PRACTICE SET

Questions

Q23-1. The answer is no. Host-to-host and process-to-process communication are needed because each computer in the Internet is designed to do multiple tasks: to run multiple application-layer programs.

Q23-3. Although any port number can be used for the client and server and they can be the same in this private communication, it is recommended to follow the division specified by ICANN:

    a. The client port number should be chosen from the dynamic range, 49,152 to 65,535.

    b. The server port number also should be chosen from the dynamic range, 49,152 to 65,535.

    c. It is advisable to choose different port numbers for the server and the client to be able to better debug the programs.

Q23-5. We check each protocol one by one:

    a. The protocol can be Stop-and-Wait with the receive window size of 1 and the send window size of 1.

    b. The protocol can also be Go-Back-*N* with the receive window size of 1 and the send window size of *n* packets.

    c. The protocol cannot be Selective-Repeat because the size of both windows should be the same (1), which means the protocol is Stop-and-Wait, not Selective-Repeat.

Q23-7. We describe the advantage and disadvantage of each first:

    a. The advantage of using the Go-Back-*N* protocol is that we can have a larger send window size. We can send more packets before waiting for their acknowledgment. The disadvantage of using this protocol is that the receive window size is only 1. The receiver cannot accept and store the out-of-order received packets; they will be discarded. Discarding of the out-of-

order packets means resending these packets by the sender, resulting in congestion of the network and reducing the capacity of the pipe. So the advantage seen by a larger send window may disappear by filling the network with resent packets.

b. The advantage of using the Selective-Repeat protocol is that the receive window can be much larger than 1. This allows the receive window to store the out-of-order packets and avoids resending them to congest the network. The disadvantage of this protocol is that the send window size is half of the Go-Back-N, which means that we can send fewer packets before waiting for the acknowledgment.

We can conclude that if the bandwidth-delay product of the network is large, the reliability is good, and the delay is low, we should choose the Go-Back-N protocol to use more of the network capacity. On the other hand, if the bandwidth-delay product is small, or the network is not very reliable, or the network creates long delays, we need to use Selective-Repeat.

Q23-9. The networks need to be carefully designed to make the time between the two wraparounds as long as possible. For example, in a protocol that uses the sequence number field of size 3 ($m = 3$), every $2^m = 8$ packets have the same sequence number. If the previous packet with sequence number x (or its accidentally created duplicate) is still wandering in the network arrives at the destination, the receiver may confuse this with the expected new packet, also with sequence number x.

Q2311. The transport-layer packets are encapsulated in the datagram at the network layer. The router through which the datagrams need to pass to reach their destination may be congested and drop the packets.

Q23-13. The rest of the packets ($2^m - 2$) are supposed to be in transit, filling the pipe. The size of the receive window is chosen to be 1 to accept only one packet, the one expected, and not out-of order packets. The receiver cannot be overwhelmed because it holds only one packet in its window. When the only packet in the window is consumed by the upper-layer protocol, the receive window slides to make it possible to receive the next packet in transit. If any packet in transit arrives before the window slides, it is discarded.

Problems

P23-1. The domain of IP addresses is universal. A device directly connected to the Internet needs a unique IP address. The domain of port numbers is local; they can be repeated. Two computers running the HTTP server process use the same well-known port number (80); two computers running the HTTP client process can use the same ephemeral port number.

P23-3. The sequence number of any packet can be found using the following relation:

$$seqNo = (\text{starting segNo} + \text{packet number} -1) \bmod 2^m$$

in which m is the number of bits used to define the sequence number. The sequence number in this case is

$$seqNo = (0 + 100 - 1) \bmod 2^5 = 99 \bmod 32 = 3$$

P23-5.

| Protocol	Max Send W_{size}	Max Receive W_{size}
Stop-and-Wait:	1	1
Go-Back-N:	$2^5 - 1 = 31$	1
Selective-Repeat:	$2^5 / 2 = 16$	$2^5 / 2 = 16$

P23-7. The following figure shows the states and events. The sender needs two states: ready and blocking. The receiver also needs these two states. To send a packet, the sender should be in the ready state and receives data from the application layer. The receiver accepts a packet from the sender when it is in the ready state. When the receiver becomes ready, it sends an ACK packet and moves to the ready state.
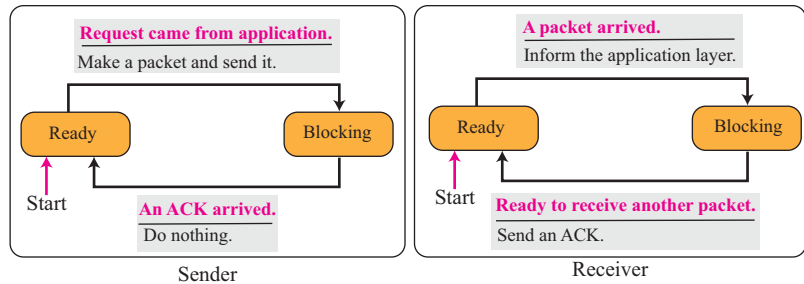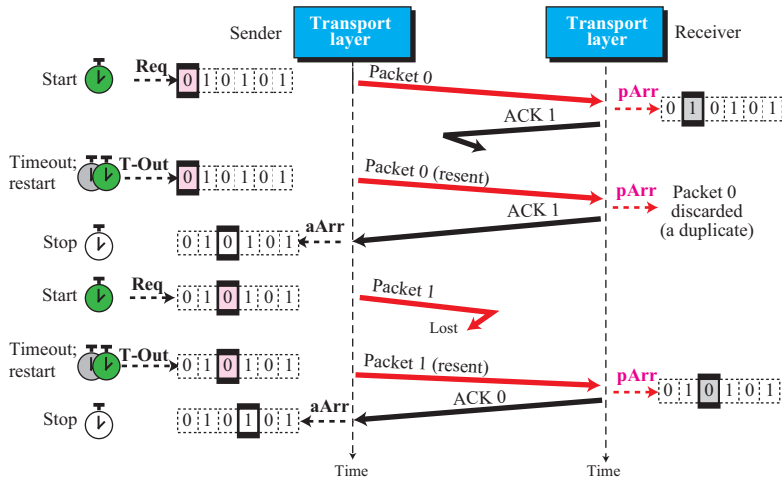

P23-9. The following figure shows the case. It happens when an ACK is delayed and the time-out occurs. The sender resends the packet that is already acknowledged by the receiver. The receiver discards the duplicate packet, but resends the previous ACK to inform the sender that there is a delay in the network.
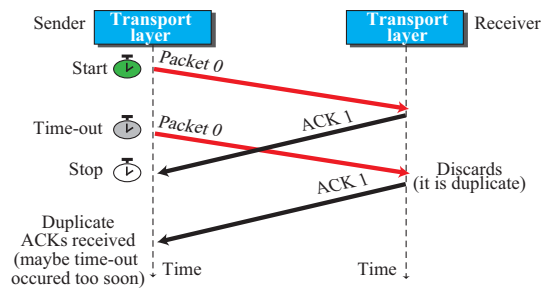
P23-11. The figure on the next page shows the outline. Note that since the simple protocol provides no error control, if a packet is lost, the receiving process is responsible for finding a solution. The transport layer is not even aware that this has happened. The packets may also be delivered out of order to the receiving process. The responsibility again is on the receiving process to reorder the packets.
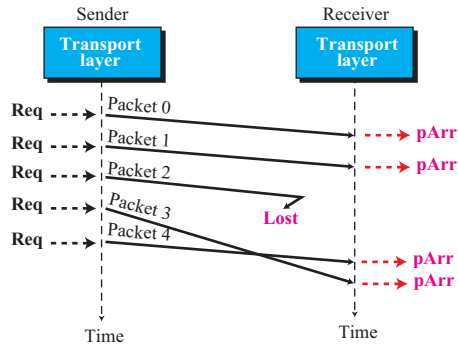
P23-13. See the following figure:

P23-15. The following figure shows the solutions:
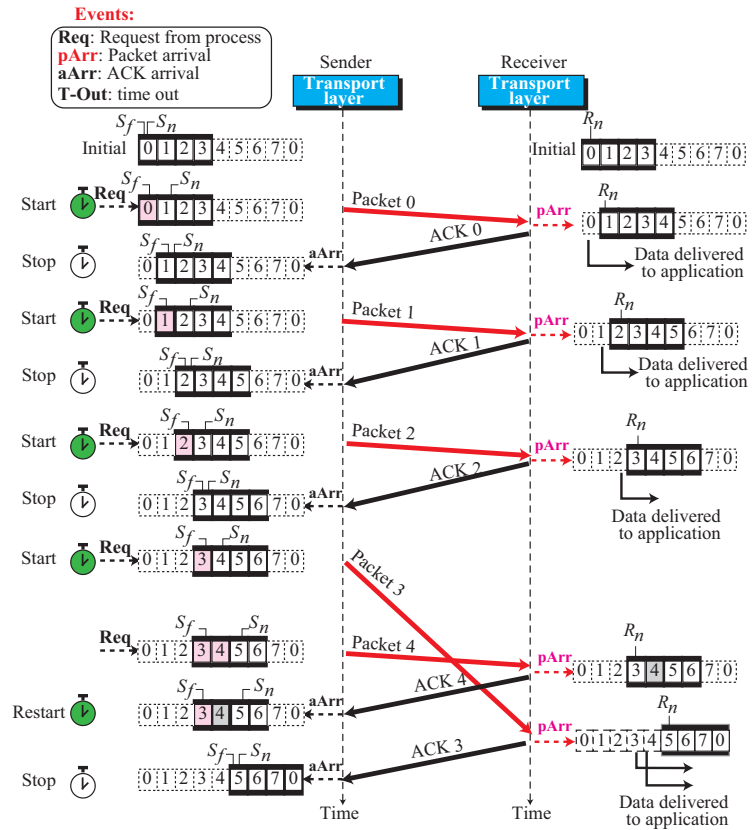
P23-17. We assume each event is independent.

    a. seqNo = 15.

    b. Five packets with seqNos set to 10, 11, 12, 13, and 14 are to be resent.

    c. $S_f = 13$ and $S_n = 15$.

    d. The size of the window remains the same. Max $W_{size} = 64 - 1 = 63$.

    e. $S_f = 18$ and $S_n = 21$. Next state = ready.

    f. $R_n = 17$. Action: message is delivered and an ACK with ackNo = 17 is sent.

P23-19. In each case we first define the bandwidth-delay product (BDP) in bits and then find it in the number of packets:

    a. BDP = 1 Mbps × 20 ms = 20,000 bits = 20 packets

      b. BDP = 10 Mbps $\times$ 20 ms = 200,000 bits = 100 packets

      c. BDP = 1 Gbps $\times$ 4 ms = 4,000,000 bits = 400 packets

P23-21. We first calculate the average round-trip time (RTT) and the number of packets in the pipe before finding the sizes of the windows, the value of m, and the time-out value.

      a. Average RTT $= 2 \times$ (5,000 Km) / $(2 \times 10^8) = 50$ ms.

      b. The bandwidth-delay product = 1 Gbps $\times$ 50 ms = 50,000,000 bits.

      c. The bandwidth-delay product = 50,000,000 bits / 50,000 bits = 1000 packets.

      d. The maximum send window size should be 1000 to allow not more than 1000 packets in the pipe.

      e. The maximum receive window size should also be 1000 packets.

      f. We know that the (window size) $\leq (2^{m-1})$ or 1000 $\leq (2^{m-1})$. This means that we need to choose $(m-1)$ to be at least 10 or $m = 11$. The sequence numbers are then 0 to 2047.

      g. The timeout value should be at least the average RTT = 50 ms to avoid early retransmission of the packets and to prevent congestion.

P23-23. The following figure shows the situation.
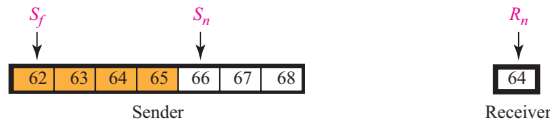
      a. If the receiver expects a packet with sequence number 64 and packets with sequence numbers 62 to 65 are already sent but not acknowledged, it means that two packets with sequence numbers 64 and 65 are in transit from the sender to the receiver.

      b. If the sender expects the acknowledgment for packet 62, but the value of R_n = 64, it means that the ACK packets with acknowledgment numbers 62 and 63 are in transit from the receiver to the sender.