CS 447-003 Networks and Data Communications
Midterm Exam (PARTIAL SOLUTIONS)
Spring 2024
3:30 - 4:45 p.m., February 27, 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: Why don't network applications perform actual network data transmissions (instead, "protocol stack" does the work)? Mention at least two different reasons.

- By separating applications and network protocols, it is easy for standard protocols (especially those developed under open software) to be used by any network applications. This will let some network protocols to be used as universal standards (standardization), without dependent on proprietary protocols.
- By using existing protocols, application programmers do not have to implement those network functions – application programmers can focus on implementing their program logics (productivity).
- Since most of the existing protocols have been used by a large number of users for long time. This means that they have been proven to be reliable.
- By separating applications and network protocols, it is easy to replace a network protocol by another one without recompiling applications (flexibility).

#2: What are the primary advantages (two different advantages) and disadvantages (two different disadvantages) in "datagram packet-switching networks"?

Advantages:

① Cheap ways to transmit data (since resource is shared)

② No path setup delay (we can transmit data anytime)

Disadvantages:

① Best-effort service (packets can be dropped, no guaranteed transmission speed)

② Slow transmission (each router on a path performs routing for every packet) – packets take longer time before they reach their destinations

#3: How can we find open TCP ports at a host computer (mention the name of the tool)?

"netstat"

#4: Why is it difficult to determine "the optimum window size" for network connections through the Internet? Mention two most significant reasons (if you provided more than two solutions, only the first two will be graded).

① The distance to each destination varies (if the destination has never been connected before)

② The network traffic in the Internet backbone dynamically fluctuates in such ways that predicting the end-to-end delay to each destination (the delay added at each intermediate router is hard to predict).

Grading criteria: the two should be one about the Internet backbone and the other about destination host computer. Two point for each.

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

Packet encapsulation means that **a packet (= header + data) in an upper network protocol layer simply becomes data in the next lower layer**.

Packet encapsulation is **an implementation of layered structure** (or **independence in each network later from other layers**) in network protocols.

QUESTION #2 (20 points, 10 minutes)

Suppose that asynchronous serial data transmission is clocked by two clocks (one at the sender and the one at the receiver) that each has a drift of 3 minutes in one year. How long a sequence of bits can be sent before possible clock could cause a problem? Assume that a bit waveform will be good if it is sampled within 27% from the center. Assume that the bit samples are taken at the middle of the clock period. Also assume that at the beginning of the start bit the clock and incoming bits are in phase. Show all your work.

Solution:

Assuming that the transmission rate between the sender and the receiver is 100bps (100 bits in each second), the time for transmitting one bit should be 1/100 seconds = 10ms.

Since the receiver's clock drifts by three minutes per year, its drift rate us:

$$(3 \text{ minutes})/(1 \text{ year}) = 3/(365 \times 24 \times 60) = 3/525{,}600$$

The above calculation indicates that, each time the sender transmits a bit, the sample point at the receiver will drift (3/525,699) to either to the left or to the right.

Assume that the receiver can receive ***x*** bits before the accumulated clock drift exceeds the 32% of one bit time, we will have the following equation:

$$\boldsymbol{x} \times (10\text{ms}) \times (3/525{,}600) < (10\text{ms}) \times 0.27$$

Since "10ms" appears in the both sides of the equation, we can cancel them out (i.e., the transmission rate does not matter):

$$\boldsymbol{x} \times (3/525{,}600) < 0.27$$
$$\boldsymbol{x} < 0.27 \times (525{,}600/3)$$
$$\boldsymbol{x} < 50{,}604$$

QUESTION #3 (20 points, 15 minutes)

Although TCP slow-start is an effective technique for dynamically adjusting the window size under various situations, it can result in long recovery times in high-speed networks.

Assume a round trip-time of 35ms and a link with an available bandwidth of 5 Gbps (1G = 10^9) and a packet size of 180 octets (1 octet = 1 byte = 8 bits). How long will it take to reach the window size that is just large enough for full (= 100%) utilization of this link? Calculate “how long” in the ms (millisecond) order (i.e., “how many milliseconds”).

Assume that no error will happen during the packet transmissions.

Show all your work (most of the credit is for showing a correct procedure to find the solution, instead of the solution itself).

QUESTION #4 (20 points, 15 minutes)

Assuming that all other factors remain unchanged, what is the effect to the link utilization (for Stop-and-Wait and Sliding-Window Flow Control) if we changed a factor (as mentioned below)? Choose one from the following four options for each: "better", "unchanged", "worse" or "can't tell" (if more than one option is selected, it will not be graded). You do NOT have to describe your solution. For sliding-window, assume that the window size is larger than one.

For each of your solutions (six of them, attach your justification(s)/explanation(s)). Not mush credit will be earned, if a correct justification is not provided (even if your choice (of "better", "unchanged", "worse" or "can't tell") is correct.

(a) if the link distance becomes shorter?

Stop-and-Wait: Sliding-Window:

(b) if the transmission rate is decreased?

Stop-and-Wait: Sliding-Window:

(c) if the frame (packet) size is decreased?

Stop-and-Wait: Sliding-Window:

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.