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EECS 325

Homework 3

1.

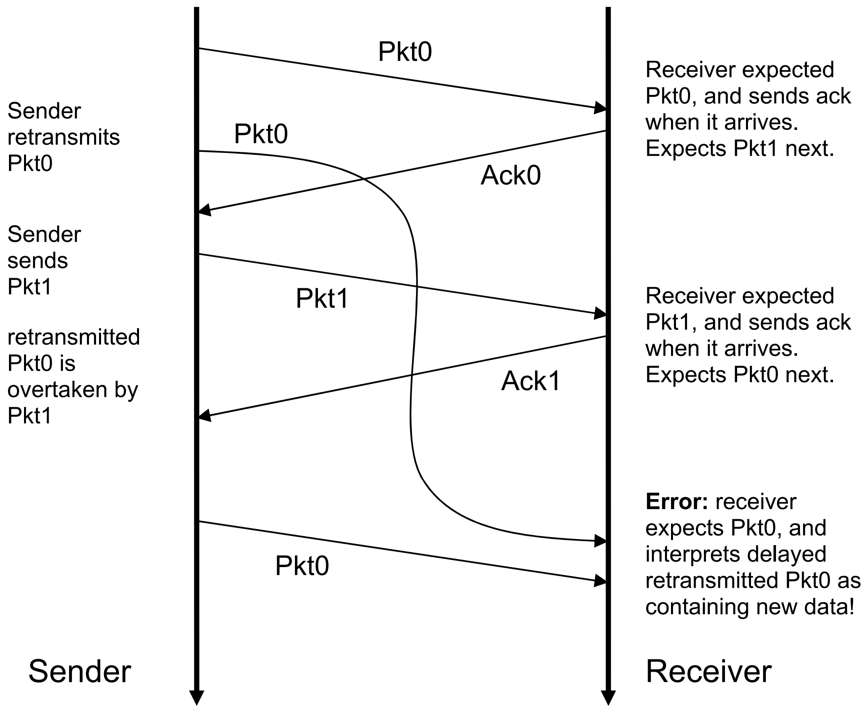
   a. The GBN protocol does guarantee reliable in-order delivery as long as the sender retransmits missing packets. GBN is an automatic repeat request protocol as well as a sliding window protocol with $w_t > 1$ but $w_r = 1$. If a packet is lost in transit, following packets are ignored until the missing packet is retransmitted. Therefore, GBN is reliable but inefficient on links that suffer frequent packet loss.

   b. The protocol would indeed behave correctly.

2. Window size should reflect the receiver's ability to receive and buffer messages, or the level of congestion in the network, or both. The sender could increase its window size without issue, as long as the size of the window does not exceed certain limitations. Specifically, the window size must be less than or equal to half the size of the sequence number space for SR protocols.

3.

   a. rdt3.0 can still fail even if no packets are lost. An error occurs when resent packets arrive much later than expected (i.e. after a timeout): they can be mistaken for new data. For example,



   b. rdt2.2 does not suffer the same issue as above. rdt3.0 differs from rdt2.2 in that timeouts have been added. The potential for timing out can improve efficiency, however it allows the above issue. Since rdt2.2 does not feature timeouts, it is not susceptible to this specific issue.

4. The SR protocol needs a sequence number range covering at least $2N$ distinct numbers. In contrast, the GBN protocol will not allow the receiver to accept packets out of order, and therefore a sequence number range covering $N + 1$ distinct numbers is necessary.

5.

a. $ERTT_1 = SRTT_1$

$$\begin{aligned}
ERTT_2 &= \alpha\, SRTT_2 + (1-\alpha)ERTT_1 \\
&= \alpha\, SRTT_2 + (1-\alpha)SRTT_1 \\
ERTT_3 &= \alpha\, SRTT_3 + (1-\alpha)ERTT_2 \\
&= \alpha\, SRTT_3 + (1-\alpha)(\alpha\, SRTT_2 + (1-\alpha)SRTT_1) \\
ERTT_4 &= \alpha\, SRTT_4 + (1-\alpha)ERTT_3 \\
&= \alpha\, SRTT_3 + (1-\alpha)\big(\alpha\, SRTT_3 + (1-\alpha)(\alpha\, SRTT_2 + (1-\alpha)SRTT_1)\big)
\end{aligned}$$

$$ERTT_n = (1-\alpha)^{n-1}SRTT_1 + \sum_{i=2}^{n}(1-\alpha)^{i-1} * \alpha * SRTT_i$$

$$ERTT_\infty = \frac{\alpha}{1-\alpha}\sum_{i=2}^{\infty}(1-\alpha)^{i-1} * \alpha * SRTT_i$$

b. $SRTT_0 = 100$ ms,
$SRTT_1 = 106$ ms,
$SRTT_2 = 120$ ms,
$SRTT_3 = 140$ ms,
$SRTT_4 = 90$ ms,
$SRTT_5 = 115$ ms,
$DRTT_0 = 5$ ms,
$\alpha = 0.125$,
$\beta = 0.25$

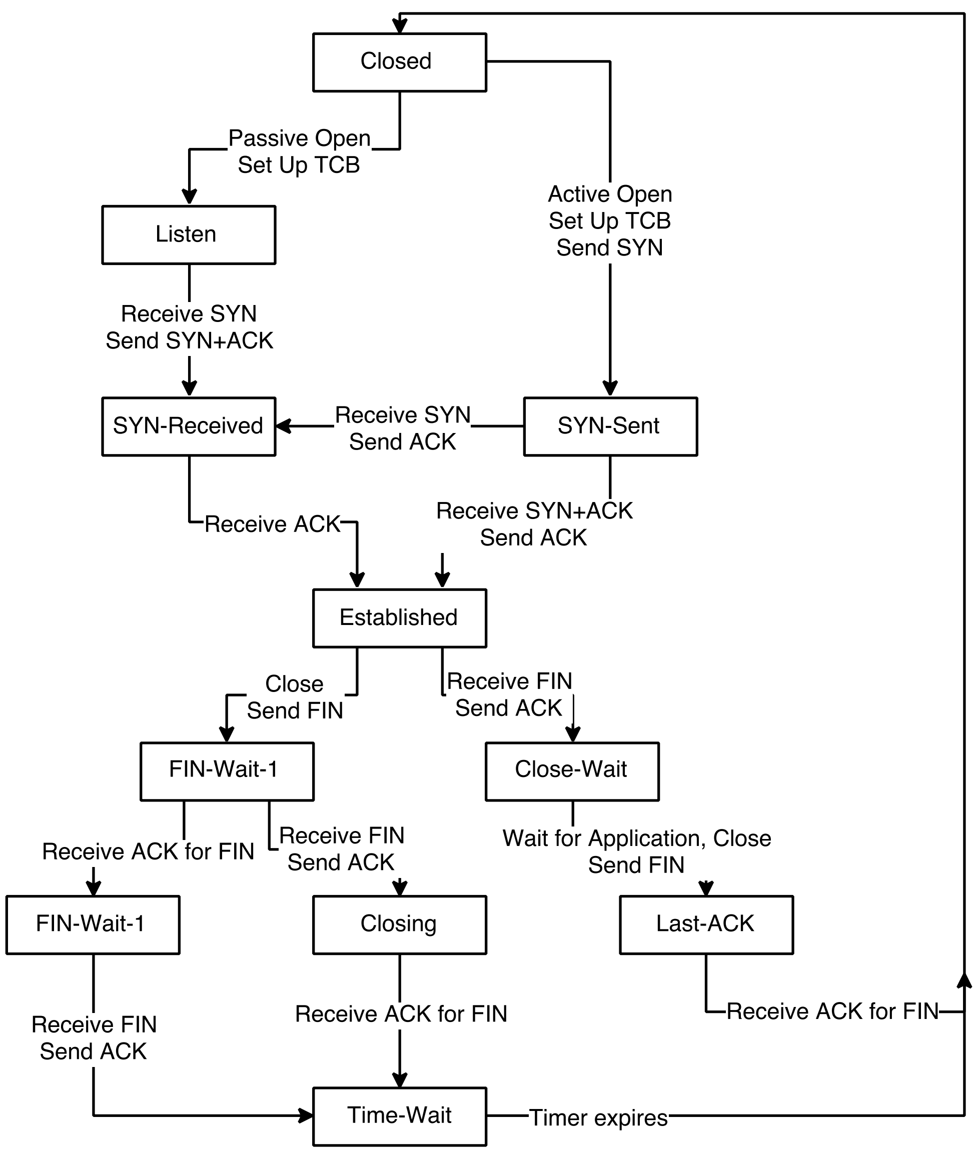
$$\begin{aligned}
ERTT_0 &= SRTT_0 \\
ERTT_1 &= \alpha\, SRTT_1 + (1-\alpha)ERTT_0 \\
&= 0.125 * 106 \text{ ms} + 0.875 * 100 \text{ ms} \\
&= \mathbf{100.75\ ms} \\
DRTT_1 &= (1-\beta)DRTT_0 + \beta|SRTT_1 - ERTT_1| \\
&= 0.75 * 5 \text{ ms} + 0.25 * |106 \text{ ms} - 100.75 \text{ ms}| \\
&= \mathbf{5.063\ ms} \\
TI_1 &= ERTT_1 + 4 * DRTT_1 \\
&= 100.75 \text{ ms} + 4 * 5.063 \text{ ms} \\
&= \mathbf{121.0\ ms}
\end{aligned}$$

$$\begin{aligned}
ERTT_2 &= \alpha\, SRTT_2 + (1-\alpha)ERTT_1 \\
&= 0.125 * 120 \text{ ms} + 0.875 * 100.75 \text{ ms} \\
&= \mathbf{103.16\ ms} \\
DRTT_2 &= (1-\beta)DRTT_1 + \beta|SRTT_2 - ERTT_2| \\
&= 0.75 * 5.063 \text{ ms} + 0.25 * |120 \text{ ms} - 103.75 \text{ ms}| \\
&= \mathbf{7.860\ ms} \\
TI_2 &= ERTT_2 + 4 * DRTT_2
\end{aligned}$$

$$= 103.16 \text{ ms} + 4 * 7.860 \text{ ms}$$
$$= \mathbf{134.6\ ms}$$

$$ERTT_3 = \alpha\, SRTT_3 + (1-\alpha) ERTT_3$$
$$= 0.125 * 140 \text{ ms} + 0.875 * 103.16 \text{ ms}$$
$$= \mathbf{107.77\ ms}$$
$$DRTT_3 = (1-\beta) DRTT_2 + \beta |SRTT_3 - ERTT_3|$$
$$= 0.75 * 7.860 \text{ ms} + 0.25 * |140 \text{ ms} - 107.77 \text{ ms}|$$
$$= \mathbf{13.95\ ms}$$
$$TI_3 = ERTT_2 + 4 * DRTT_2$$
$$= 107.77 \text{ ms} + 4 * 13.95 \text{ ms}$$
$$= \mathbf{163.6\ ms}$$

6.



7. The round trip times were as expected (i.e. similar to ping latency).