2. GO-BACK-N ARQ

In Stop-and-Wait ARQ, at any point in time for a sender, there is only one frame, the outstanding frame, that is sent and waiting to be acknowledged. This is not a good use of the transmission medium. To improve the efficiency, multiple frames should be in transition while waiting for acknowledgment. In other words, we need to let more than one frame be outstanding. Two protocols use this concept: Go-Back-N ARQ and Selective Repeat ARQ.

In Go-Back-N ARQ, we can send up to W frames before worrying about acknowledgments; we keep a copy of these frames until the acknowledgments arrive. This procedure requires additional features to be added to Stop-and-Wait ARQ.

Sequence Numbers

Frames from a sending station are numbered sequentially. However, because we need to include the sequence number of each frame in the header, we need to set a limit. If the header of the frame allows m bits for the sequence number, the sequence numbers range from 0 to 2^m-1. For example, if m is 3, the only sequence numbers are 0 through 7 inclusive. However, we can repeat the sequence. So the sequence numbers are

0,l,2,3,4,5,6,7, 0,l,2,3,4,5,6,7....1

OPERATION

Normal Operation

Figure 9 shows a normal operation of Go-Back-N ARQ. The sender keeps track of the outstanding frames and updates the variables and windows as the acknowledgments arrive.

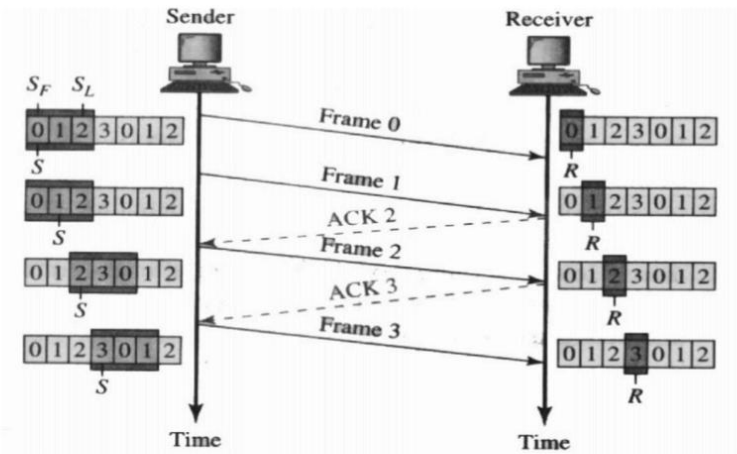

Figure 9 Go-Back-N ARQ, normal operation

Damaged or Lost Frame

Figure 10 shows, the situation when a frame is lost. It shows that frame 2 is lost. Note that when the receiver receives frame 3, it is discarded because the receiver is expecting frame 2, not frame 3 (according to its window). After the timer for frame 2 expires at the sender site, the sender sends frames 2 and 3 (it goes back to 2).

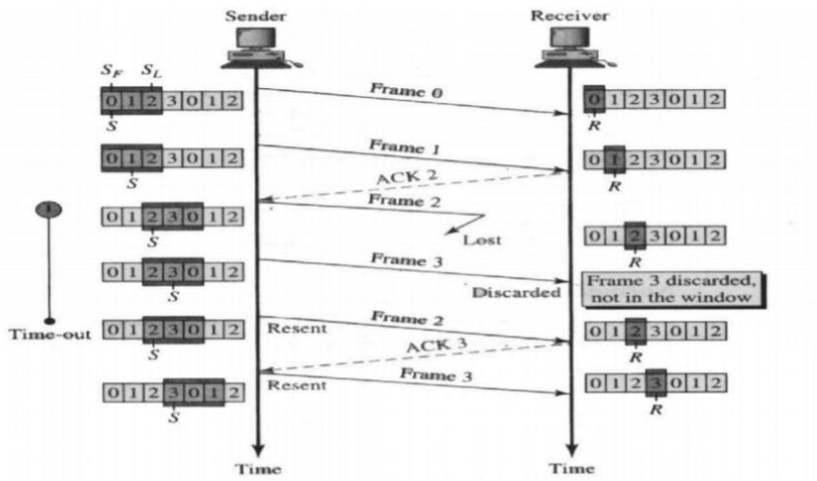

Figure 10: Damaged or Lost Frame

Damaged or lost Acknowledgment

If an acknowledgment is damaged or lost, we can have two situations. If the next acknowledgment arrives before the expiration of any timer, there is no need for retransmission of frames because acknowledgments are cumulative in this protocol. ACK 4 means ACK 1 to ACK 4. So if ACK 1, ACK 2, and ACK 3 are lost, ACK 4 covers them. However, if the next ACK arrives after the time-out, the frame and all the frames after that are resent. The receiver never resends an ACK.

Delayed Acknowledgment

A delayed acknowledgment triggers the resending of frames.

Sender Window Size

We can now show why the size of the sender window must be less than 2^m. As an example, we choose m = 2, which means the size of the window can be 2^m — 1, or 3. Figure 11 compares a window size of 3 and 4.

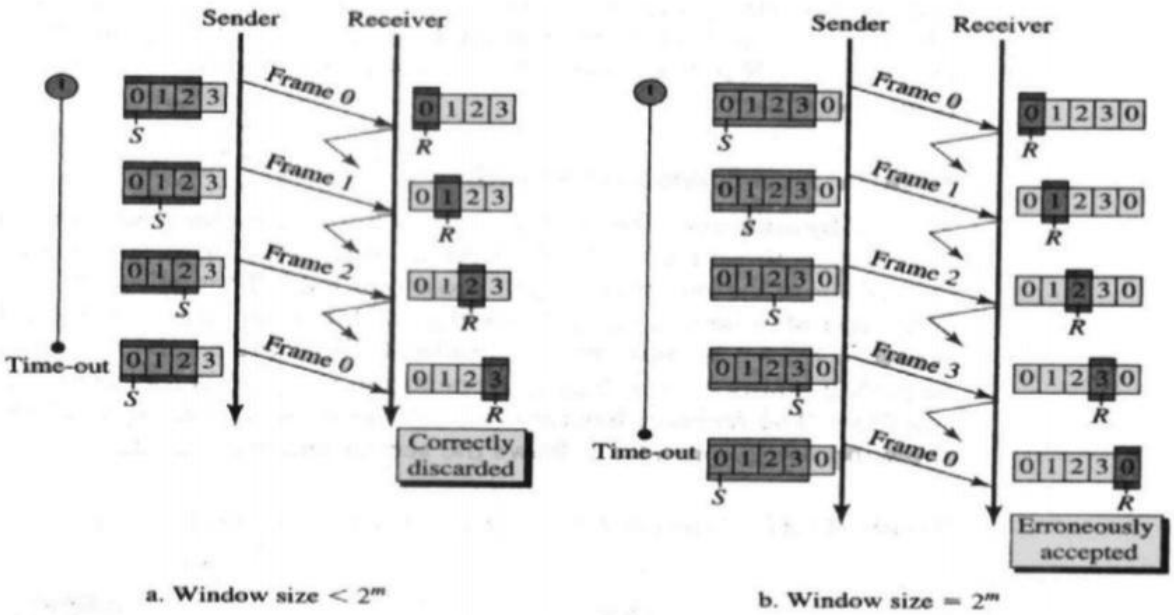

Figure 11 Go-Back-N ARQ: sender Window size

If the size of the window is 3 (less than 22) and all three acknowledgments are lost, the frame 0 timer expires and all three frames are resent. However, the window of the receiver is now expecting frame 3, not frame 0, so the duplicate frame is correctly discarded. On the other hand, if the size of the window is 4 (equal to 22) and all acknowledgments are lost, the sender will send the duplicate of frame 0. However, this time the window of the receiver expects to receive frame 0, so it accepts frame 0, not as a duplicate, but as the first frame in the next cycle. This is an error.

Bidirectional Transmission and Piggybacking

As in the case of Stop-and-Wait ARQ, Go-Back N ARQ can also be bidirectional We can also use piggybacking to improve the efficiency of the transmission However, each direction needs both a sender window and a receiver window.