DATA LINK LAYER

Part 2

Ref: Forouzan, Data communications and networking.

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Noisy Channels
(Stop-and-Wait Automatic Repeat Request)

Example 2:

Assume that, in a Stop-and-Wait ARQ system, the bandwidth of the line is 1 Mbps, and 1 bit takes 20 ms to make a round trip. What is the bandwidth-delay product? If the system data frames are 1000 bits in length, what is the utilization percentage of the link?

Noisy Channels
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Solution:

The bandwidth-delay product is

$$(1 \times 10^6) \times (20 \times 10^{-3}) = 20{,}000 \text{ bits}$$

The system can send 20,000 bits during the time it takes for the data to go from the sender to the receiver and then back again. However, the system sends only 1000 bits. We can say that the link utilization is only 1000/20,000, or 5 percent. For this reason, for a link with a high bandwidth or long delay, the use of Stop-and-Wait ARQ wastes the capacity of the link.

Noisy Channels
(Stop-and-Wait Automatic Repeat Request)

Example 3:

What is the utilization percentage of the link in Example 2, if we have a protocol that can send up to 15 frames before stopping and worrying about the acknowledgments?

Noisy Channels
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Solution:

The bandwidth-delay product is still 20,000 bits. The system can send up to 15 frames or 15,000 bits during a round trip. This means the utilization is 15,000/20,000, or 75 percent. Of course, if there are damaged frames, the utilization percentage is much less because frames have to be resent.

Noisy Channels
(Go-Back-N Automatic Repeat Request)

In the Go-Back-N Protocol, the sequence numbers are modulo 2^m, where m is the size of the sequence number field in bits.

Noisy Channels
(Go-Back-N Automatic Repeat Request)

For example:

If *m* is 4, the only sequence numbers are 0 through 15 inclusive. However, we can repeat the sequence. So the sequence numbers are:

0, 1,2,3,4,5,6, 7,8,9, 10, 11, 12, 13, 14, 15,0, 1,2,3,4,5,6,7,8,9,10, 11, ...

In other words, the sequence numbers are modulo- 2^m

Noisy Channels
(Go-Back-N Automatic Repeat Request)

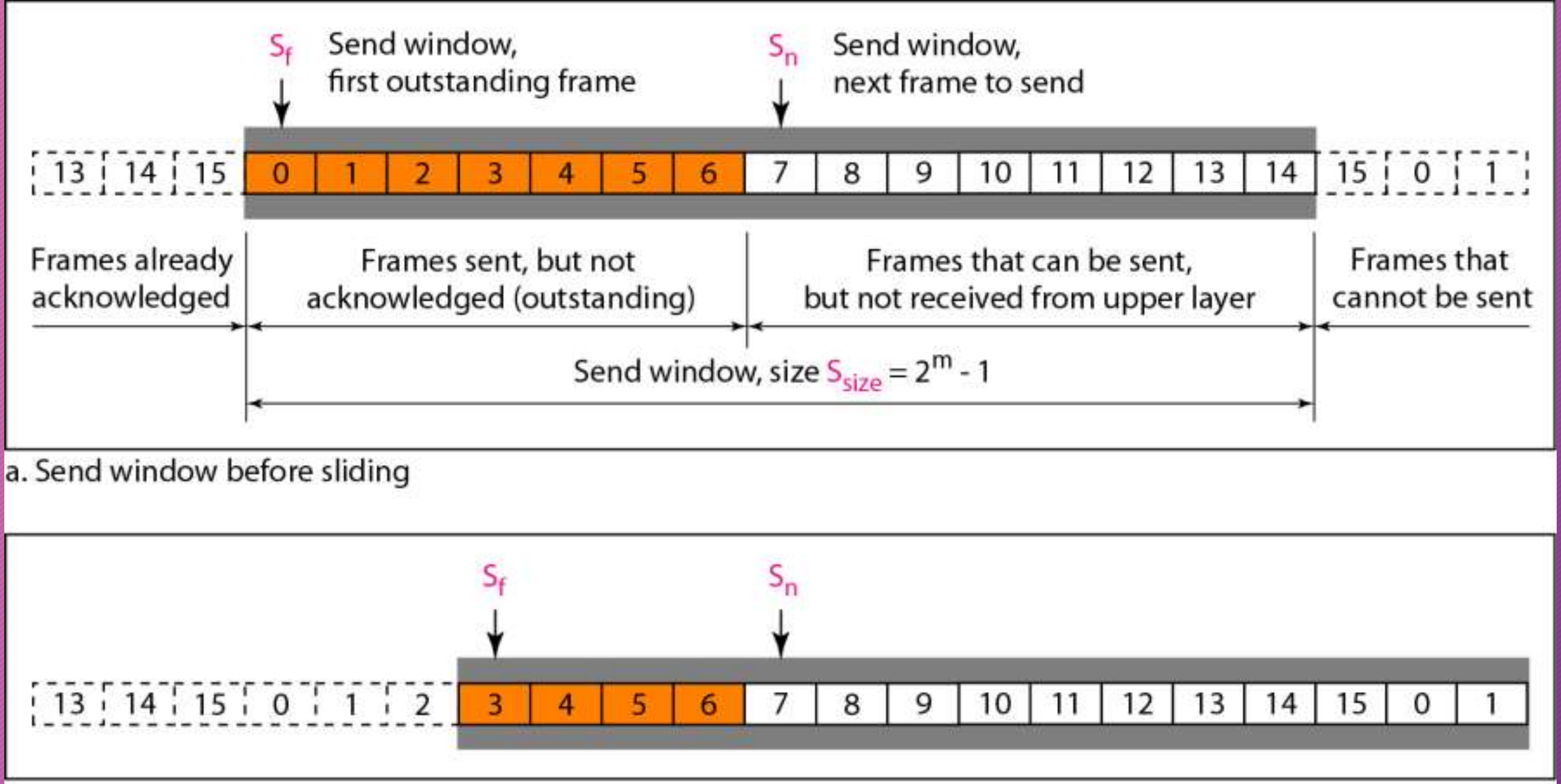
- Sliding Window
  - ✓ ***The sliding window*** is an abstract concept that defines the range of sequence numbers that is the concern of the sender and receiver.
  - ✓ The range which is the concern of the sender is called the send sliding window.
  - ✓ the range that is the concern of the receiver is called the receive sliding window.
  - ✓ The send window is an imaginary box covering the sequence numbers of the data frames which can be in transit.
  - ✓ The maximum size of the window is $2^m - 1$

Noisy Channels
(Go-Back-N Automatic Repeat Request)

The send window is an abstract concept defining an imaginary box of size $2^m - 1$ with three variables: Sf, Sn, and S_{size}.

Noisy Channels
(Go-Back-N Automatic Repeat Request)

The send window can slide one or more slots when a valid acknowledgment arrives.



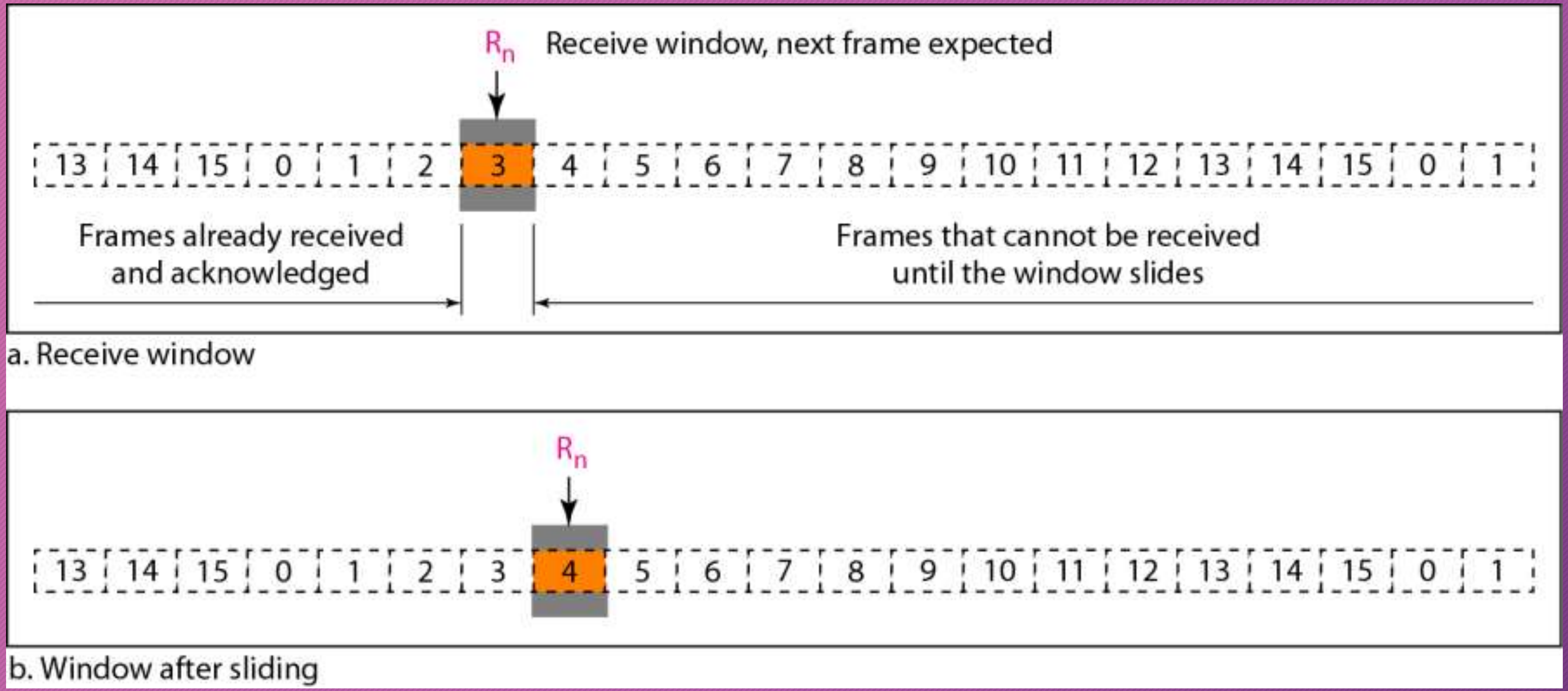
a. Send window before sliding

b. Send window after sliding

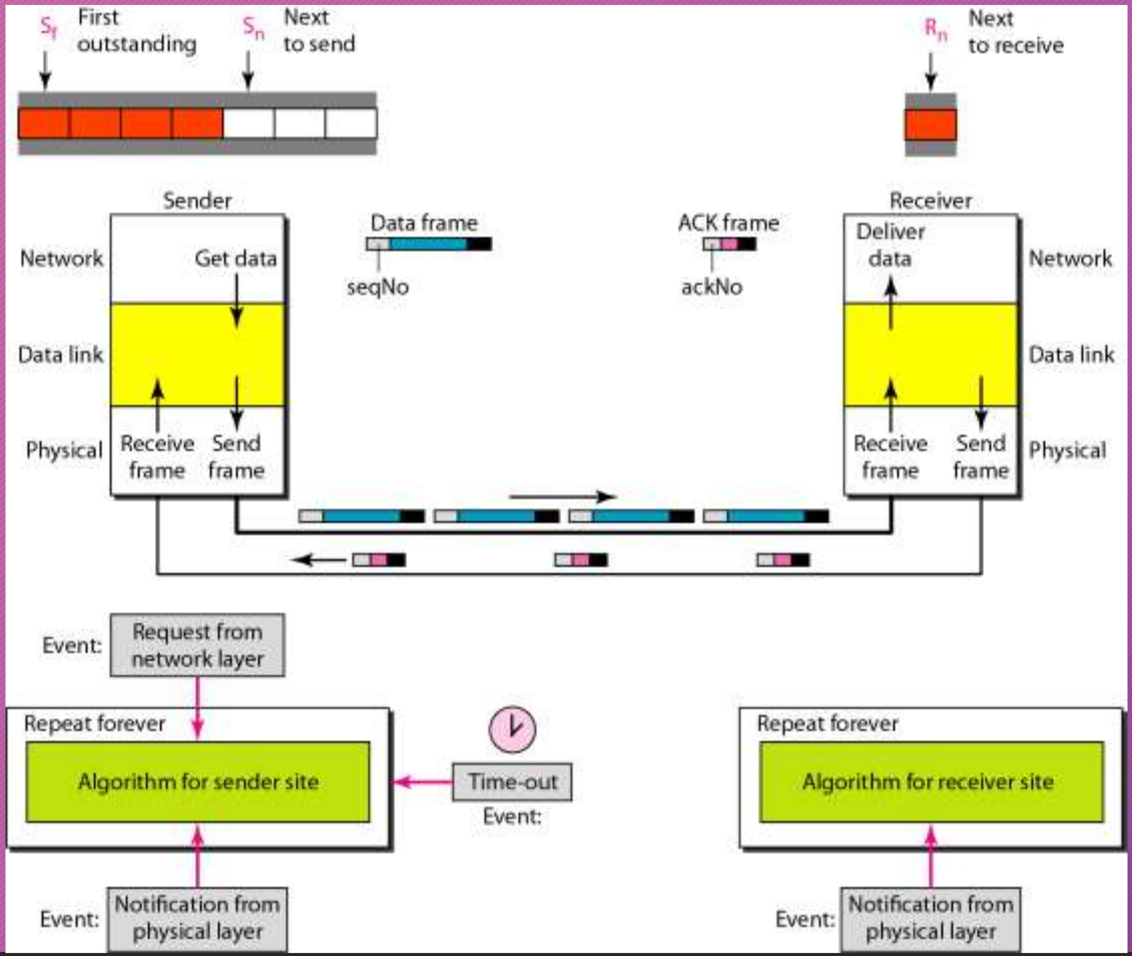
Send window for Go-Back-N ARQ

Noisy Channels
(Go-Back-N Automatic Repeat Request)

The receive window is an abstract concept defining an imaginary box of size 1 with one single variable R_n. The window slides when a correct frame has arrived; sliding occurs one slot at a time.



Receive window for Go-Back-N ARQ



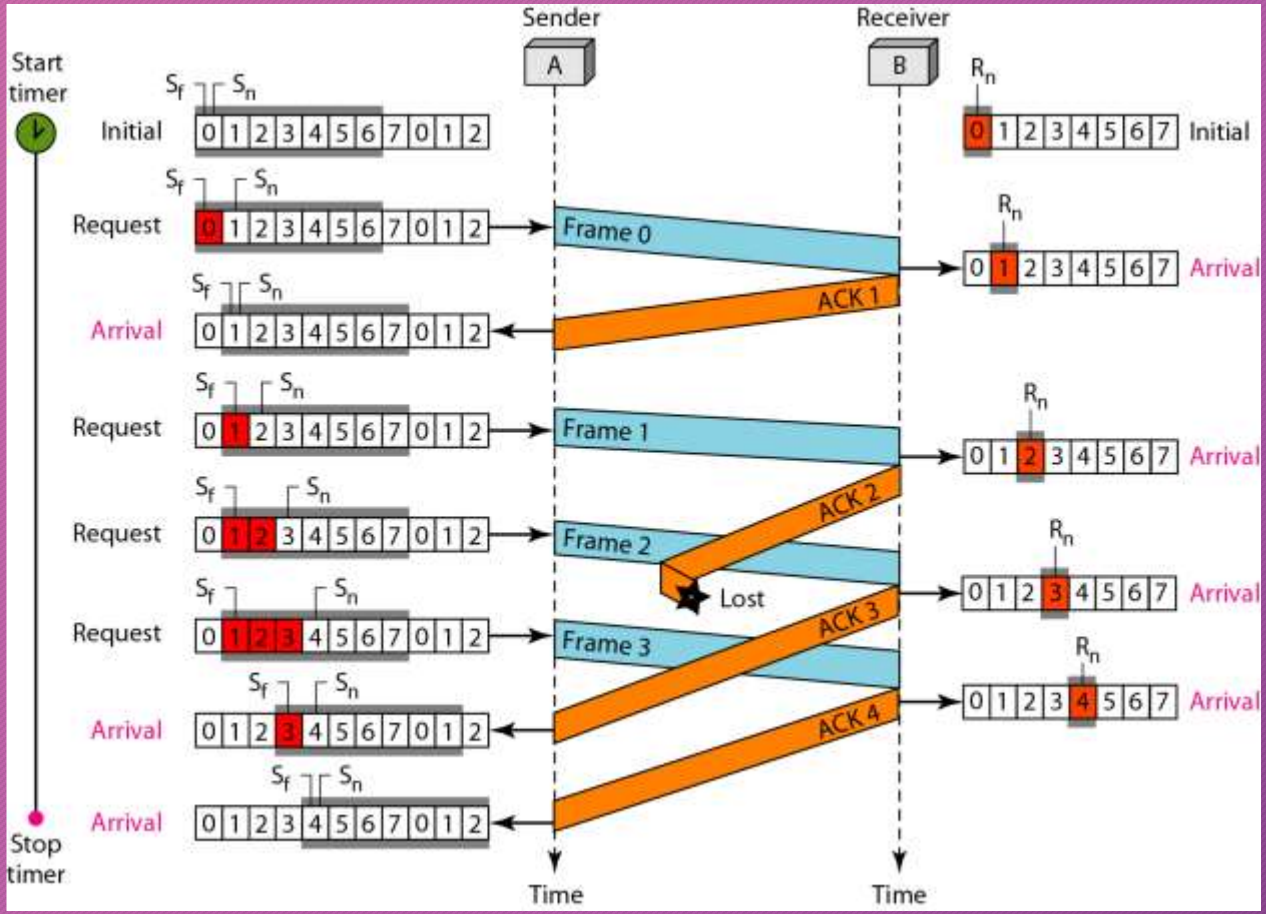
Design of Go-Back-N ARQ

In Go-Back-N ARQ, the size of the send window must be less than 2^m;
the size of the receiver window
is always 1.

Noisy Channels
(Go-Back-N Automatic Repeat Request)

An example of Go-Back-N.

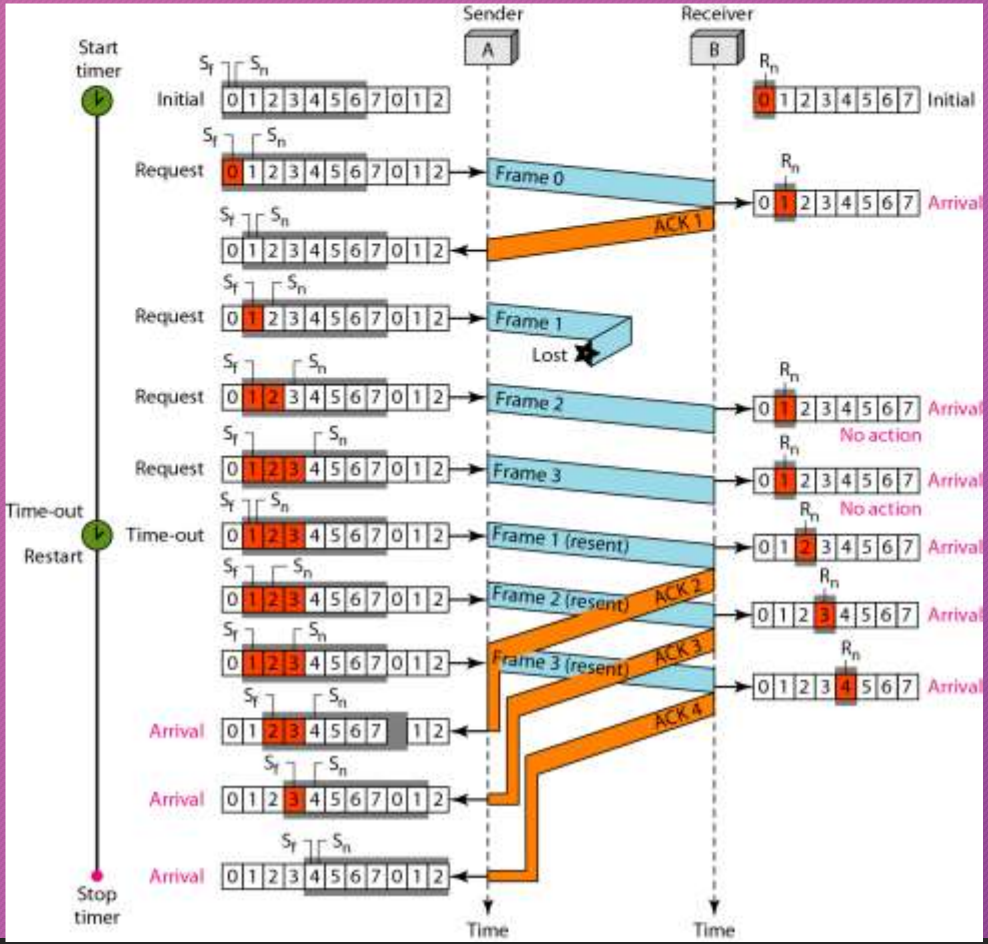
1. This is an example of a case where the forward channel is reliable, but the reverse is not. No data frames are lost, but some ACKs are delayed and one is lost. The example also shows how cumulative acknowledgments can help if acknowledgments are delayed or lost. After initialization, there are seven sender events. Request events are triggered by data from the network layer; arrival events are triggered by acknowledgments from the physical layer. There is no time-out event here because all outstanding frames are acknowledged before the timer expires. Note that although ACK 2 is lost, ACK 3 serves as both ACK 2 and ACK 3.



Flow diagram for Example

Noisy Channels
(Go-Back-N Automatic Repeat Request)

2. The second example shows what happens when a frame is lost. Frames 0, 1, 2, and 3 are sent. However, frame 1 is lost. The receiver receives frames 2 and 3, but they are discarded because they are received out of order. The sender receives no acknowledgment about frames 1, 2, or 3. Its timer finally expires. The sender sends all outstanding frames (1, 2, and 3) because it does not know what is wrong. Note that the resending of frames 1, 2, and 3 is the response to one single event. When the sender is responding to this event, it cannot accept the triggering of other events. This means that when ACK 2 arrives, the sender is still busy with sending frame 3. The physical layer must wait until this event is completed and the data link layer goes back to its sleeping state. We have shown a vertical line to indicate the delay. It is the same story with ACK 3; but when ACK 3 arrives, the sender is busy responding to ACK 2. It happens again when ACK 4 arrives. Note that before the second timer expires, all outstanding frames have been sent and the timer is stopped.



Flow diagram for Example

Task 2

1. Assume that, in a Stop-and-Wait ARQ system, the bandwidth of the line is 3 Mbps, and 1 bit takes 10 ms to make a round trip. What is the bandwidth-delay product? If the system data frames are 1200 bits in length, what is the utilization percentage of the link?
2. What is the utilization percentage of the link above, if we have a protocol that can send up to 22 frames before stopping and worrying about the acknowledgments?