

HW3

P6, P23, P26, P27, P31, P37, P40, P47, P48

P6. Consider our motivation for correcting protocol rdt2.1. Show that the receiver, shown in Figure 3.60, when operating with the sender shown in Figure 3.11, can lead the sender and receiver to enter into a deadlock state, where each is waiting for an event that will never occur.

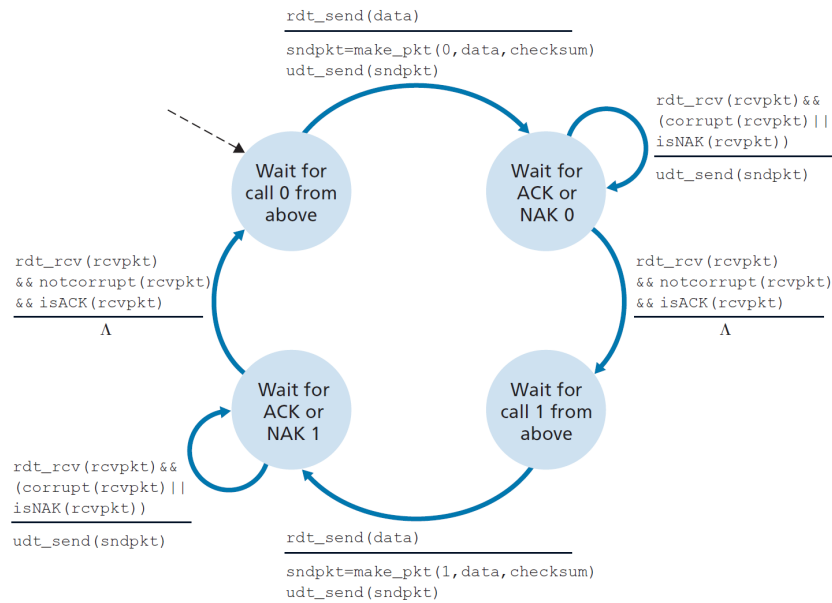


Figure 3.11 ♦ rdt2.1 sender

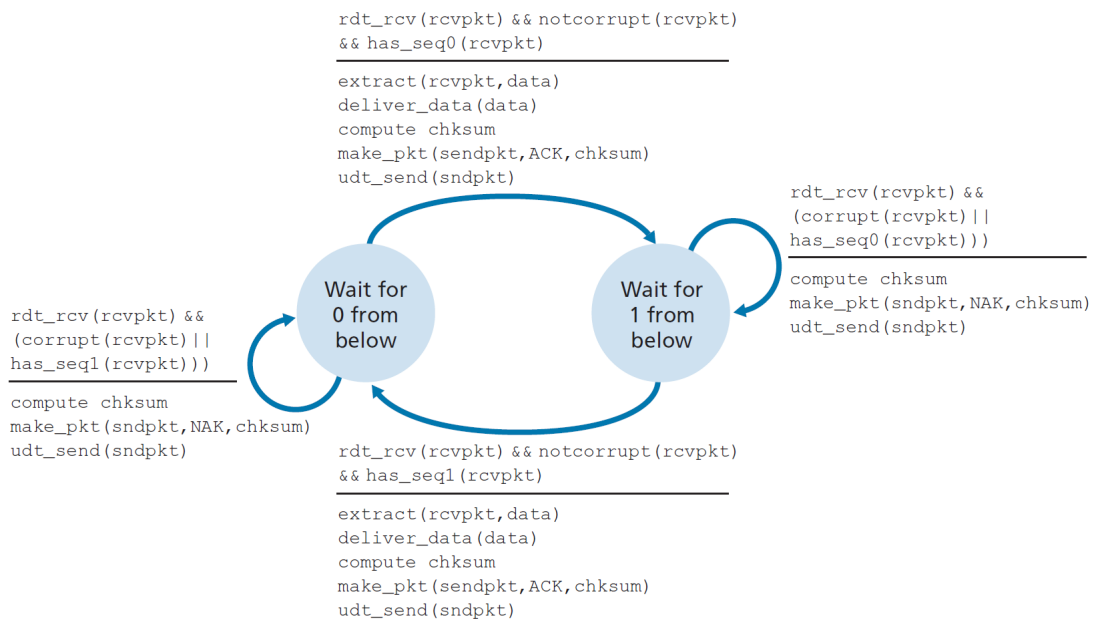


Figure 3.60 ♦ An incorrect receiver for protocol rdt 2.1

P23 Consider the GBN and SR protocols. Suppose the sequence number space is of size k . What is the largest allowable sender window that will avoid the occurrence of problems such as that in Figure 3.27 for each of these protocols?

P26 Consider transferring an enormous file of L bytes from Host A to Host B. Assume an MSS of 536 bytes.

- a. What is the maximum value of L such that TCP sequence numbers are not exhausted? Recall that the TCP sequence number field has 4 bytes.
- b. For the L you obtain in (a), find how long it takes to transmit the file. Assume that a total of 66 bytes of transport, network, and data-link header are added to each segment before the resulting packet is sent out over a 155 Mbps link. Ignore flow control and congestion control so A can pump out the segments back to back and continuously.

P27 Host A and B are communicating over a TCP connection, and Host B has already received from A all bytes up through byte 126. Suppose Host A then sends two segments to Host B back-to-back. The first and second segments contain 80 and 40 bytes of data, respectively. In the first segment, the sequence number is 127, the source port number is 302, and the destination port number is 80. Host B sends an acknowledgment whenever it receives a segment from Host A.

- a. In the second segment sent from Host A to B, what are the sequence number, source port number, and destination port number?
- b. If the first segment arrives before the second segment, in the acknowledgment of the first arriving segment, what is the acknowledgment number, the source port number, and the destination port number?
- c. If the second segment arrives before the first segment, in the acknowledgment of the first arriving segment, what is the acknowledgment number?
- d. Suppose the two segments sent by A arrive in order at B. The first acknowledgment is lost and the second acknowledgment arrives after the first timeout interval. Draw a timing diagram, showing these segments and all other segments and acknowledgments sent. (Assume there is no additional packet loss.) For each segment in your figure, provide the sequence number and the number of bytes of data; for each acknowledgment that you add, provide the acknowledgment number.

P31 Suppose that the five measured SampleRTT values (see Section 3.5.3) are 106 ms, 120 ms, 140 ms, 90 ms, and 115 ms. Compute the EstimatedRTT after each of these SampleRTT values is obtained, using a value of $\alpha = 0.125$ and assuming that the value of EstimatedRTT was 100 ms just before the first of these five samples were obtained. Compute also the DevRTT after each sample is obtained, assuming a value of $\beta = 0.25$ and assuming the value of DevRTT was 5 ms just before the first of these five samples was obtained. Last, compute the TCP TimeoutInterval after each of these samples is obtained.

P37 Compare GBN, SR, and TCP (no delayed ACK). Assume that the timeout values for all three protocols are sufficiently long such that five consecutive data segments and their corresponding ACKs can be received (if not lost in the channel) by the receiving host (Host B) and the sending host (Host A) respectively. Suppose Host A sends five data segments to Host B, and the second segment (sent from A) is lost. In the end, all five data segments have been correctly received by Host B.

- How many segments has Host A sent in total and how many ACKs has Host B sent in total? What are their sequence numbers? Answer this question for all three protocols.
- If the timeout values for all three protocols are much longer than 5 RTT, then which protocol successfully delivers all five data segments in shortest time interval?

P40 Consider Figure 3.61. Assuming TCP Reno is the protocol experiencing the behavior shown above, answer the following questions. In all cases, you should provide a short discussion justifying your answer.

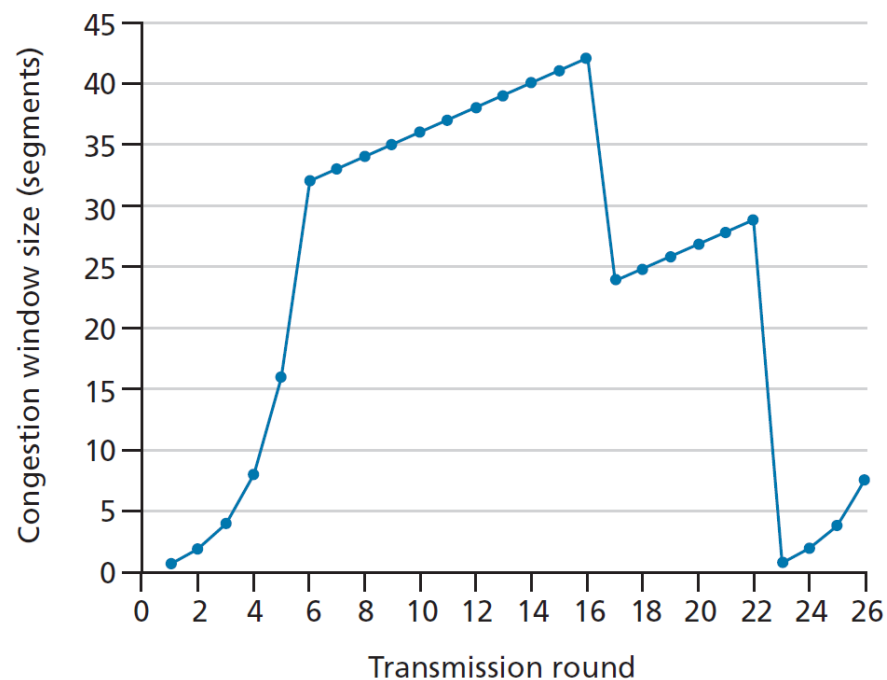


Figure 3.61 ♦ TCP window size as a function of time

- Identify the intervals of time when TCP slow start is operating.
- Identify the intervals of time when TCP congestion avoidance is operating.
- After the 16th transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?
- After the 22nd transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?
- What is the initial value of ssthresh at the first transmission round?
- What is the value of ssthresh at the 18th transmission round?
- What is the value of ssthresh at the 24th transmission round?

- h. During what transmission round is the 70th segment sent?
- i. 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?
- j. 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?
- k. 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?

P47 Recall the macroscopic description of TCP throughput. In the period of time from when the connection's rate varies from $W/(2RTT)$ to W/RTT , only one packet is lost (at the very end of the period).

- a. Show that the loss rate (fraction of packets lost) is equal to:

$$L = \text{loss rate} = \frac{1}{\frac{3}{8}w^2 + \frac{3}{4}w}$$

- b. Use the result above to show that if a connection has loss rate L , then its average rate is approximately given by

$$\text{average rate} \approx \frac{1.22MSS}{RTT\sqrt{L}}$$

P48 Consider that only a single TCP (Reno) connection uses one 10 Mbps link which does not buffer any data. Suppose that this link is the only congested link between the sending and receiving hosts. Assume that the TCP sender has a huge file to send to the receiver, and the receiver's receive buffer is much larger than the congestion window. We also make the following assumptions: each TCP segment size is 1,500 bytes; the two-way propagation delay of this connection is 150 msec; and this TCP connection is always in congestion avoidance phase, that is, ignore slow start.

- a. What is the maximum window size (in segments) that this TCP connection can achieve?
- b. What is the average window size (in segments) and average throughput (in bps) of this TCP connection?
- c. How long would it take for this TCP connection to reach its maximum window again after recovering from a packet loss?