ALEYAN

64/100

Midterm Examination, October 28, 2019, Duration: 1.5 hrs
Computer Communication networks (ECE 7428)

Instructions:

1. This examination will be administered to students over a period of 3 days in different locations and at different times. In order to keep the process fair, you **may not** discuss the questions or answers on this examination with anyone before Saturday 11/01/2019. Violation of this rule constitutes violation of our academic integrity policy.
2. You may use only your handwritten cheat sheet (US letter sized, both sides) and a scientific calculator, if needed; no other study aids are permissible. Your cell phone must remain OFF.
3. You may not leave the examination room for *any* reason for the duration of this examination.
4. Illustrate your answers with figures wherever appropriate. Show your work for numerical problems.
5. If you believe that any question is ambiguous or incomplete, you may seek clarification from me if you are taking the examination in class. If taking the examination from a remote location, then please make reasonable assumptions, state them clearly in your answer, and continue answering the question.
6. **This part applies only to examinees proctored online on ZOOM**:

   You may **take a printout** of the PDF of the exam paper and write your answers directly in the space provided for answers **if you have a printer nearby**. Otherwise, blank scrap paper will be needed to write your answers and for scratch work.

   This file must be emailed to me (sarvesh.kulkarni@villanova.edu). You will be granted additional time to do so. You can use either a nearby scanner, or, turn ON your cell phone and use the CamScanner app available for mobile devices to create a PDF for submission.

5

Answer ALL of the following short questions very briefly in 5-6 lines at most. **[6 marks x 8]**

1. State the main differences in the network and transport layers of the ISO OSI and the TCP/IP reference models. 5

- TCP/IP is widely used in practice, ISO/OSI is not. not relevant
- TCP/IP has 4 layers (Physical + Data Link Layer, Network layer, transport layer, Application layer) while ISO/OSI has 7 (Physical, Data Link, Network, Transport, Session, Presentation, Application).
- ~~TCP/IP implements Client/Server approach, ISO/OSI not~~
- ISO/OSI's transport layer is connection oriented only while TCP/IP's transport layer is both connection and connectionless oriented OK
- ISO/OSI's Network layer is both connection and connectionless oriented; TCP/IP's Network layer is only connectionless oriented. OK.

Congestion control < nwk layer (ISO-OSI) / transp. layer (TCP/IP).

2. Name the protocol for the functionality described below.
   a. Network layer protocol in the TCP/IP stack that provides routing and packet forwarding service 0

      ~~SNMP~~ IP.

   b. Application protocol that provides the IP address of a host, given that host's fully qualified domain name

      ~~DHCP~~ DNS

   c. A protocol that helps a client program to discover the port number of a remote server for a given service.

      X Port-mapper

3. Which **transport protocol** from the TCP/IP protocol suite would you choose for the following applications? *Provide a valid reason for your answer.* 3
   a. Video streaming of movies and TV shows.

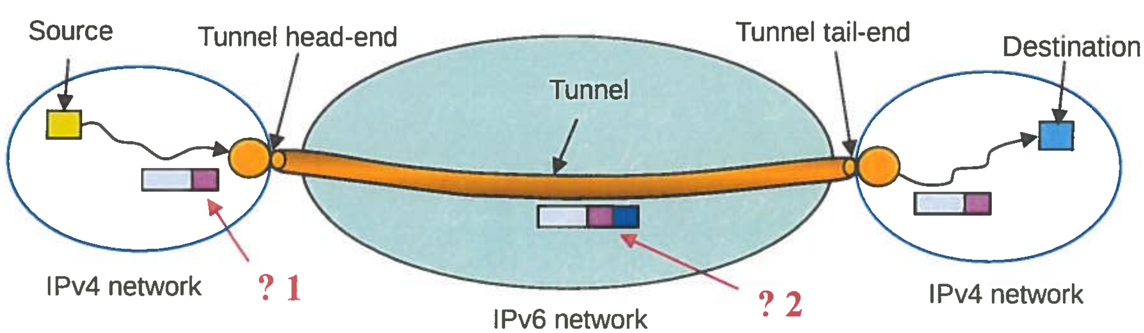
      TCP/IP ok. but why?

   b. Video-conferencing (live) among multiple participants.

      UDP (not a TCP at all)
      OK, but why?

3

4. A packet travels from a source host to destination host over the TCP/IP network shown below. Note that the source and destination reside on IPv4 networks, but the packet must traverse an IPv6 network in the middle.



Suppose the packet sent is an HTTP packet; draw and label the complete packet formats including headers and trailers (for each layer), and the payload in the zones marked with question marks 1 and 2 above. *Do not show* the fields within headers or trailers.

X ?

0

5. In the "Indirect TCP" protocol suggested by Bakre and Badrinath for wireless networks, in what way are TCP semantics violated? 0

6. Can a single TCP source ever saturate a communication link? Provide a reason, preferably by means of an illustration.

Yes. 0

12

7. Assume that you are designing a low-power, low performance embedded network appliance. A customized version of TCP is needed for the device's OS and you have the choice to use a suitable adaptive retransmission timer. Would you use RFC 793 (exponential forgetting) or the Jacobson-Karels algorithm? Explain your choice. 6

RFC 793 since RFC 793 uses sampl and estimated RTT values. Using Jacobson-Karel would be undesirable in this case due to the computational overhead added by determining mean deviation of the RTTs

8. A user decides to opens two different browsers in order to fetch the webpage www.xyz.com/index.html. Is it ever possible that both copies of the webpage will be delivered to the *same* browser? Explain your answer. 6

No since each browser will differ in destination port number provided by the server once the connection is established.

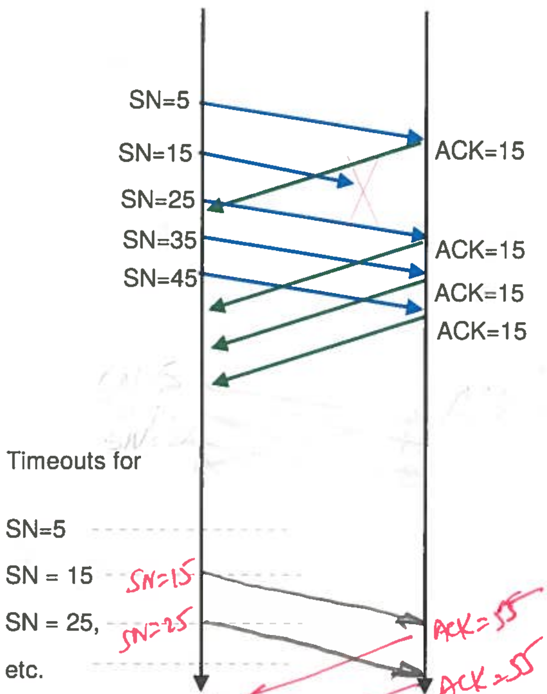
ok.

The following questions require longer answers and will take more time to answer. Answer all questions.

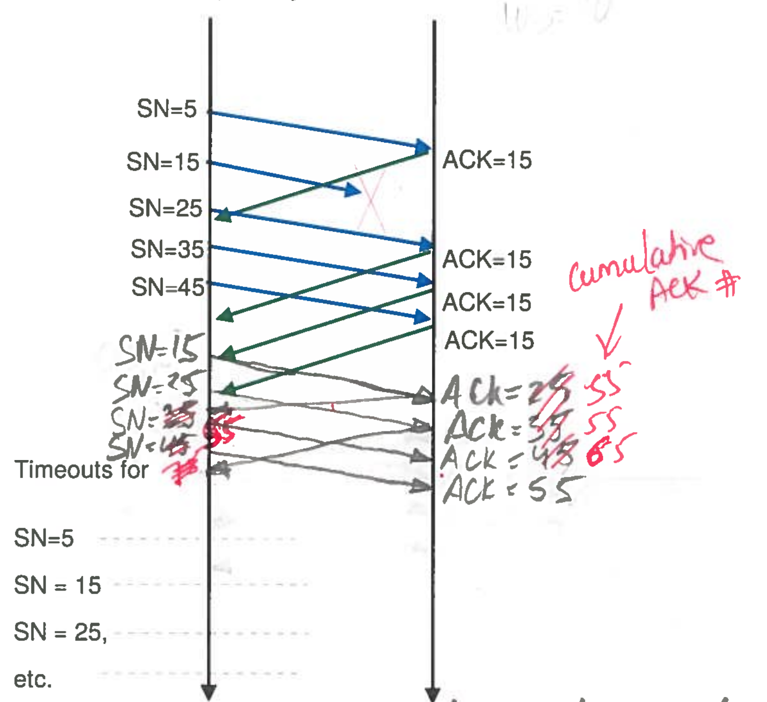
9. Consider the following TCP connection where each segment has 10 bytes of data and segment #15 is lost; the remaining segments are delivered correctly, in order. Extend the message exchange to illustrate how TCP would behave (i) *without fast retransmit* and (ii) *with fast retransmit*. **[12 marks]**

10

(i) ***without*** *fast retransmit*



(ii) ***with*** *fast retransmit.*



In the diagram above, the sender times out waiting for the 5th ACK=55 to arrive. Once time out occurs, the sender will transmit 5 more packets starting with SN=15.

From the diagram above it can be seen that ACK=~~35~~ 55 reaches the sender before the time out occurs. Because ACK=~~35~~ 55 may or may not arrive prior the time out occurs, the next window will either start with either SN=45 or SN=35 respectively.

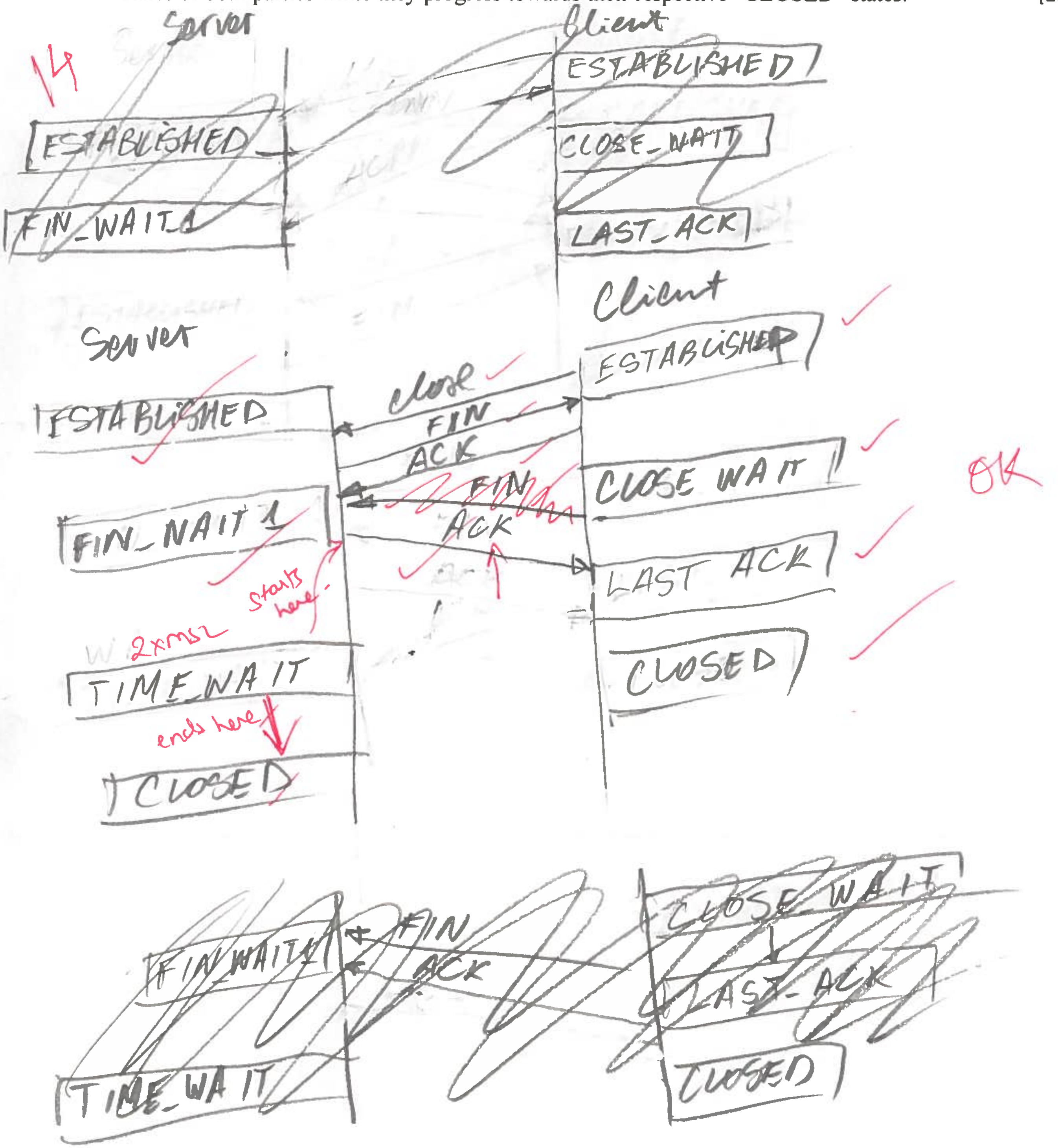
cwnd = cwnd +1 per ack, prior congestion avoidance
after that cwnd = cwnd + $\frac{1}{cwnd}$

10. Sketch a rough plot of a TCP Reno sender's congestion window (`cwnd`, measured in # of segments) against round trip times (RTT) of TCP segments under the following scenario:

The TCP Reno sender starts in slow start phase until it reaches a slow-start threshold of 6 segments. It then goes into congestion avoidance phase till it notices 3 duplicate ACKs which occur when the `cwnd` is 12 segments. At this point, the slow-start threshold is adjusted (show new value) and TCP transmission continues. Next, a multi-segment loss is seen when `cwnd` is 10 causing the threshold to be adjusted again (show new value), and the transmission continues. **[12 marks]**

3 duplicates indicat packet #9 was lost

11. Refer to the TCP state diagram *given in the appendix*, and imagine the following:
Suppose a client and server are both initially in their "ESTABLISHED" states. Then, the **client initiates** a connection teardown with the server. The progression of both client and server towards their respective "CLOSED" states is shown (Client: solid blue curve on the left, Server: dashed green curve on the right)
Show the corresponding message-exchange diagram between the client and the server; clearly label ALL the states of both parties while they progress towards their respective "CLOSED" states. **[15 marks]**



12. Suppose, on a cross-country link between two TCP entities, the bandwidth is 1 Gbps and the round trip time (RTT) is 100 ms. What should be the advertised window size (awnd) in order to maximize TCP's link utilization? What, if any, *window scaling factor* would the receiver's TCP process need to use in its options field (in the TCP header)? Note that in the TCP header, the awnd is a 16-bit field. **[13 marks]**

$B = 1 Gb_1 = 10^9$

$RTT = 100\ ms = 100 \cdot 10^{-3} s = 10^{-1}$

9

Advertised window size should be $\geq$ DBP

$DBP = RTT \cdot R = 10^{-1} \cdot 10^9 = 10^8$

a. awnd $\geq 10^8 / 8$

awnd $\geq$ 100 M / 8 = 1.25 MByte

awnd $\geq$ 1.25 MByte

so, window scaling factor will be:

$$\frac{12.5 \times 10^6 \text{ bytes}}{2^{16} \text{ bytes}} = 190.735$$

i.e. = 256 (next higher power of 2).