INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Mid-Spring Semester Examination 2023-24

Date of Examination: 19.02.2024 **Session: (FN/AN) AN** **Duration: 2 hrs.** **Full Marks: 60**
Subject No.: CS31204/31006 **Subject: Computer Networks**
Department: Computer Science and Engineering
Specific charts, graph paper, log book etc., required: NONE
Special Instructions (if any): No clarification will be provided during the exam. State any assumption made. Answer written in the space below each question will only be evaluated.

1. **No clarification will be provided during the exam.**
2. **State any assumption made. You will get credit only if the assumption is justified.**
3. **Answer written in the designated space after each question will only be evaluated. This does not mean you need to fill up the space always. Write briefly and to the point. Do not write long answers unnecessarily even if space is left.**

Answer ALL questions

1. (a) Suppose a server having a 10 Gbps Ethernet card is to be connected to a switch around 100 meters away. What kind of cable will you use and why? Justify in 1-2 sentence only. (2)

We will use a MMF optical fiber, as it can be used up to around 550 m.

Grading remarks: 1 mark for saying OFC, 1 for saying MMF. CAT7 is also given some marks but 100m at 10Gbps is borderline for it.

(b) If the bit stream 00111111000111101111000111111 is to be transmitted with a preamble of 0111110, what will be the final bit stream transmitted (not including the preamble)? No explanation is needed. (2)

00111101100011110011110000111101

Grading remarks: 0.5 for each of the four replacements

(c) Synchronous communication needs the clock of the sender and the receiver to be synchronized. If a sender does not send any frames to a receiver for a long time, and then sends a sequence of frames, how is synchronization achieved? (2)

Synchronization has to be re-established first by a special preamble sequence that will indicate the start of transmission (by sending something other than line-idle state signal) and will have enough transitions to synchronize the clock.

Grading remark: 1 mark for start of transmission and 1 mark for clock sync. Given marks as long as preamble is mentioned.

(d) Recall the definition of vulnerable time taught for Aloha (no need to write it). With that same definition, what is the vulnerable time of CSMA/CD? Justify your answer in 1-2 sentences. (2)

The vulnerable time in CSMA/CD is the longest propagation delay (time for 1 bit to travel) between two machines. This is because after a machine starts to transmit, within this time every other machine will get the first bit and so will know channel is being used and so will not transmit anymore if not already started.

Grading remark: 1 mark for correct answer and 1 mark for justification. No marks for anything else.

(e) How can you distinguish between an Ethernet-II and an IEEE 802.3 frame? (2)

The two frames can be distinguished by looking at the type/length field. If the value of the field is <= 1500, it is an Ethernet-II frame, otherwise it is a IEEE 802.3 frame.

Grading remarks: 1 mark for saying type/length field, 1 mark for how to use it.

(f) You have to transmit 16 voice signals, each with a bandwidth of 20 KHz, using FDM. It is given that the bandpass filters used at the receiver side will also accept, with some attenuation, frequencies 5% below the specified lower cutoff frequency and 5% above the specified higher cutoff frequency of the filter. What is the minimum bandwidth of the channel needed to transmit the voice signals without any interference? No calculations need to be shown. . (2)

There are 16 channels. Guard band needed between two consecutive channels is 2 KHz. No. of guard bands needed is 15. So total bandwidth needed is 320 + 30 = 350 KHz.

Grading remarks:2 marks for correct answer, 1 mark for close answers (for ex. that add an extra guard band etc.), 0 otherwise.

(g) A transmitter sends 10 frames, each of size 1000 bytes to a receiver 1 km away using stop-and-wait flow control. The propagation delay is 2 x 10^8 m/sec. The date rate is 10 Mbps. The buffer at the receiver end is checked by the higher layer protocol every 100 microseconds, if a frame is found it is removed, otherwise it checks again after 100 microseconds (so the check is non-blocking). All processing times and the ACK size are negligible. What will be the total time to transmit the 10 frames (from start of transmission of first frame to receiving ACK for the last frame)? Show all calculations for at least the first 3 frames. (3)

Transmission time is 800 microseconds. Propagation delay is 5 microseconds. So Frame 1 is received at 805 microseconds. So it will be picked up at 900 microseconds. ACK will be received back and hence Frame 2 sent at 905 microseconds. This will reach at 1710 microseconds, and will be picked up at 1800 microsecond. So Frame 3 will be sent at 1805 microseconds, which will reach at 2610 microseconds, and picked up at 2700 microsecond. Continuing in this manner, Frame 10 will complete (ACK received) at 9005 microseconds. So total time needed is 9005 microseconds = 9.005 millisecond.

Grading remark: 3 marks only if fully correct and calculations shown for 3 frames. Otherwise 0 to 2 depending on answer.

2. (a) A bit stream 10001101101 is to be transmitted with CRC used for error detection. The generator polynomial for CRC is $X^5 + X^3 + X + 1$. What is the final bit stream sent? Show all calculations. (6)

The final bit stream sent is 1000110110111101. Computation is simple

Grading remarks: 2 mark for final answer, 4 marks for calculations

(b) Explain with an example (list the sequence of events clearly) why in a Go-back-N ARQ scheme with 3-bit sequence numbers, the window size cannot be more than 7. Assume that there is no cumulative ACK. Your answer should show a problem occurring on the receiver side. (4)

3-bit sequence no. means frames are numbered 0, 1, 2, 3, …, 7.
Suppose window size is 8. Consider the following sequence of events:

- *At start, receiver window is at 0 (seq. no. of first frame which is the next frame to receive)*
- *The sender has sent 0,1,2,3,4,5,6,7 without waiting for an ACK.*
- *Since no ACK is received, sender is blocked, sender window is [0,1,2,3,4,5,6,7]*
- *The receiver receives all of them in order and sends one ACK for each, so sends ACK 1, ACK 2, ACK 3, ……, ACK 0.*
- *So receiver window is now at 0 (next frame seq number it expects)*
- *All ACKs sent by receiver except the ACK 0 are lost*
- *Sender receives only ACK 0, thinks all 8 frames sent are lost (given that there is no cumulative ACK). Resends the first frame again (among others).*
- *Receiver receives a frame with sequence no. 0, accepts it as a new frame (the 9^{th} frame) as it is within its receiver window.*

So duplicate frame, which should be discarded, accepted as new frame at receiver.

Grading remarks: Subjective depending on answer. But 0 if sender-side problem shown instead of receiver-side problem as asked, even if it is correct.

3. (a) Consider a CSMA/CA system with IFS period = 10 millisecond and slot time = 100 milliseconds. A node X starts transmitting a frame at t = 0, which will keep the medium busy for 50 milliseconds. Two other nodes A and B get ready to send data at the same time at t = 30 millisecond and each will transmit one frame that takes 60 milliseconds. Binary exponential backoff is used to select the backoff period. What is the earliest time both A and B can complete their transmissions successfully? Justify your answer showing timing diagrams/calculations/steps clearly. (6)

- *B and C both sense the medium at 30, finds it busy, wait till it is free*
- *B and C both find it idle at 50, both wait for IFS till 60*
- *B and C both find it idle again at 60, goes for backoff. Since there is no collision, backoff periods are chosen from 0 or 1 slot (note that given that you are trying to avoid collision, there is no point waiting for a deterministic 0 slot, as then collision is guaranteed if another one finds free.).*
- *Combinations (BC) possible are 00, 01, 10, 11.*
- *For 00 and 11, they will both transmit together again causing a collision, which will be detected after some time, and then they will start from the first step again*
- *So 01 or 10 will give the earliest time*
- *Say B chooses 0, C chooses 1*
- *Then B transmits immediately starting from 60, finishes at 120.*
- *During this time, C's timer is switched off. So C will now wait till 120+100 = 220*
- *C will start to transmit at 220, will finish at 280.*
- *Same happens if B chooses 1 and C chooses 0.*
- *So the earliest time both can finish is 280.*

Grading remarks: 1 mark for initial wait, 1 mark for IFS wait, 2 marks for choosing correct backoff for earliest time finish, 2 marks for C's timer switching off during wait. Marks given varied depending on answer.

(b) Consider 3 nodes trying to transmit one frame each in a system using p-persistent CSMA, with p = 0.3. All three nodes start at the same time and each frame transmission can be completed within a slot time. What is the probability that they will all complete transmitting their frames within 3 time slots? Show all calculations. (4)

Suppose the three nodes are A, B, and C. If they are to complete within 3 time slots, one must transmit in each slot successfully. Suppose they transmit in the order A, B, C.

Probability that A will transmit and B, C will not in 1st time slot = $p(1-p)^2$
Probability that B will transmit and C will not transmit in 2nd time slot = $p(1-p)$
Probability that C will transmit in 3rd time slot = p
So the probability of the transmission happening in A, B, C order = $p(1-p)^2 \times p(1-p) \times p = 0.009261$

Now the number of such orderings possible is 3!, any of which will allow completion in 3 time periods and they are mutually exclusive. So total probability = 6 x 0.009261 = 0.055566

Grading remarks: subjective. However, note that CSMA does not specify how collisions, if they happen, are handled, so if you have considered collision cases with exponential backoff etc, you lost some marks.

4. (a) Suppose that a higher layer protocol gives 38 bytes of data to Ethernet for transmission. What will be the size of the Ethernet frame sent by the sender NIC? How many bytes will be transferred by the Ethernet layer at the receiver to the higher layer protocol? Justify your answer briefly. (4)

Since minimum frame size means at least 46 bytes of data, 8 bytes will be padded. So the size of the frame sent will be 46 + 18 (header) = 64 bytes.

At the receiver side, all 46 bytes will be sent to the higher layer as Ethernet does not have any means of distinguishing data from pad.

Grading remarks: 2 + 2. Binary marked, given 0 or 2. No deduction is done if you have included preamble and said 72 bytes instead of 64, though as mentioned in class, normally preamble is not counted when specifying Ethernet frame size.

(b) Three 8-port Ethernet switches, S_1, S_2, S_3, are purchased and connected in the following fashion. Let the ports in any switch be numbered P_1, P_2,…, P_8. The port P_1 of S_2 is connected to port P_1 of S_1, and port P_1 of S_3 is connected to port P_2 of S_1. The rest of the ports in all switches have desktop PCs connected with them. Draw the diagram first showing the connections, then explain what will happen at each switch when the following events happen in sequence: (i) a machine M (with MAC address M_A) connected to Port P_2 of S_2 sends a frame to a machine N (with MAC address N_A) connected to Port P_4 of S_3, (ii) a reply frame is sent from N to M, and (iii) the machine M is disconnected from the switch. List the steps clearly. (8)

Draw the diagram, it is trivial.

For (i):

- *Since there is no entry for N in S_2, the frame is broadcasted on all ports. The same happens at S_1 and S_3. The broadcasting at S_3 means N receives the frame.*
- *At S_1, an entry is made in the MAC address table of the form $< P_1, M_A >$*
- *At S_2, an entry is made in the MAC address table of the form $< P_2, M_A >$*
- *At S_3, an entry is made in the MAC address table of the form $< P_1, M_A >$*

For (ii):

- *At S_3, the frame is forwarded to port P_1 and an entry is made in the MAC address table of the form $< P_4, N_A >$*

- *At S_1, the frame is forwarded to port P_1 and an entry is made in the MAC address table of the form < P_2, N_A >*
- *At S_2, the frame is forwarded to port P_2 and an entry is made in the MAC address table of the form < P_1, N_A >*

For (iii):

- *The entry for M is removed from all switches when no frames are received from M for a designated timeout period in that switch. During this period, frames sent to M will still be forwarded to Port P_2 of S_2.*

Grading Remarks: 3 + 3 + 2. Heavy penalty in parts (i) and (ii) if you assumed the switch already have the table and no learning is shown. For part (iii), if you have written anything else, you mostly got 0 except in very few cases.

(c) A DLINK DGS-1016 Ethernet switch lists in its specification that it is an "unmanaged" switch and has 16 no. ports that support "10BASE-T, 100BASE-TX, 1000BASE-T". What do you understand from the quoted parts? (3)

"Unmanaged" means that the switch cannot be monitored remotely from a central location.

16 no. ports that support "10BASE-T, 100BASE-TX, 1000BASE-T" means that it has 16 ports, each of which can be connected to a device operating at 10 Mbps or 100 Mbps or 1000 Mbps. Examples of such devices are NICs, ports in other switches etc.

Grading remarks: 1.5 + 1.5. For the "16 no…." part, 0.5 is deduced if it is not clear that each of these ports can support any of these standards.

5. Consider two directly connected nodes that sends data to each other. Selective-Repeat ARQ scheme is used with a window size of W = 9. Frames are numbered from 0. The ARQ scheme sends an ACK for every correct data frame received. ACKs are not cumulative and no piggybacking is used. No NACKs are sent. The frames received are delivered to the user from a buffer B of size N frames (N > W) when the user asks for them. No out-of-order frame is ever stored in B. Assume that B always have enough space and flow control is not needed. Show the essential header fields for data and ACK frames. Then write the pseudocode of the receiver part for any of the nodes. (10)

Since W = 9, sequence numbers must be at least 5-bits, 4-bits allows W to be at most 8.
Since they both will send and receive data, they both will also send and receive ACK, so need to distinguish.
Finally, must have some sort of FCS bits, or ARQ schemes cannot work.
So, Header field of both data and ACK frames: 1-bit Type field indicating data or ACK, 5-bit sequence no., k-bit FCS (any k is fine as long as you noted it).

Psuedocode: First note that Selective-Repeat needs to store out of order packets, so if B cannot store them, another buffer is needed. This is the point most of you missed. So do Selective-Repeat with a window-sized buffer, and when you get an inorder sequence, copy it up to B for user to pick up whenever it wants.

wL = 0 / Initialize left boundary of receive window */*
Initialize a buffer P of size W frames to empty / buffer to hold frames received out of order */*

On receiving a data frame F with sequence no SQN:

/ Discard if frame is in error */*
Check for FCS bits. If frame is in error, drop it and exit receive function.

/ Discard if not in receive window */*
If SQN is not within wL and wL + W – 1 (mod W), discard frame and return.

/ Discard but send ACK if duplicate frame */*
If frame with sequence no. SQN already in P, send ACK SQN and return

Else
/ new frame within receive window. Add to P and check if it completes an in-order sequence now */*
Add F to P
If there is a set S of frames in P with sequence no.s from wL to some wL + x (mod W) with no gap,
/ An in-order sequence is created. Copy to B and remove from P */*
Copy S to B
Remove S from P
/ Move left boundary of receive window */*
wL = wL + x + 1 (mod W)

Grading remarks: 1 marks for sequence no. header field (0.5 deducted if mentioned but size not proper), 1 mark for type header fields, 1 mark for FCS field and FCS processing, 1 mark for in receive window check, 1 mark for duplicate check, 2 marks for in-order seq formed check, 1 mark for moving window boundary, 2 marks for using separate buffer. In general, if you have either copied directly to B, or have just dropped out-of-order frames, you have hardly got any marks in the pseudocode part.

The receiver must also process ACKs, not show here as almost none of you did this, so I didn't penalize. The very few of you who did this, if correct, got 1 mark extra credit.