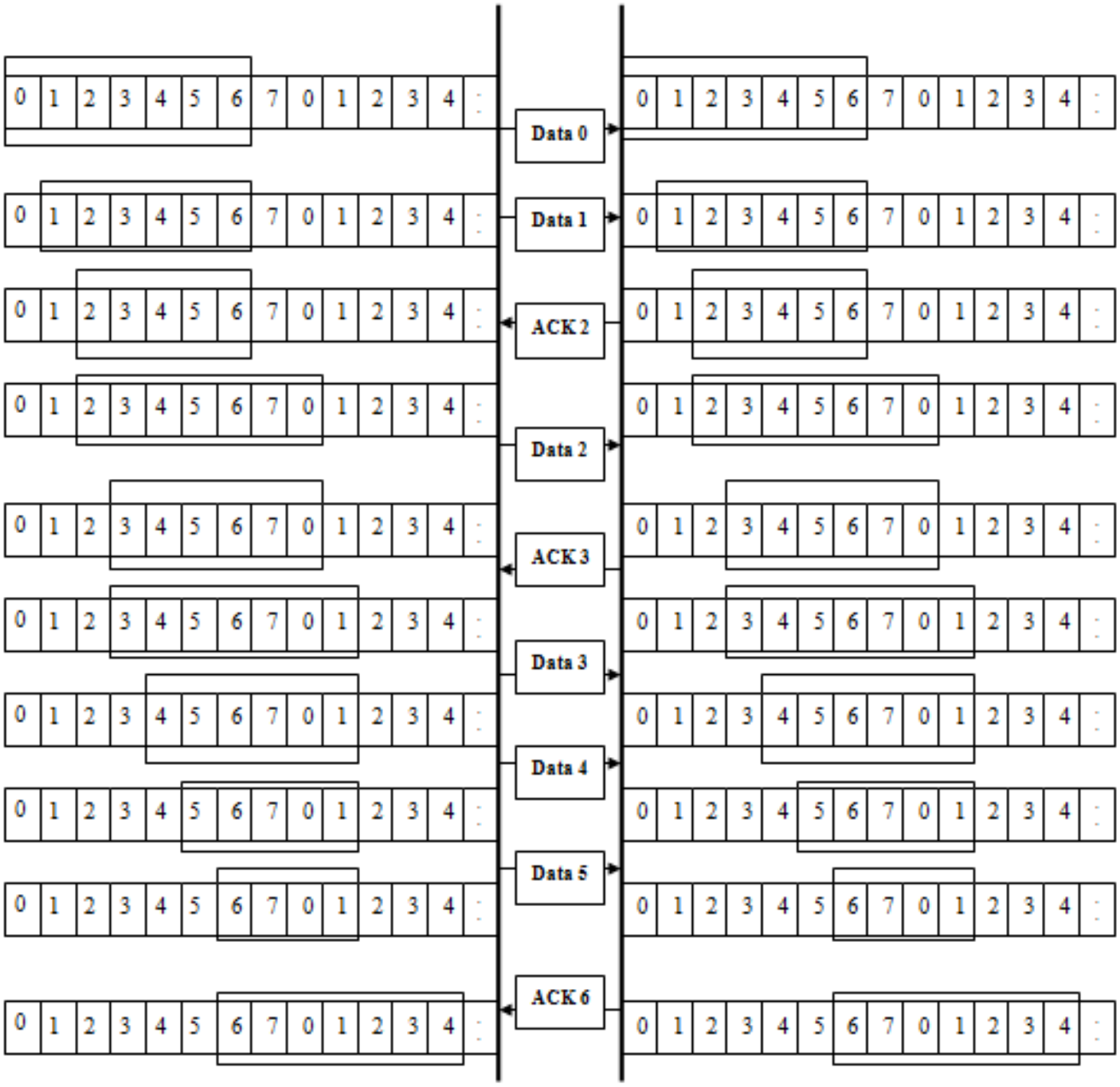


Error Control:

Error correction is implemented simply: anytime an error is detected in an exchange, a negative acknowledgement (NAK) is returned and the specified frames are retransmitted. This process is called Automatic Repeat Request (ARQ).

Error control refers to methods of error detection and retransmission. Error control is based on Automatic Repeat Request (ARQ), which means retransmission of data in three cases: damaged frame, lost frame, and lost acknowledgment.

ARQ error control is implemented as an adjunct to flow control. In fact, stop and wait flow control is usually implemented as stop and wait ARQ and sliding window is usually implemented as one of two variants of sliding window ARQ, called (go back n) or (selective reject).

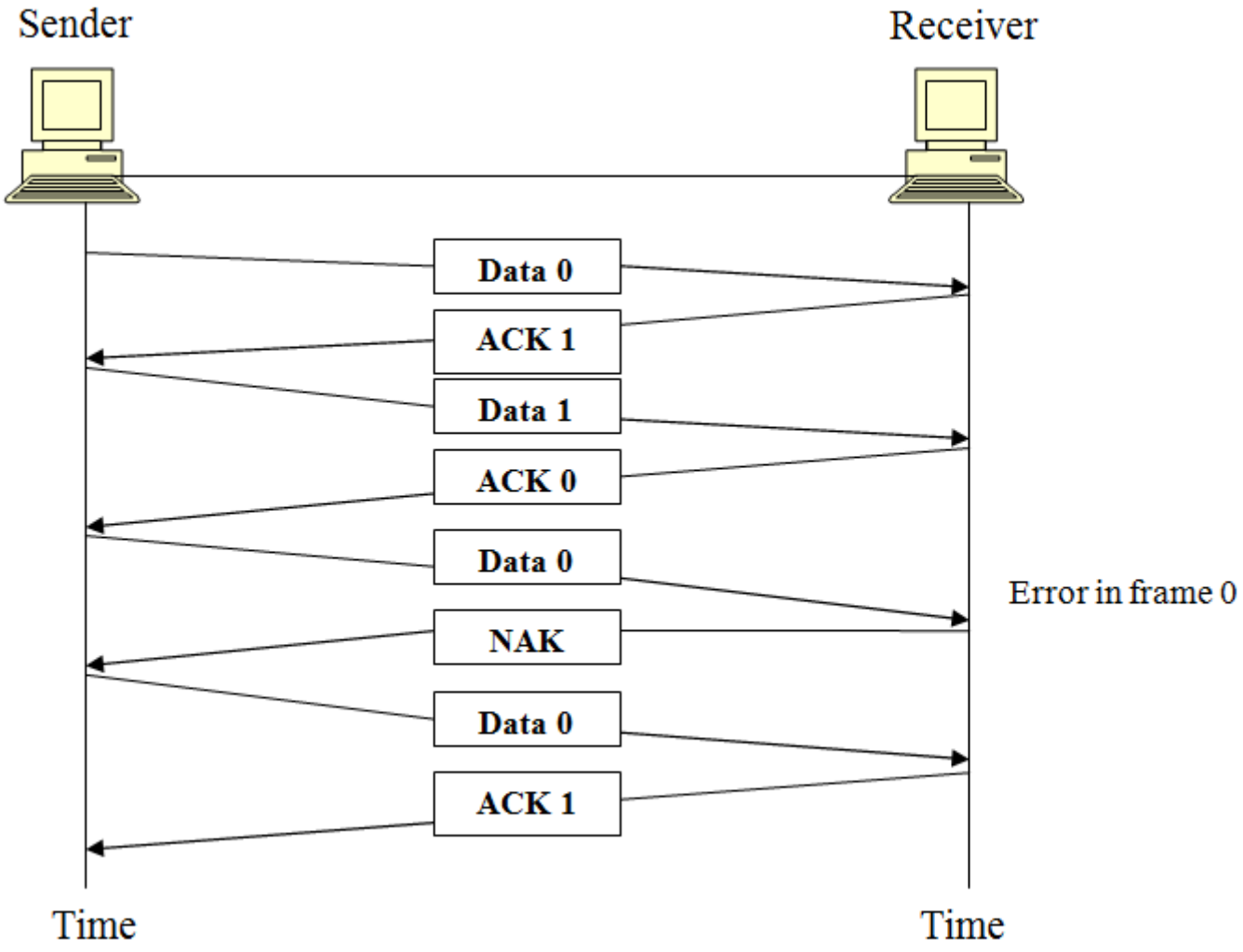
a- Stop and Wait ARQ:

Is a form of stop and wait flow control extended to include retransmission of data in case of lost or damaged frames. For retransmission to work four features are added to the basic flow control mechanism:

1- The sending device keeps a copy of the last frame transmitted until it receives an acknowledgement for that frame. Keeping a copy allows the sender to retransmit. Lost or damaged frames until they are received correctly.
2- For identification purposes, both data frames and ACK frames are numbered alternately 0 and 1. A data frame is acknowledged by an ACK 1 frame, indicating that the receiver has gotten data 0 and is now expecting data 1. This numbering allows for identification of data frames in case of duplicate transmission (important in the case of lost acknowledgements).
3- If an error is discovered in a data frame, indicating that it has been corrupted in transit, a NAK frame is returned. NAK frames, which are not numbered. Tell the sender to retransmit the last frame sent.
4- The sending device is equipped with a timer. If an expected acknowledgment is not received within an allotted time period, the sender assumes that the last data frame was lost in transit and sends it again.

Damaged Frames:

As shown in following figure:

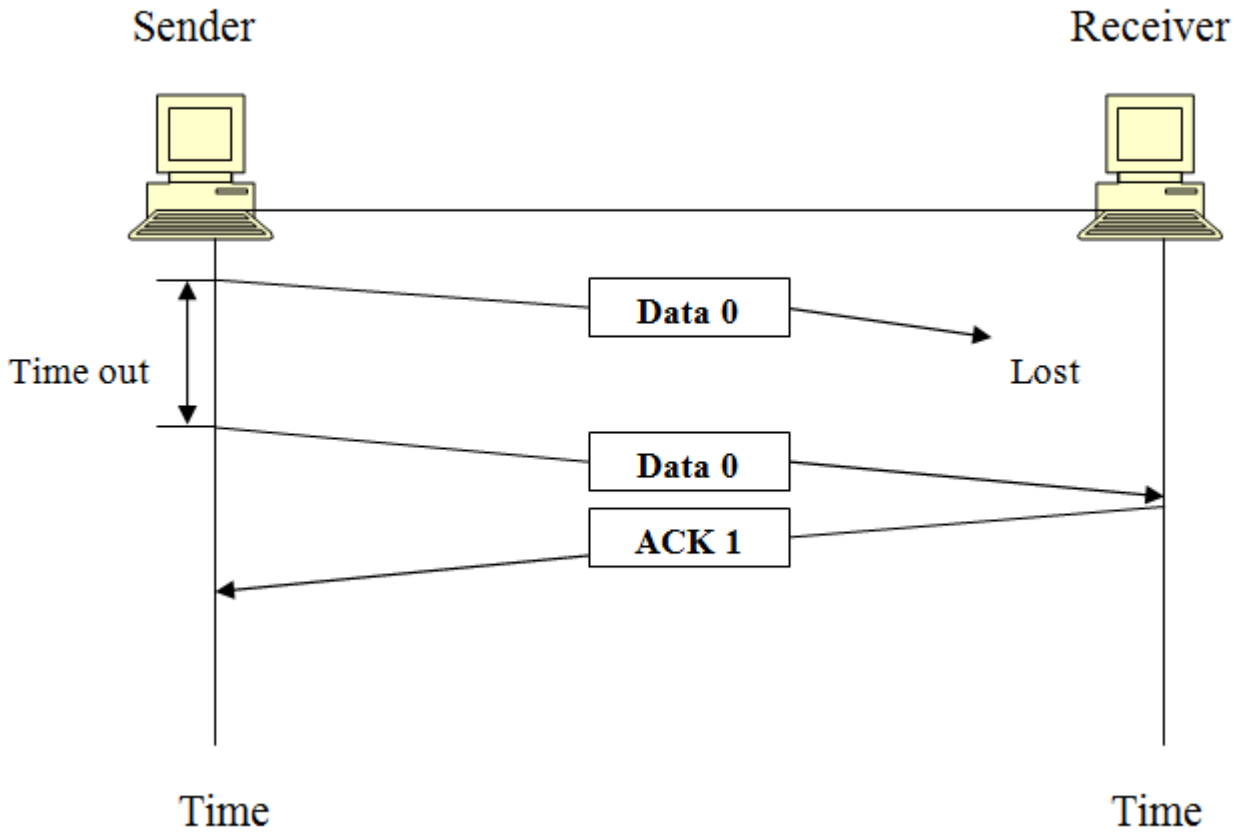


Lost Frame:

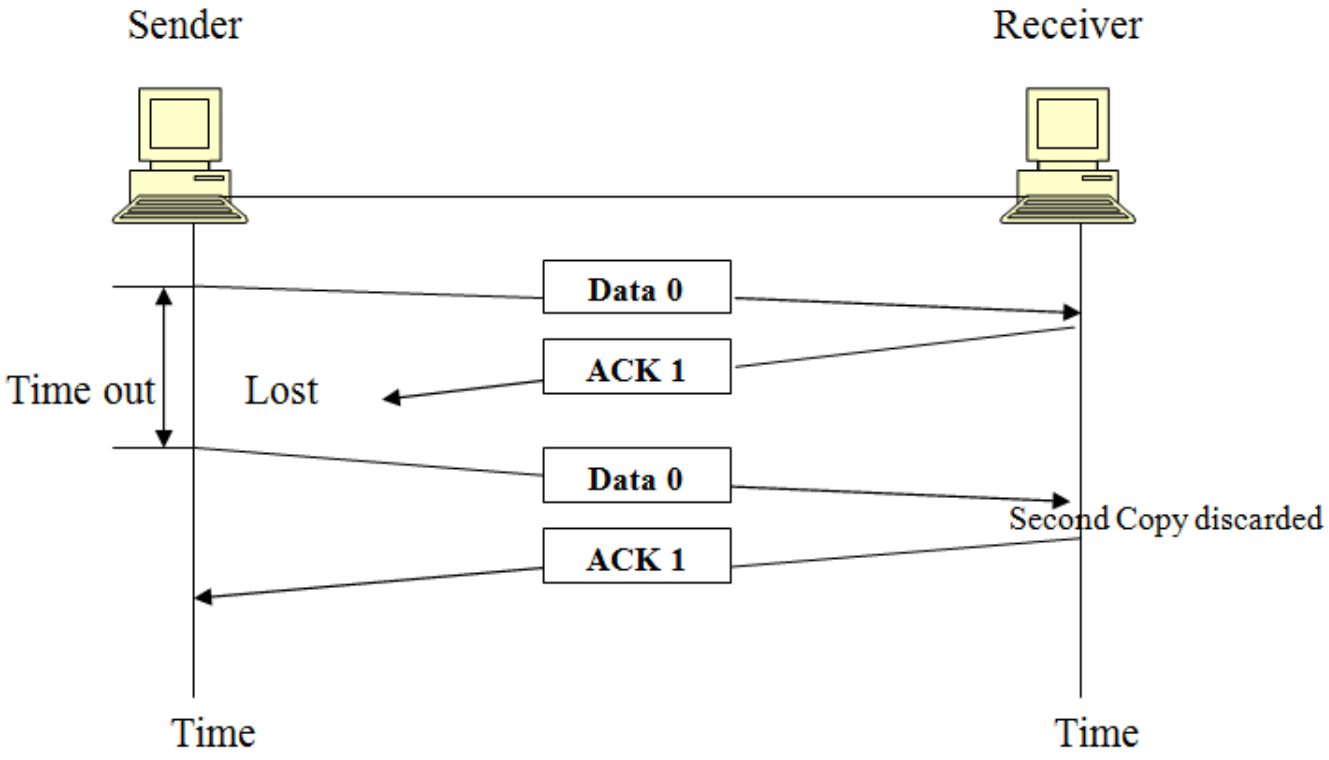
An of the frame types can be lost in transit:

Lost Data Frame:

As shown in following figure:



Lost Acknowledgement: As shown in following figure:



b- Sliding Window ARQ:

Among several popular mechanism for continuous transmission error control, two protocols are the most popular: go back n and selective reject ARQ, both based on sliding window flow control. To extend sliding window to cover retransmission of lost or damaged frames, three features are added to the basic flow control mechanism:

1- The sending device keeps copies of all transmitted frames until they have been acknowledged. If frames 0 through 6 have been transmitted, and the last acknowledgement was for frame 2 (expecting 3), the sender keeps copies of frames 3 through 6 until it know that they have been received undamaged.

2- In addition to ACK frames, the receiver has the option of returning a NAK frame if the data have been received damaged. The NAK frame tells the sender to transmit a damaged frame. Because sliding window is a continuous transmission mechanism (as apposed to stop and wait), both ACK and NAK frames must be numbered for identification. ACK frames, you will recall, carry the number of the damaged frame expected. NAK frames, on the other hand, carry the number of the damaged frame itself. In both cases, the message to the sender is the number of the frame that the receiver expects next. Note that data frames that are received without errors do not have to be acknowledged individually.

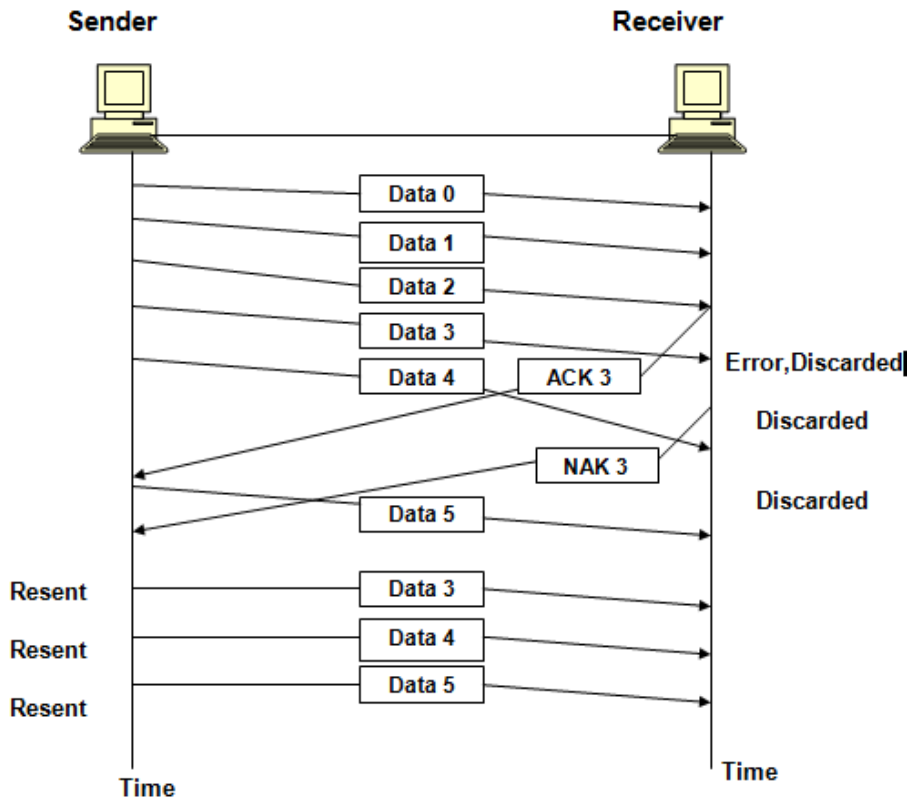
3- Like stop and wait ARQ, the sending device in sliding window ARQ is equipped with a timer to enable it to handle lost acknowledgements. In sliding window ARQ, n-1 frames (the size of the window) may be sent before an acknowledgement must be received. If the allotted time has run out with no acknowledgement, the sender assumes that the frames were not received and retransmits one or all of the frames depending on the protocol.

Go Back n ARQ:

In this sliding window go back n ARQ method, if one frame is lost or damaged, all frames sent since the last frame acknowledged are retransmitted.

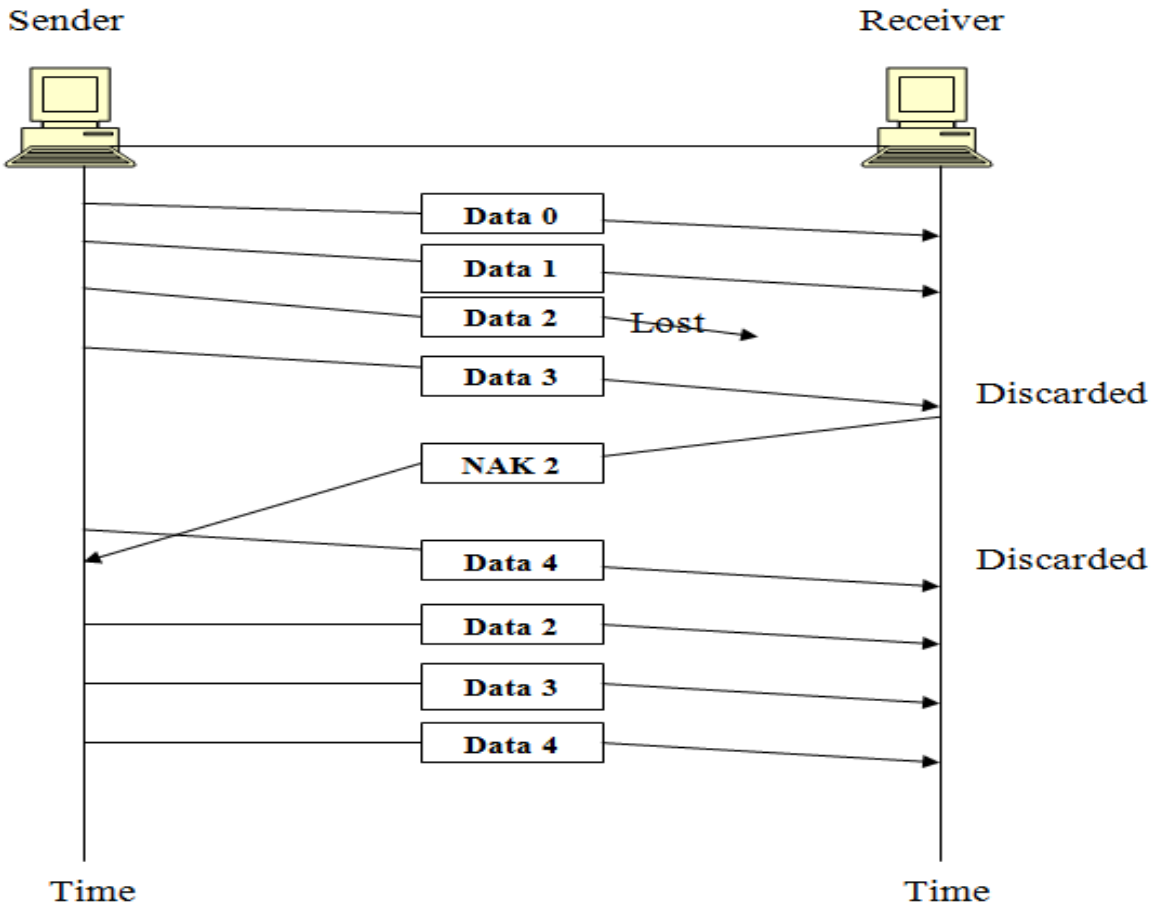
Damaged Frames:

As shown in following figure:



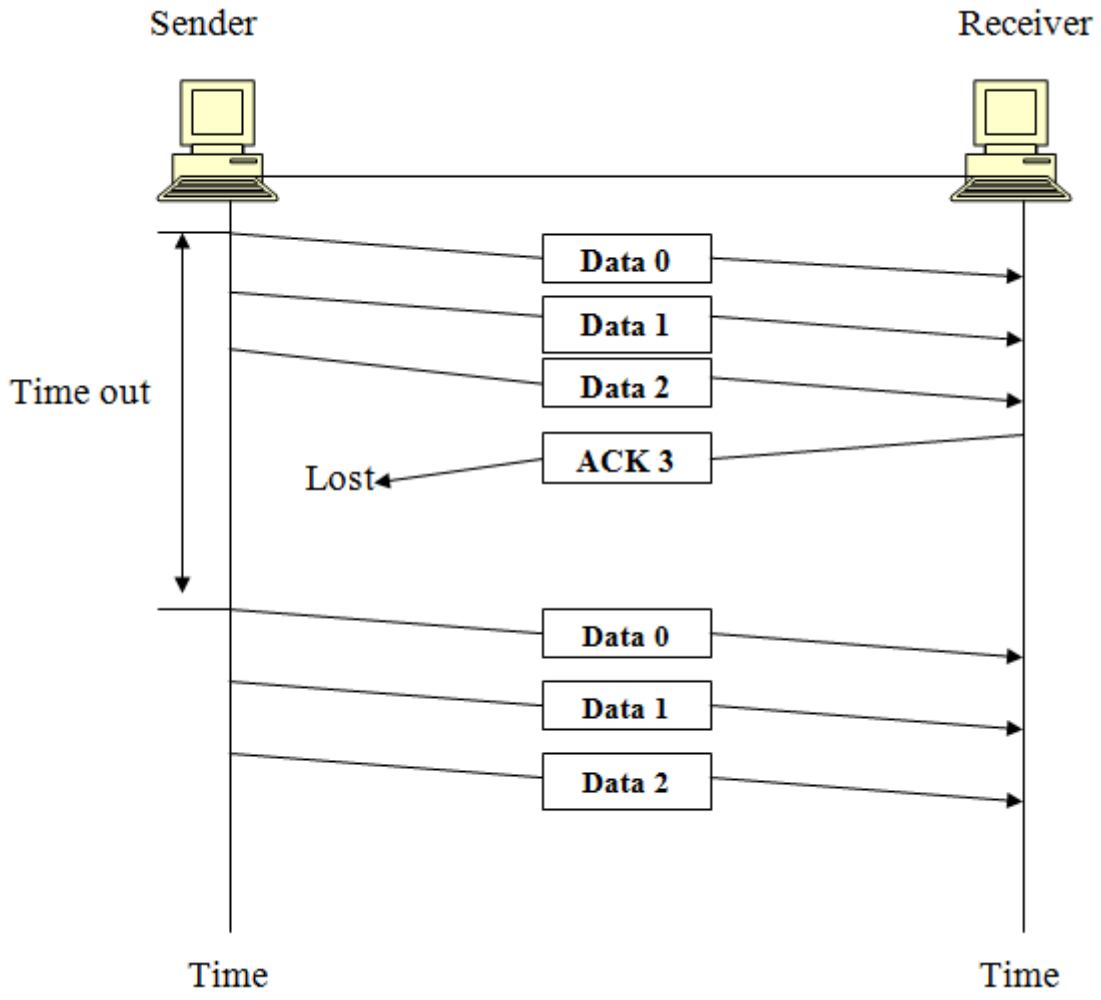
Lost Data Frame:

As shown in following figure:



Lost Acknowledgement Frame:

As shown in following figure:



Selective Reject ARQ:

In selective reject ARQ, only the specific damaged or lost frame is retransmitted. If a frame is corrupted in transit, a NAK is returned and the frame is resent out of sequence. The receiving device must be able to sort the frames it has and insert the retransmitted frame into its proper place in the sequence. To make such selectivity possible, a selective reject ARQ system differs from a go back n ARQ system in the following ways:

1-The receiving device must contain sorting logic to enable it to reorder frames received out of sequence. It must also be able to sort frames received after a NAK has been sent until the damaged frame has been replaced.

2- The sending device must contain a searching mechanism that allows it to find and select only the requested frame for retransmission.

3. A buffer in the receiver must keep all previously received frames on hold until all retransmissions have been sorted and any duplicate frames have been identified and discarded.

4-To aid selectivity, ACK numbers, like NAK numbers, must refer to the frame received (or lost) instead of the next frame expected.

5-This complexity requires a smaller window size than is needed by the go back n method if it is to work efficiently. It is recommended that the window size be less than or equal to (n+1)/2, where n-1 is the go back n window size.