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COMP 4320 – Assignment (3)

Problem 1:

Imagine you are designing a high-performance transport protocol for a system that requires both reliable data transfer and efficient congestion control. Using your understanding of TCP, reliable data transfer mechanisms (rdt), and pipelined protocols (Go-Back-N and Selective Repeat), answer the following questions:

1. **Explain how rdt3.0 ensures reliable data transfer in the presence of packet loss and errors. Discuss the role of ACKs, sequence numbers, and timers in preventing duplicate and lost packets.**

Rdt3.0 has the ability to ensure reliable data transfer through the use of ACKs, sequence numbers, and timers. The receiver will either send an ACK, if successful received packet, or send a NAK, if there is an error. This allows to protect from packet loss. Also, every packet that is transmitted will be assigned a sequence number. This is mainly used to show the difference between old data and a retransmission. There is always a timer that is used when a packet is being transmitted. If no ACK is received within the timer then it will be retransmitted within a timely manner.

1. **Describe how TCP congestion control dynamically adjust transmission rates based on network conditions. Compare slow start, congestion avoidance, and fast recover, and explain how these mechanisms help maintain optimal performance.**

Slow start is when the sender will begin the transmission with a slow congestion window. Then when an ACK is received it will increase exponentially. This allows for packets to be sent at a higher rate without flooding the system. The slow start continues on until it reaches the slow start threshold or packet loss is seen. Congestion avoidance will begin to occur whenever the congestion window is greater than the slow start threshold. It will then limit the growth to a linear growth. This occurs to stop congestion all of a sudden and then it will increase the transmission rate at a normal and linear rate. Fast recovery is seen whenever there is a triple duplicate ACK. It is inferred that only 1 packet is lost compared to all of` them being lost. That 1 singular packet will be transmitted at that time. The congestion window is then cut in half and congestion avoidance will then be the protocol for transmission.

1. **Compare Go-Back-N (GBN) and Selective Repeat (SR) in terms of efficiency, buffer requirements, and retransmission strategies. Discuss which approach would be more suitable for high-speed, low-error networks and why.**

GBN is less efficient due to the fact because it will retransmit all of the window on an error. This is inefficiency because it will repeatedly retransmit packets that already made it. SR on the other hand is much more efficient because the method only retransmits the packets that are lost. This allows for more packets to be sent faster because it does not waste its time on repeating transmission of packets. GBN will only have a buffer on the sender’s end, while SR has buffers on both ends. As stated earlier the retransmission strategy for GBN is to retransmit all of the packets after a single error. SR will only retransmit the packets that are seen as lost. Overall SR is the better option for a high-speed network because it does not waste time on retransmitting unnecessary packets and can use that time and effort elsewhere. It also supports the idea of out of order processing which allows for packets to be sent in any order.

Problem 2:

Imagine you are designing a transport-layer protocol for a network that requires both reliable data transfer and efficient congestion control. Using your understanding of TCP retransmission mechanisms, flow control, congestion control, and connection management, answer the following questions:

1. **Explain how TCP ensures reliable data transfer using cumulative ACKs, retransmissions, and timers. Describe how Fast Retransmit improves TCP efficiency by detecting lost packets early and avoiding long timeout delays.**

Cumulative ACKs will show that the ACKs show all of the bytes to a point in the process. The retransmissions will be sent if it is not seen within a certain time using the timers. This allows for an efficient and speedy process of packet transfer. Those timers will use the idea of RTT. The fast retransmit allows for errors to be seen in advance. This can be seen in the idea of duplicate ACKs. It does not have to wait for a timeout with the timers if there is 3 ACKs that point to the same byte in a row.

1. **Compare TCP congestion control and TCP flow control in terms of their objectives and mechanisms. Explain how TCP dynamically adjusts transmission rates to prevent congestion collapse while ensuring that the receiver’s buffer is not overwhelmed.**

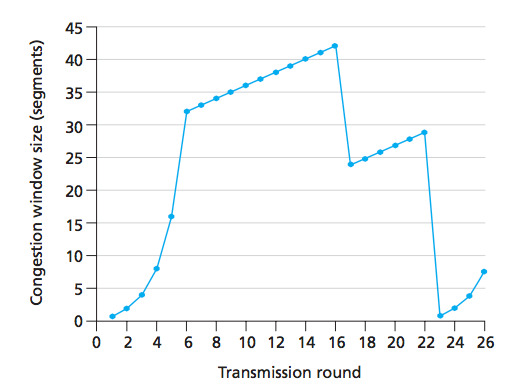
Congestion control’s main objective is to help stop network congestion. This is achieved through changing the rates of sending using the ability of the network. Flow control is mainly used to help stop buffer overflow on the side of the receiver. This is shown by changing the rate of the sender by analyzing what the receiver can handle. TCP is able to control congestion collapse without activating buffer overflow on the sender’s side by using congestion control and flow control. TCP is able to change the congestion windows by implementing slow start, congestion avoidance, and fast recovery that was mention earlier. Flow control is also utilized because it is able to show the receiver window to determine how many packets are sent at a certain time.

1. **Describe the TCP 3-way handshake and explain why it is necessary for establishing a reliable connection. Explain the TCP connection termination process, including how the four-step termination (FIN/ACK exchange) ensures both sides close the connection properly.**

The 3-way handshake begins by the sender sending an initial SYN message with it equal to the sequence number. After that a SYN-ACK will be sent which will show that it acknowledges the ACK number and it will send its own sequence number. The receiver will finally send out an ACK containing the value of the next sequence number that should be sent out. This ensures that all of the packets made it correctly without any loss. It also shows that the sender and receiver are both functioning correctly. It will stop any past packets being implemented in the current handshake. The 4-way handshake beings with a FIN which will start the process of terminating the connection between sender and receiver. The ACK is sent by the receiver to show that the message is understood by the receiver. The receiver will also send a FIN to show that it is ready to end on its end. The sender will send an ACK to show that the connection is closed all the way. This process ensures that no data is lost during the termination process and gives both sides the ability and time to fully end and cut off its connection.

Problem 3:

Consider the following figure showing the TCP window size as a function of time. Assuming TCP Reno is the protocol experiencing the behavior shown in the figure, answer the following questions. In all cases, you should provide a detailed discussion justifying your answer.



1. **Identify the intervals of time when TCP slow start is operating.**

Slow start is operating at time 1-6 and 23 – 26. This is clear by the exponential growth.

1. **Identify the intervals of time when TCP congestion avoidance is operating.**

Congestion avoidance is operating at time 5 – 16 and 16-22. This is clear by the linear growth.

1. **After the 16th transmission round, is segment loss detected by a triple duplicate ACK or by a timeout.**

After the 16th transmission round the segment loss is detected by a triple duplicate ACK because the congestion window size did not drop to 1.

1. **After the 22nd transmission round, is segment loss detected by a triple duplication ACK or by a timeout?**

After the 22nd transmission round the segment loss is detected by a triple duplication ACK because the congestion window size did not drop to 1.

1. **What is the initial value of ssthresh at the first transmission round? What is the value of ssthresh at the 18th transmission round?**

The value of the initial ssthesh at the first transmission round is 32 because that is when the slow start ends and when the congestion avoidance starts. The ssthreshold at 18th transmission round is 21 because loss is seen at 16 and the congestion window size is 42 and it should be cut in half.

1. **What is the value of ssthresh at the 24th transmission round? During what transmission round is the 70th segment sent? Assuming a packet loss is detected after the 26th round by the receipt of a triple duplicate ACK, what will be the values of the congestion window size and of ssthresh?**

The value of sstheshold at the 24th transmission round is 13 because transmission loss is detected at 22 and the congestion windows size is 26. The 70th segment is sent at the 7th transmission round because the segment value at that time is 96. The value of the congestion window is 4 and the ssthesh will be congestion window + 3 so 7.

1. **Suppose TCP Tahoe is used (instead of TCP Reno), and assume that triple duplicate ACKs are received at the 16th round. What are the ssthresh and the congestion window size at the 19th round?**

The congestion window will be set to 1 because it is reset at 16 so if you add 3 it will be 4. The ssthresh is halved so 21.

1. **Again suppose TCP Tahoe is used, and there is a timeout event at 22nd round. How many packets have been sent out from 17th round till 22nd round, inclusive?**

At round 17 there is 1 packet. At 18 there are 2 packets. At 19 there are 4 packets. At round 20 there are 8 packets. At round 21 there are 16 packets. At round 22 there are 21 packets. The total is 52.

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| Q1: |  | Q2: |  | Q3: | Q4: | Q5: |  | Q6: |  |  |  | Q7: |  | Q8: |
| 1-6 | 23-26 | 5-16 | 16-22 | Triple ACKs | Triple ACKs | 32 | 21 | 13 | 7 | 4 | 7 | 21 | 4 | 52 |

**YouTube Links:**

Problem 1: <https://youtu.be/17r1AIr-edc>

Problem 2: <https://youtu.be/JV0RK95bbFA>

Problem 3: <https://youtu.be/VaqIDNnD7V0>