ECS152A Computer Networks – Fall 2002
HW 5 Solutions
Posted: 11/12/2002
Due: 11/19/2002 by 4pm
Homework Box: Room 86

1. (10 pts) Consider the following questions for Stop-and-Wait ARQ:

(a) What does it mean when the receiver receives a segment with the wrong sequence number?

Solution

The receiver receives a duplicate frame. The frame is a retransmission, which means **the previous ACK is lost**.

2. (20 pts) Consider the following questions for Stop-and-Wait ARQ:

(a) What is the disadvantage of having a premature-timeout?

Solution

Redundant retransmissions.

(b) What is the disadvantage of having too long of a timeout interval?

Solution

Slow reaction to packet loss.

(c) Suppose the sender has premature-timeout values. Sketch the sequence of frame exchanges that transpire between two stations when station A sends 5 frames to station B. Assume no losses and errors occur during the transmission.

Solution

Sender sends every frame twice.

Note: Depending on how you arranged for the premature timeout, there are other solutions including: Sender sends every frame X times, etc.

(diagram)

3. (20 pts) Consider the following questions for Go-Back-N ARQ:

(a) Can you make Go-Back-N ARQ to work like Stop-and-Wait ARQ? If so, how? If not, explain.

<u>Solution</u>

Stop-and-Wait = Go-Back-1

(b) Suppose the entire (including all data and headers) object size, *O*, of 12,000 bytes is to be transmitted in an error-free and loss-free link. The object is split into multiple frames for transmission. Here are the characteristics of the transmission:

- The window size, *W*, is 4.
- The frame size, *S*, is 1000 bytes each.
- The data rate of the link, *R*, is 64,000 bits/second.
- The receiver sends an ACK for each frame received. The time it takes for the ACK to arrive at the sender is 2 seconds.

Assume propagation delay, processing delay, and queuing delay are negligible, and no connection establishment is needed. What is the total time for the receiver to receive the entire object?

<u>Solution</u>

Total number of frames = O/S = 12
Total number of windows needed = (O/S) / W = 12 / 4 = 3
Time to send each frame = time for receiver to get each frame = S/R = 0.125 sec

Time it takes to send the first 4 frames = W*(S/R) = 4 * 0.125 = 0.5 second

Time it takes for the receiver to receive the 1^{st} frame = S/R = 0.125 second
Time it takes for the sender to receive the 1^{st} ACK = (S/R) + 2 = 2.125 seconds

Stall time of sender = 2.125 – 0.5 = 1.625 seconds

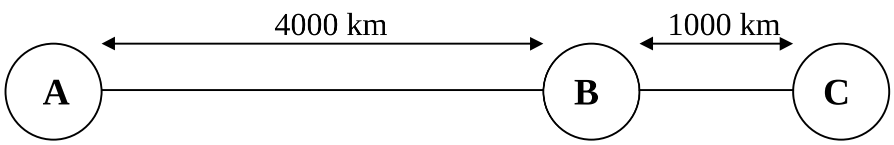
Total time needed = (time to send the first 4 frames + stall time) +
(time to send the second 4 frames + stall time) +
(time to send the third 4 frames)

= (2.125) + (2.125) + (0.5) = **<u>4.75 seconds</u>**

4. (30 pts) In the figure below, all frames are generated at node A and sent to node C through node B. Determine the minimum transmission rate required between nodes B and C so that the buffers of node B are not flooded, based on the following:

- The data rate between A and B is 100 kilobits/s.
- The propagation delay is 5 μs/km for both lines.
- There are full-duplex lines between the nodes.
- All data frames are 1000 bits long; ACK frames are separate frames of negligible length.
- Between A and B, a sliding-window flow control with a window size of 3 is used.
- Between B and C, stop-and-wait flow control is used.
- There are no errors.

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.



SOLUTION:

Since the size of an ACK is negligible, we assume that $t_{ACK} = t_{prop}$

$$t_{ab} = \textit{Time to send one frame and recieve its ACK between nodes A and B}$$

$$= 2t_{prop(A,B)} + \frac{L_{frame}}{R_{AB}}$$

$$= 2\left(\frac{5x10^{-6}s}{1km} * 4000km\right) + \frac{1000bits}{100x10^{3}bits/s}$$

$$= 0.04s + 0.01s = 0.05s$$

Since the link between node A and B uses Sliding-window flow control, the average rate that data is sent (data arriving at B) is (see p. 297-298):

$$E[rate_{AB}] = \frac{W_s}{t_{ab}} = \frac{3\,frames}{0.05s} = 60\,frames/s$$

Thus, in order to not flood B's buffer,

$$E[rate_{AB}] \le E[rate_{BC}]$$

$$60\,frames/s \le E[rate_{BC}] = \frac{W_s}{t_{BC}}$$

Since the Stop-and-Wait flow control protocol is simply the Sliding Window protocol with $W_s = 1$:

$$60\,frames/s \le \frac{W_s}{t_{BC}} = \frac{Ws}{t_{prop(B,C)} + L_{frame}/R_{BC}}$$

Finding the bit-rate between node B and C, R_{BC}:

$$
\begin{aligned}
60\,frames/s &\le \frac{W_s}{t_{BC}} = \frac{Ws}{t_{prop(B,C)} + L_{frame}/R_{BC}} \\
&\le \frac{1}{2*\left(\frac{5x10^{-6}s}{1km}\right)*1000km + \frac{1000bits}{R_{BC}}} \\
1/(60\,frames/s) &\le 2*\left(\frac{5x10^{-6}s}{1km}\right)*1000km + \frac{1000bits}{R_{BC}} \\
0.01667s/\,frame &\le 0.01s + \frac{1000bits}{R_{BC}} \\
0.01667s - 0.01s &\le \frac{1000bits}{R_{BC}} \\
\frac{1000bits}{6.6667x10^{-3}s} &\le R_{BC} \\
149999.999bps &\le R_{BC} \\
R_{BC} &\ge 150kilobits/s
\end{aligned}
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