CS 447-002 Networks and Data Communications
Midterm Exam (PARTIAL SOLUTIONS)
Spring 2024
1:30 -2:45 p.m., February 26, 2024

This exam is a closed-book and closed note exam. There are 5 questions in this exam. You have 75 minutes to finish the questions. Please write your answers on separated piece of papers. To avoid grading problems, please staple your papers in the ascending order in the question number. Calculator can be used during this exam, but you can not share a calculator with anyone else.

Your last 3 digits: ____________________

QUESTION #1 (4 points for each, 15 minutes)

#1: What is "packet encapsulation"? What is it for (i.e., what is the purpose of "packet encapsulation")?

- The term, "packet encapsulation" means that the whole packet in the above (the next higher) protocol layer becomes the payload for this protocol layer.
- The packet encapsulation is for isolating each protocol layer from other layers.

#2: What are "virtual-circuit packet-switching networks"?

Virtual-circuit-switching networks are a type of switching networks (those networks that do not require a full-mesh network, where each switch relays (or "forwards") network payload traffic (signals or packets) to its correct destination with the following properties*[1]:

① Path set-up is required before data transmission starts

② Data will be transferred as a collection of packets

③ All data (as packets) follow exactly the same path (order of bits transmitted by a sender is preserved at a receiver)

④ Network resource can be shared (because data is transferred as packets) but guaranteed.

Note 1: the four properties about circuit-switching networks are those we agreed (to be those that should be mentioned for this question) at the end of the CS447 lecture on 8/24.

Note 2: if you did not earn the credit for "an example for circuit-switching networks) even if you found that example based on some research you conducted prior to Quiz #2 on 8/29, I suggest you come to see me with the source of the information (example) and the credit for your "example" will be returned to your Quiz #2 grade.

#3: What is the counter concept of "point-to-point"?

"end-to-end"

Note: "peer-to-peer" is not the counter concept of "point-to-point". It is the one for "client and server".

#4: What are the primary disadvantages of “selective-reject ARQ” over “GBN-ARQ”?

Using the selective-reject ARQ, a receiving host computer has to keep (buffer) all packets after a packet error is detected until the packet in error is retransmitted. This is a safe design for high-speed network (by reducing the chance of eating up large memory space).

#5: What are the primary advantages (two major advantages) and disadvantage (one primary disadvantage) in using a large packet size (compared with to a smaller packet size) in datagram packet switching networks? Mention at least two for each of the advantages and disadvantages.

Advantages:

- The total amount of the network traffic is less (because a fewer packets are needed).
- The processor workload at routers/switches is less (because a fewer packets are needed).

Disadvantages:

- When a packet is lost (if packet errors and/or routers too busy), a larger amount of network traffic will be re-transmitted (not efficient for unreliable networks).

QUESTION #2 (20 points, 15 minutes)

Using the following given Message (M) and Key (K), mathematically demonstrate (show the procedures) how CRC error detection can end up with an undetectable error using a complete example ("complete" means that you need to show the procedure at both sender and receiver).

- Message (M) = "1 0 1 0 1 0 0" (7 bits)
- Key (K) = "1 1 0 1" (4 bits)

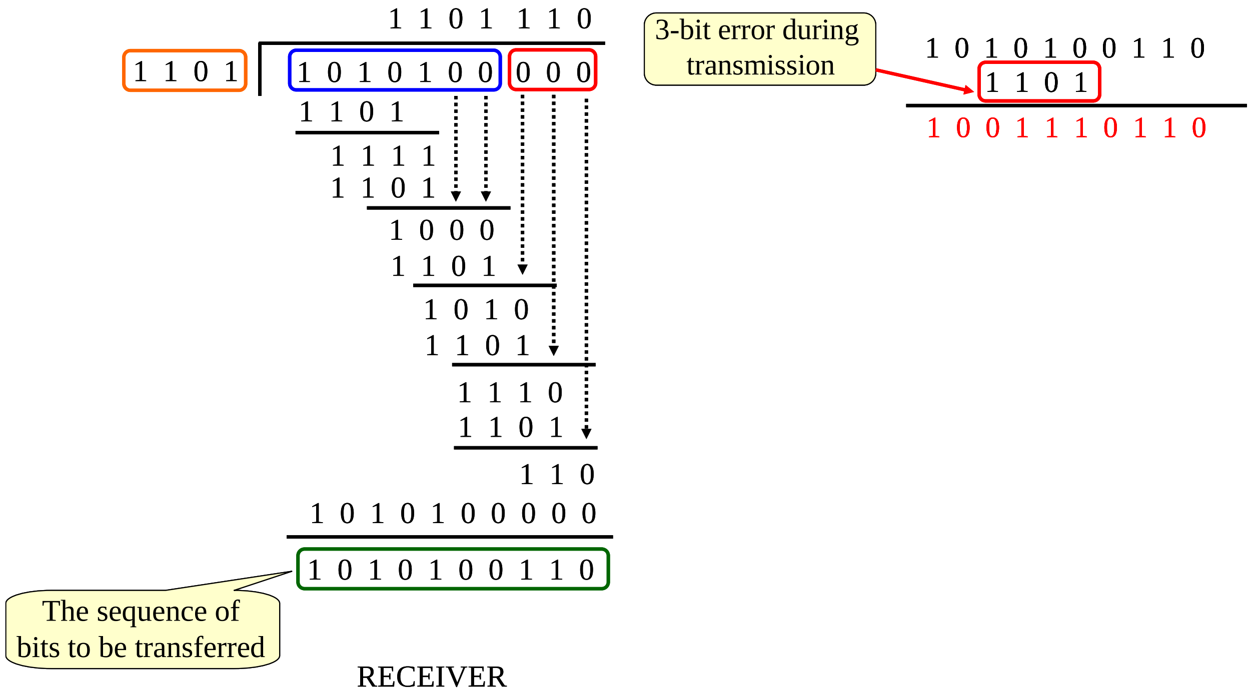
with the following three assumptions (three requirements):

(a) bit-errors occur in following ways: the error bits must be over at most six bits (e.g., "bcbcbc" where b = a bad (error) bit and c = a good (no error) bit).
(b) the number of the bits in bit errors should be less than six bits
(c) bit errors did not occur either at the beginning or the end of the transferred bit sequence

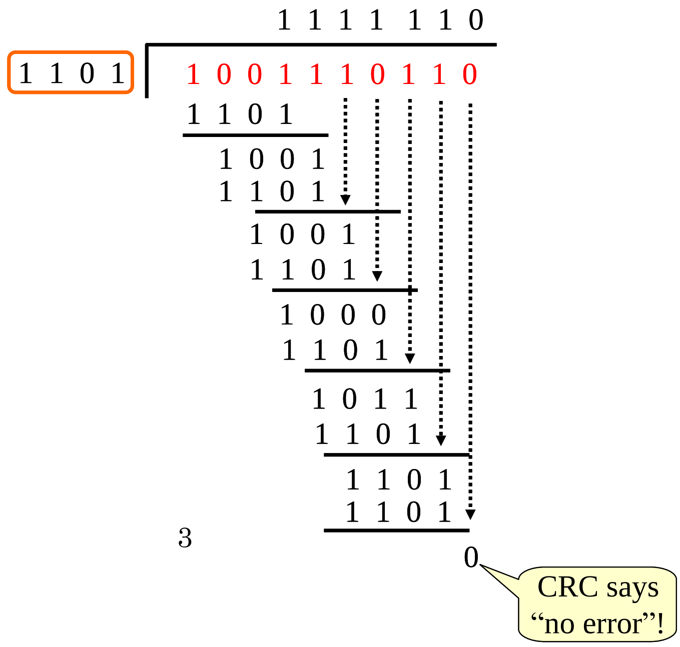
Show all your work.

Solution:

SENDER



RECEIVER



QUESTION #3 (20 points, 15 minutes)

Two host computers (A and B) use a sliding-window flow control with a 4-bit sequence number. Thus, the sequence numbers of 0 through 15 (= $2^4 - 1$) are used to uniquely identify each packet between A and B. Assume that A is transmitting and B is receiving. Each packet carries a sequence number in the order of their transmissions (the first packet carries "0") by A. If the sequence number reaches 15, then the next sequence number will be 0. Let us assume that the window size is 8 (for the error control, assume GBN-ARQ).

Question: Show the window positions (where the open window starts and ends) for both A and B for each of the situations described by (a) and (b) (i.e., at the end of (a) and (b) each). Please take the descriptions exactly as they do (i.e., if something is not mentioned, please assume that it has not happened yet). Show all your work.

First, A establishes a connection with B. Then:

(a) A sent frames, 0, 1, 2, 3, and 4 to B. B received 0, 1, 2, and 3 from A. B sent ACK frames for frames 0, 1, 2, and 3. A received ACK 0 and 1.

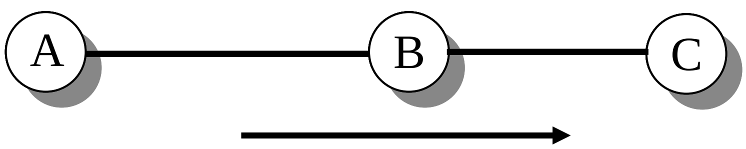
(b) After (a), A sent frames 5, 6, 7, 8, 9, and 10 to B. A sent whichever packets A was allowed to send to B at this time. Then frame 7 got an uncorrectable bit error on the fly from A to B (and it was detected by B). B received all the frames A sent to B so far (since the very beginning) except frame 7.

Note: Dr. Fujinoki assumes it is your responsibility to present your solutions in such a way that Dr. Fujinoki can understand your ideas in your solutions (i.e., you are expected to present your solutions neatly enough for others to understand your ideas in your solutions). If I (Fujinoki) can not understand your solutions, it is difficult for me to give credit to your solution(s).

QUESTION #4 (20 points, 20 minutes)

In the figure below, frames (packets) are generated at node A and sent to node C through node B. Determine the sliding window size for link A-B so that the buffer at node B will never overflow, based on the following conditions:

- The data rate between A and B is 4 Gbps (G = 10^9)
- The data rate between B and C is 1 Gbps
- The propagation delay is 10µs and 80µs for link A-B and B-C, respectively.
- The links are both full-duplex links.
- All data frames are 200 bits long; ACK messages are separate frames of negligible length (frame transmission delay = 0).
- For link A-B, sliding window flow control is used.
- For link B-C, stop-and-wait flow control is used.
- Assume no error.



Note: For this question, completing your calculation(s) is required. Show all your work.

QUESTION #5 (20 points, 15 minutes)

In the asynchronous transmission as defined below, what is the minimum receiver-side clock drift rate that can cause a framing error? For the frame structure (every frame has the same structure), assume:

- 1 start bit
- 10 payload bits
- 1 parity bit
- 1 stop bit

Also assume that the receiver will correctly reads (samples) each bit anywhere in each bit (anywhere from the beginning to the end of each bit).

Show all your work (please make sure to make your idea(s) clearly presented to Dr. Fujinoki). Your solution for this question will be evaluated also based on how clearly you present your idea(s) to Dr. Fujinoki.