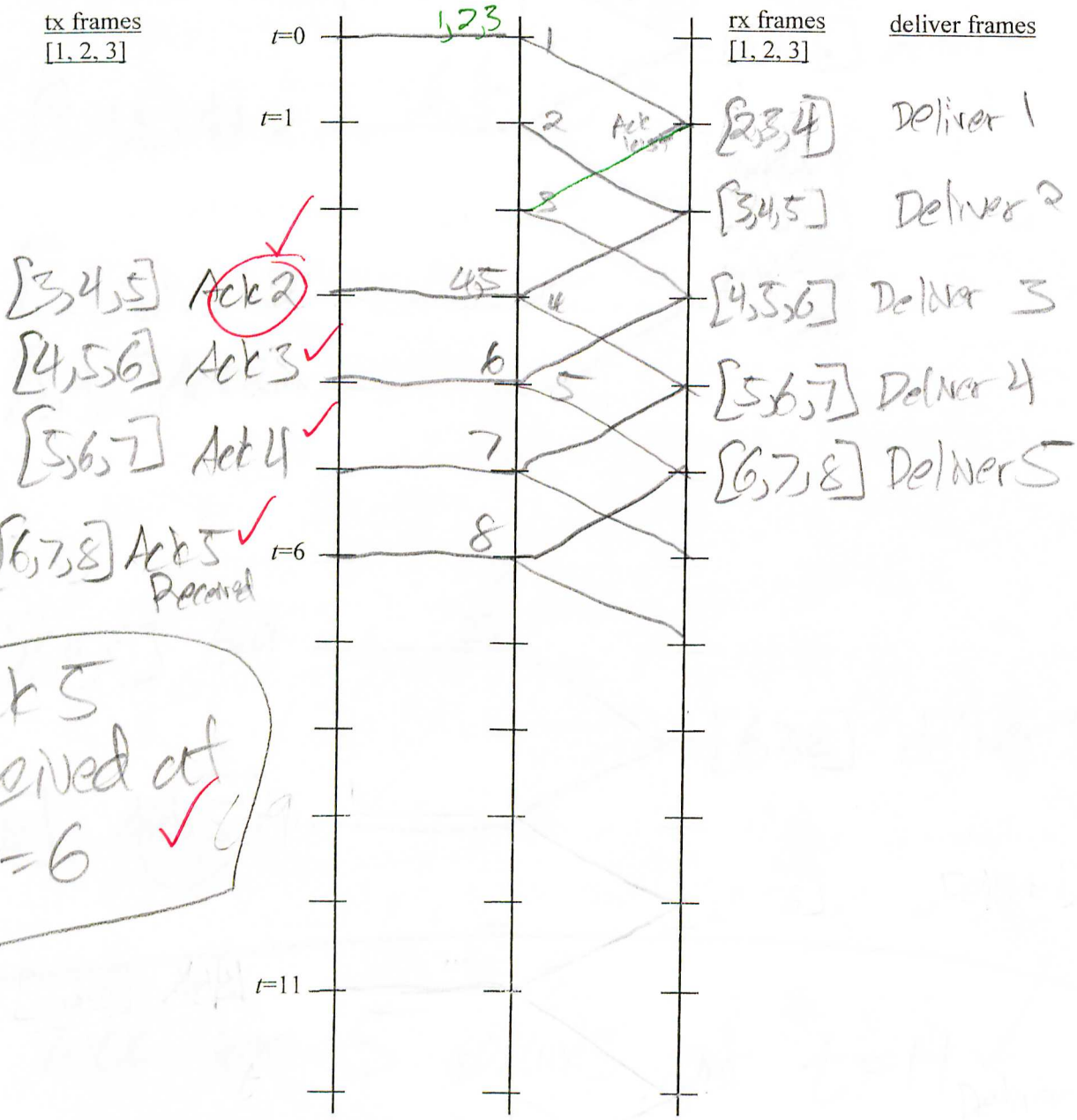
2.6) if C chose 0, A + B would start at 76.8us + 83.2us respectively, C would have first bits reach A + B at 48us + 40us respectively, well before A + B would transmit, so C also succeeds

25

3. Sliding window protocol. 25 points

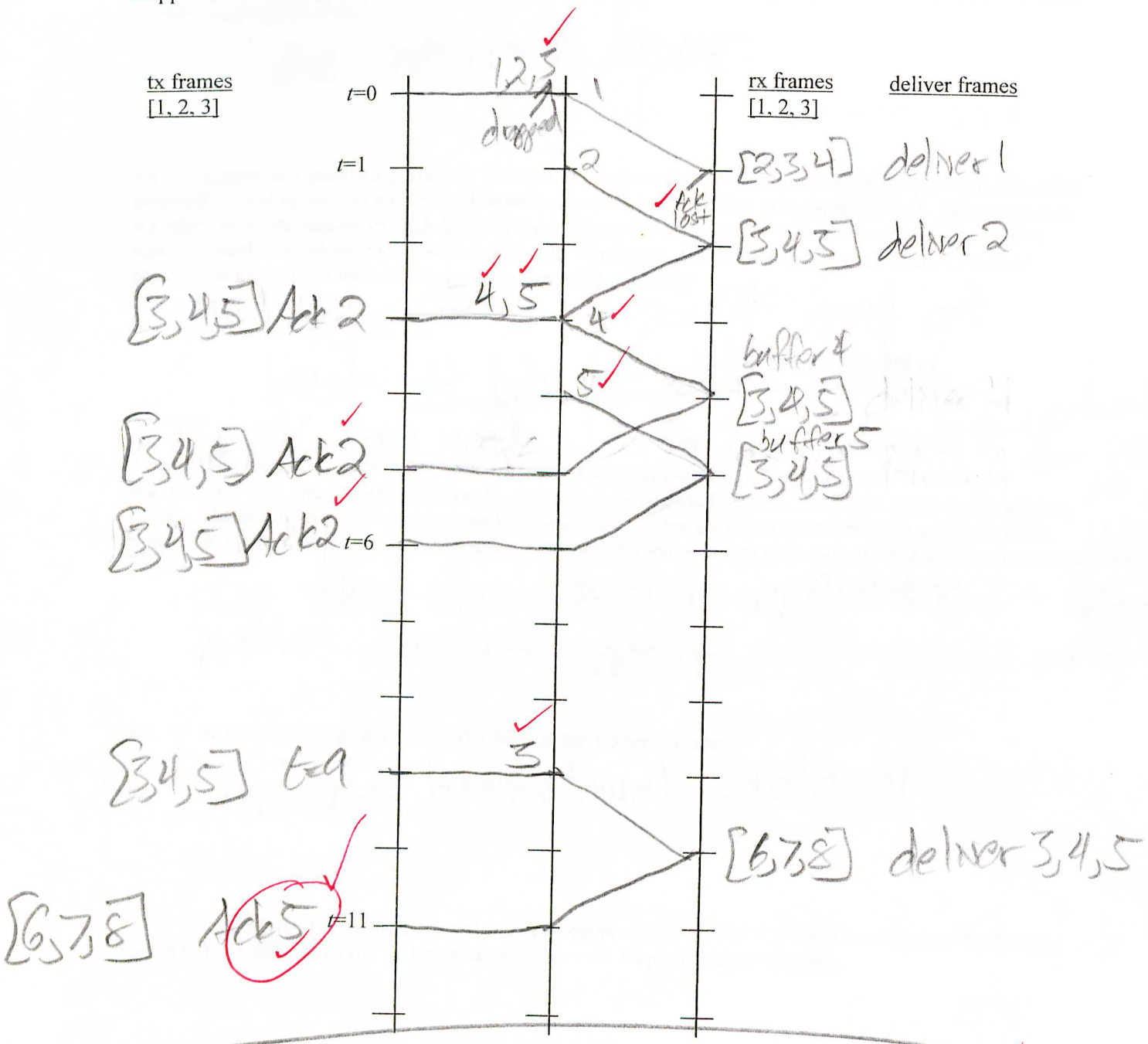
Suppose that host A is connected to host B via an intermediate router R. The link between A and R is instantaneous, but the link between R and B transmits only one frame each second, one at a time. This makes the round-trip time between A and B equal to 2 seconds. All links are full-duplex so that the two directions transmit independently. Assume that at time $t = 0$ host A has a large number of frames to send to host B. Assume the sliding window protocol with SWS=RWS=3 is utilized between host A and B. The source, host A, sets a timer for each outstanding frame and if an acknowledgment is not received in 9 seconds the frame is retransmitted. For all parts of this problem assume that, due to errors on the channel, the transmission of the first acknowledgement by host B is not received correctly at host A, but that all other transmissions are successful.

3.1. Assume the queue size at router R is large enough so that no frames are ever dropped. At what time does host A receive the acknowledgement for the 5-th frame?



Ack 5 received at t=6

3.2. For this question assume the queue size at the router is 1. That is, if 3 frames arrive instantaneously fast from host *A*, the router begins to transmit the first frame, queues the second, but drops the third frame since the queue is full. At what time does host *A* receive the acknowledgement for the 5-th frame? (Hint: just like the previous part, the first ack is lost. In addition the third frame is dropped due to buffer overflow.)



Ack for 5 returns at t=11

25

4. Short Answer. 25 points

Your answer to each question should be twenty words or less. (6380 students: I'll count your 8 best answers. 4380 students: I'll count your 6 best answers.)

4.1. In the OSI architecture, which layer is responsible for forwarding of packets among nodes within a packet-switched network?

The network layer

4.2. Consider a point-to-point link in which it has been determined that to keep the pipe full, the ARQ protocol should be able to transmit 7 frames before receiving the first acknowledgement. How many bits are required in the header of each frame if the sliding window protocol with send window size (SWS) equal to receive window size (RWS) is utilized? How many bits are needed in each frame if instead concurrent logical channels is employed as the ARQ protocol?

RWS = SWS = 7 7·2 = 14 need at least 4 bits for sliding window.

For C/C you need 3 bits for 7 logical channels + 1 extra bit for seq nums so also 4 bits for C/C protocol

4.3. The sliding window ARQ protocol utilizes cumulative acknowledgements. If the sender's window size is N, the sender could see N - 1 duplicate acknowledgements if the first frame in the window is lost. The sliding window protocol we have studied does not attempt a retransmission until a timeout. Why does the sender ignore duplicate acknowledgements even though they indicate that a frame has been lost?

So that the sorcerers apprentice problem does not occur

4.4. What is the purpose of the Type field in the Ethernet frame?

indicates higher level protocol

4.5. Suppose the following error polynomial occurs: $E(x) = x^8 + x^4 + x + 1$. Can this error be detected by the CRC-4 with generator polynomial is $x^4 + x + 1$? Explain why or why not.

4.6. Assume one node on an Ethernet local area network has a very large number of frames to transmit. This node must include a delay of 9.6 μsec between its transmission of each frame. This additional overhead means that the node is not able to achieve the maximum throughput (i.e., the pipe is not kept full). Why does the Ethernet standard require this delay even though it reduces the throughput?

So that no one node grabs the pipe and sends a lot of continuous frames w/o anyone else getting a chance to send

4.7. For a node connected to an Ethernet LAN, CSMA/CD is used to detect a collision and a slotted protocol is used to determine when to schedule a retransmission. If the node has attempted to forward a packet three times and each time it has detected a collision, what is the probability that the node selects the third slot for the next forwarding attempt for this packet?

2^3 slot choices = 8 therefore the probability of choosing the third slot is $\boxed{\frac{1}{8}}$

4.8. The Ethernet protocol was developed for a network in which the nodes are connected by a coax cable. Many current implementations use a star configuration in which each node is connected to a hub by a twisted pair cable. Describe two functions that are performed by the transceiver for a coax-based network but that must be performed by the hub for a star-based network.

The transceiver must both detect collisions and send jamming signals in a coax network. A hub does that in a star network

4.9. The 4B/5B encoding approach adds one additional bit to every four bits that are transmitted. What is the purpose of sending five bits instead of just four?

Adds the possibility of using sentinels as it adds possible sequences that can be used when transmitting

4.10. The Ethernet standard requires that each adaptor connected to a local area network (LAN) must have a unique MAC address. What mechanism ensures that an adaptor (that is compliant with the standard) has an address that is different from the addresses for all other nodes on the LAN?

The NIC has its MAC address burned into it & it cannot send data if its address is not unique