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Two Pages, Front and Back. Total Time: One Hour. 14 Questions.

Questions 1-8: 3 Points Each; Questions 9-10: 10 Points Each; Question 11-14: 14 Points Each.

1. List Seven Layers of ISO/OSI Reference Model and Five Layers of Internet Protocol Stack and explain how Internet Protocol Stack model implements the function of ISO/OSI Reference Model.

   Seven Layers of ISO/OSI Reference Model:
   Application, presentation, session, transport, network, link, physical.

   Five Layers of Internet Protocol Stack:
   Application, transport, network, link, physical.

   The presentation and session service if needed are implemented in the application.

2. Explain the difference between Flow Control and Congestion Control.

   Flow control: uses a modified version of the sliding window. Flow from sender to receiver, TCP uses "Window Size" field to tell the sender how many bytes it may transfer and this would help control the rate of sending, so that it can help avoid the packet loss.

   Congestion Control: Traffics are controlled entering to the network, it is done end-to-end by TCP. It wants to fully utilize the resource and achieve self-blocking state. It uses slow start, congestion-avoid and fast retransmit to avoid the packet loss and excessive network load.

3. Explain why TCP connection needs two double handshakes instead of one double handshake.

   To make sure that both of the hosts can be torn down we need to have two double handshakes here. For one double handshake, we could just send one fin and one ack to make one host torn down. To make sure that the other host is also torn down, we need to send another fin to the other host, and receive the ack from it. Then both of them would be torn down. So that is the reason why we need two double handshakes.

4. Differentiate between Non-persistent HTTP and Persistent HTTP

   Non-persistent HTTP: At most one object is sent over a single TCP connection. requires 2 RTTs per object. Browsers can open parallel TCP connections to fetch objects.

Persistent HTTP: Multiple objects can be sent over a single TCP connection between client and server. Server leaves TCP connection open after sending response. Subsequent HTTP messages sent over open connection

5. Differentiate between circuit-switched network and packet-switched network

   Packet Switching is store and forward: entire packet must arrive at router before it can be transmitted on next link. (there is less waste)
   Yet, Circuit Switching is for reserved resources, and it is end-end resources reserved for "call" between source & dest. Circuit segment idle if not used by call (so there is more waste), and it is commonly used in traditional telephone networks

6. List Key Differences between Go-Back N and Selective Repeat

   Go-Back N: For Go-Back N, when it detects frame with error, the packets send after it will be discarded. Until the retransmit of all the packets again, then it will receive the packets successfully.

   Selective Repeat : For Selective Repeat, when it detects frame with error, it will send back the same ack for many times, until the sender send the error packet again, it will return the normal ack.

   This means that for Go-Back N, it re-sends all the packets again to the receiver when there is an error, but for Selective Repeat, it just re-sends the packet which had error.

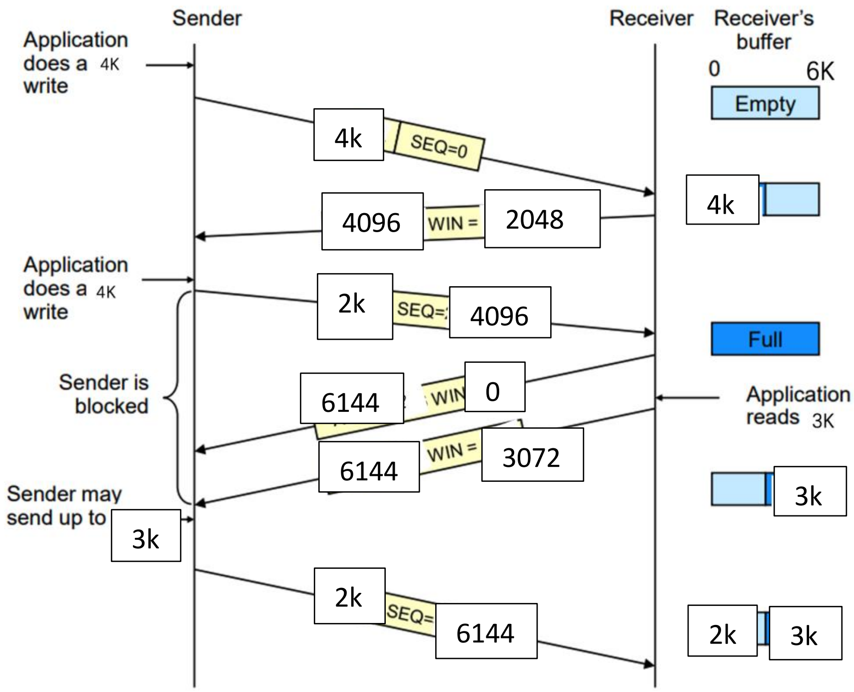
7. How can one tell there is a network congestion?

   When too many sources sending too much data too fast for network to handle, and we would find lost packets (buffer overflow at routers) and long delays (queueing in router buffers).

8. How can a protocol keep the unknown network bottleneck link busy?

   Increase the usage (window size) to keep probing the network
   Decrease the usage when congestion is detected
   We can use TCP slow start and TCP linear increase to achieve this goal.

9. Please finish the 16 "?" fields in the packets based on TCP Flow Control protocol.



10. Please calculate the following SRTT and Timeout Interval based on Initial SRTT and parameters listed.

Initial SRTT = 2 S (two seconds)

α = 0.5 , β = 3

RTT Meas.	SRTT	Timeout
2 S	= 2 S	= β*2 = 6
3 S	= 2 * α + 3* (1- α) = 2.5	= β*2.5 = 7.5
4 S	= 2.5 * α + 4* (1- α) = 3.25	= β*3.25 = 9.75
1 S	3.25 * α + 1* (1- α) = 2.125	= β*2.125 = 6.375
5 S	2.125 * α + 5* (1- α) = 3.56	= β*3.56 = 10.68

11. Suppose you click on a link to obtain a Web page in your Web browser. Assume that the IP address for the associated URL is not cached in your local host, and 6 DNS servers are visited before your host receives the IP address from DNS; the successive visits incur an RTT of RTT1,...,RTT6. If the Web page associated with the link contains a HTML referencing 11 very small objects on the same server, how much time it will take from when the client clicks on the link until the client receives 11 objects assuming (i) we use Persistent HTTP connection without pipelining or (ii) we use non-persistent HTTP with 5 parallel connections?

The total amount of time to get the IP address:
RTT1+ RTT2 + RTT3 +RTT4+RTT5+RTT6

i) .
2RTT0 + 11RTT0 +RTT1+ RTT2 + RTT3 +RTT4+RTT5+RTT6
= 13RTT0 + RTT1+ RTT2 + RTT3 +RTT4+RTT5+RTT6

ii)
2RTT0 + 2*3RTT0 +RTT1+ RTT2 + RTT3 +RTT4+RTT5+RTT6
=8RTT0 +RTT1+ RTT2 + RTT3 +RTT4+RTT5+RTT6

12. A TCP connection is established between two hosts A and B connected over 5 links in tandem. The bandwidth of the first link is 1 Mbps (bps=bits per sec, M = 10^6), and the bandwidth of the next 3 links is ½ of the previous link, and the bandwidth of the last link is ¼ of the first link. What is the maximum bandwidth of the connection?

    Bandwidth of first link : 1 Mbps
    Bandwidth of second link : 1 /2 = 0.5 Mbps
    Bandwidth of third link : 0.5/2 = 0.25 Mbps
    Bandwidth of fourth link : 0.25 /2 = 0.125 Mbps
    Bandwidth of last link : 1/4 = 0.25 Mbps
    The maximum bandwidth connection is the fourth link which is 0.125 Mbps

13. Consider the GO back N protocol with a sender window size of 5 and a sequence number starting from 1. At some time t, the receiver sends an acknowledgment for 10 (received all packets up to 10). What are the possible sequence numbers of packets in the sender's window at time t?

    We have a window size N = 5, and it is mentioned that At some time t, the receiver sends an acknowledgment for 10. So:
    If the sender receives all the ACK: it would be 10 11 12 13 14
    If there is packet lost during the transmission:
    lost ack6: 6,7,8,9,10
    lost ack7 : 7,8,9,10,11
    lost ack8 : 8,9,10,11,12
    lost ack9 : 9,10,11,12,13

14. A TCP connection with a flow control window of 50 packets uses slow start with a minimum congestion window of 1 with ss_thresh=40. How many RTTs are required to send 25 packets (with sequence number 1 through 25), assuming packets with sequence number 6 and 7 are lost and retransmitted. No other packets are lost.

RTT 1 CW=1: 1

RTT 2 CW=2: 2,3

RTT 3 CW=4: 4,5,6,7 (6,7 are lost)

RTT 4 CW=6: 8,9,10,11,12,13 (Because 6,7 are lost, so here are six packets here)

RTT 5 Retransmit 6,7

RTT 6 CW=1 : 14

RTT 7 CW=2 : 15,16

RTT 8 CW=4: 17, 18, 19, 20

RTT 9 CW=8: 21, 22, 23, 24, 25, 26, 27, 28

As a result, it needs 9 RTTs to send 25 packets.