EE 4204 Computer Networks (Part 1)

Semester 1, 2021-22

TUTORIAL 3: PROBLEMS & SOLUTIONS

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Problem 1

- <u>Problem</u>:
  - Suppose that node A sends frames to node B using sliding window protocol.
  - Assume that the size of the window is 7 and the sequence number of frames is in the range from 0 to 7. Further assume error-free communication.
  - Set S_A corresponds to the set of frames transmitted but not yet acknowledged at node A. Set W_A corresponds to the set of frames that may be transmitted at node A. Set R_B corresponds to the set of frames received but not yet acknowledged by node B. Set W_B corresponds to the set of frames that may be received by node B.

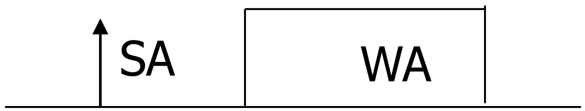
Problem 1 (contd.)

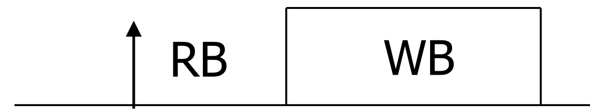
- Problem (contd.):
  - Initially at time T_0, set S_A and set R_B are empty and $W_A = W_B = \{0,1,2,3,4,5,6\}$.
  - At time T_1, node A has transmitted frame 1.
  - At time T_2, node A has transmitted frame 4.
  - At time T_3, node B has received frame 3.
  - At time T_4, node B has transmitted an acknowledgement frame RR_4.
  - At time T_5, node A has transmitted frame 6.
  - At time T_6, node A has received RR_4 and node B has received frame 5.

Problem 1 (contd.)

- Problem (contd.):
  - Write down the contents of the sets at various time instants in the Table below. given below. Ignore the shaded cells in the table. Assume that T_0 precedes T_1, T_1 precedes T_2, and so on.

Time	$\mathbf{S_A}$	$\mathbf{W_A}$	$\mathbf{R_B}$	$\mathbf{W_B}$
T_0	{}	{0,1,2,3,4,5,6}	{}	{0,1,2,3,4,5,6}
T_1				
T_2				
T_3				
T_4				
T_5				
T_6				





Problem 1 (contd.)

- Solution:

Time	S_A	W_A	R_B	W_B
T_0	{}	{0,1,2,3,4,5,6}	{}	{0,1,2,3,4,5,6}
T_1	{0,1}	{2,3,4,5,6}		
T_2	{0,1,2,3,4}	{5,6}		
T_3			{0,1,2,3}	{4,5,6}
T_4			{}	{4,5,6,7,0,1,2}
T_5	{0,1,2,3,4,5,6}	{}		
T_6	{4,5,6}	{7,0,1,2}	{4,5}	{6,7,0,1,2}

Problem 2

- <u>Problem</u>:
  - Give an example to illustrate the difference between flow control and congestion control?

- <u>Solution</u>:
  - Flow control relates to the point to point traffic between a given sender node and a receiver node.
    - It has to make sure that a fast sender cannot continuously transmit data faster than the receiver is able to absorb it.
  - On the other hand congestion control has to make sure the network is able to carry the offered traffic.

Problem 2 (contd.)

- Solution (contd.):
  - Congestion is a global issue, involving the behaviour of all the nodes, i.e., hosts, switches, routers, store-and forwarding processing and other factors such as buffer and link capacity etc. The following scenarios will explain the differences between the flow control and congestion control.
  - Consider a fiber optic network with a carrying capacity of 1000 Gbps on which a super computer is trying to transfer a file to a personal computer at 1 Gbps. Although there is no congestion in the network, flow control is needed to give the personal computer a chance to breathe.

Problem 2 (contd.)

- <u>Solution (contd.)</u>:
  - At the other extreme, consider a store-and-forward network with 1-Mbps links and 1000 large computers, half of which are trying to transfer files at 100 kbps to the other half. Here the problem is not that of fast senders overpowering slow receivers, but that the total offered traffic exceeds what the network can handle. If we assume 50 links and each traffic traverses 4 links and all the links are evenly loaded, then the offered load to a link is at least $(500 \times 4 \times 100\text{kbps})/50 = 4$ Mbps which is larger than the link rate of 1Mbps. This could possibly lead to congestion.
  - **Ref: S. Tanenbaum, "Computer Networks",** *Prentice Hall*, **PTR.**

Problem 3

- Describe a scenario to illustrate the need for limiting the maximum window size to 2^k-1 for a k-bit frame sequence number with Go-back-N ARQ.

  - Ref: S. Tanenbaum, "Computer Networks", Prentice Hall, PTR.

Problem 3 - Solution

- As an example consider the case of k=3 with frames numbered from 0 through 7. Suppose that W=8. This means at any instant of time there can be up to 8 outstanding frames. Now consider the scenario below.
  - i) The sender sends eight frames F0 through F7.
  - ii) A piggybacked acknowledgement for frame F7 (say RR0) comes back to the sender. (Acknowledges frame 7,6,…,1, and 0), window expands to 8
  - iii) The sender sends another eight frames F0 through F7.
  - iv) Another piggybacked acknowledgement for frame F7 (say RR0) comes back to the sender. (Acknowledges frame 7,6,…,1, and 0),
- Now the question is this: Did all eight frames belonging to the second batch arrive successfully or did all get lost. In both cases, the receiver will send the acknowledgement RR0. The sender has no way of telling. Because of this reason, we restrict the window size W to 7.

Problem 4

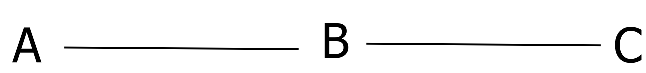
- Problem:
  - Node A transmits 1000 byte frames to node B using selective-repeat ARQ protocol with window size 3 over a 10 Mbps link. The link is 200 km long. The frame error probability is 0.1. The propagation delay on the link is 5μs/km. Calculate the link utilization.
- Solution:
  - Frame transmission time T_f = 8000bits/10Mbps = 0.8 ms
  - Link propagation time $T_p = 200 \times 5 = 1$ ms
  - Frame success probability $p = 1-0.1 = 0.9$
  - $a = T_p/T_f = 1/0.8 = 1.25$; $1+2a = 3.5 > W$
  - Utilization = $W \times p / (1+2a) = 3 \times 0.9/3.5 = 0.77$

Problem 5

- <u>Problem</u>:
  - Suppose that Host A transfers frames to host B using stop and wait protocol through a 100 km-long 10 Mbps link with a propagation delay of 5 μs per km. Assume that each frame carries 500 bytes of data and the communication is error-free. Approximately how many frames are transferred per second?
- <u>Solution</u>: U = Tf/(Tf+2Tp) = 1/1+2a
  - Frame transmission time Tf = 4000/10= 400μs. Link propagation time Tp =500 μs. Since 1 frame is transferred for every Tf+2TP time, the number of frames transferred per second = 1/(Tf+2Tp) = 1000/1.4 = 714 (approx).

Problem 6

- <u>Problem</u>:
  - Node A transmits 1000-bit frames to node C through node B. Link A-B is 4000km long and link B-C is 1000 km long.
  - The frame error probability is 0.1 for link A-B and 0.2 for link B-C.
  - The propagation delay is 5μs/km for each of the links.
  - Between A and B, selective-repeat ARQ with a window size of 3 is used.
  - Between B and C, stop-and-wait ARQ is used.
  - The transmission time of ACK frames is negligible. Node A transmits at the rate of 100 kbps.



Problem 6 (contd.)

- Problem (contd.):
  - (a) How many (original) frames are transferred by node A on link A-B in one second?
  - (b) Calculate the utilization on link A-B.
  - (c) Determine the minimum transmission rate required by B so that the buffers of node B are not flooded.
  - [*Hint:* In order not to flood the buffers of B, the average number of frames entering and leaving B must be the same over a long interval.]

Problem 6 (contd.)

- Solution:
  - Let Tf1 and Tf2 be the frame transmission time at nodes A and B, respectively.
  - Let Tp1 and Tp2 be the propagation delay over links A-B and B-C, respectively.
  - Let p1 and p2 be the frame error probability on links A-B and B-C, respectively.
  - Tf1 = 1000bits/100kbps = 10 ms
  - Tp1 = 20 ms; Tp2 = 5 ms
  - P1 = 0.1 ; p2=0.2; Window size W =3.

Problem 6 (contd.)

- Solution (a):
  - For link A-B, $a = Tp1/Tf1 = 2 \Rightarrow 1+2a = 5 \Rightarrow W < (1+2a)$.
  - Therefore, W (1-P1) frames are transmitted per Tf1+2Tp1 (=50 ms)time.
  - The number of frames transmitted per second = $(3\times0.9/50)\times1000 = 54$

- Solution (b):
  - Utilization = $W(1-P1) / (1+2a) = 2.7/5 = 0.54$

Problem 6 (contd.)

- Solution (c):
  - Node A transmits W(1-P1) frames per Tf1+2Tp1 time.
  - Node B transmits (1-P2) frames per Tf2+2Tp2 time.
  - To avoid flooding of buffers, W(1-P1) / (Tf1+2Tp1) must be smaller than or equal to (1-P2) / (Tf2+2Tp2)
    - no. of frames that can be sent per unit time on the first link must be smaller than or equal to no. of frames that can be sent per unit time on the second link
  - Substituting the values, we have Tf2 $\leq$ 40/2.7 - 10; ie. Tf2 $\leq$ 4.815 ms.
  - The required transmission rate at node B $\geq$ 1000bits/4.815ms = 207.7 kbps   size/B = Tf2; B = size/Tf2