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Function of OSI and TCP/IP Layers Part-4

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Elementary Data Link Protocol :

An Unrestricted Simplex Protocol :

- This protocol is simplest possible protocol
- The transmission of data take place in only one direction. So it is simplex (unidirectional) protocol
- It is assumed that the network layers of sender and receiver are always ready.
- It is also assumed that the processing time can be ignored and infinite buffer space is available
- The communication channel is imagined to be noise free so it does not damage or lose any frames .
- All this is highly unrealistic. This protocol is also called as “utopia “
- This protocol consists of two distinct procedures , namely a sender and receiver
- The sender runs the data link layer of the sender machine whereas the receiver runs in the data link layer of the receiver machine
- No sequence number or acknowledgement are used

A Simplex Stop and Wait protocol :

- The most unrealistic restriction in the previous protocol is assumption that the receiving network layer can process the data with zero processing time
- In this protocol it is assumed that a finite processing time is essential

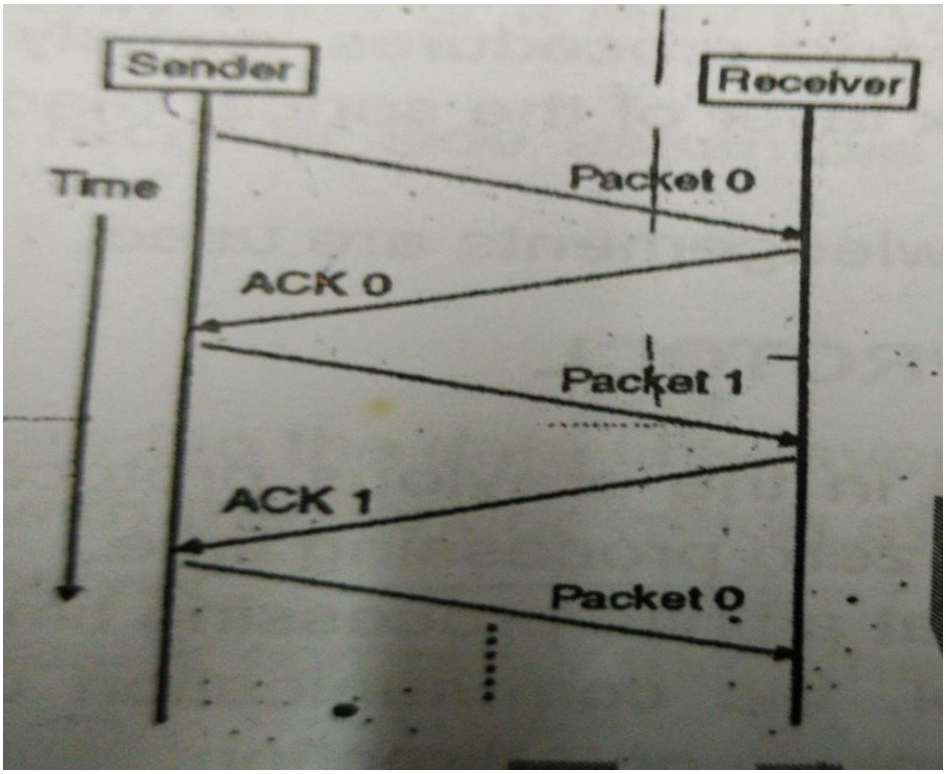
- However like the first protocol , the communication channel is assumed to be noise free and the communication i.e. only in one direction
- This protocol deals with an important problems i.e. how to prevent the sender from flooding the receiver with data faster than its processing speed
- In this protocol , a small dummy face is sent back from the receiver to the transmitter to indicate that it can send the next frame
- The transmitter sends one frame and then waits for the dummy frame called acknowledgement
- Once the acknowledgement is received , it sends the next frame , hence the name stop-and-wait
- The best thing about this protocol is that the incoming frame is always an acknowledgement

A Simplex Protocol for Noisy Channel :

- This is the third protocol in which we go one step ahead and assume that the communication channel is noisy and can introduce errors in the data travelling over it
- Frames may either be damaged or lost completely
- In this protocol , the sender waits for a positive acknowledgment before advancing to the next data item
- So it is called as PAR (Positive acknowledgement with Retransmission) or automatic repeat request(ARQ)
- Note that due to retransmission , there is always a possibility of duplication of frames at the receiver
- To avoid this , sender puts sequence number in the header of each frame it sends
- The sender can check the sequence number of each arriving frame o check the possible duplication . If a frame is duplicated then receiver will be discard it
- The operation can be divided into two modes
  1. Normal operation
  2. Time out

Normal Operation :

- After transmitting one packet , the sender waits for an acknowledgement(ACK) from the receiver before transmitting the next one
- In this way the sender can recognize that the previous packet is transmitted successfully we could say “stop and wait” guarantees reliable transfer between nodes
- To support this feature , the sender keeps a record of each packet it sends

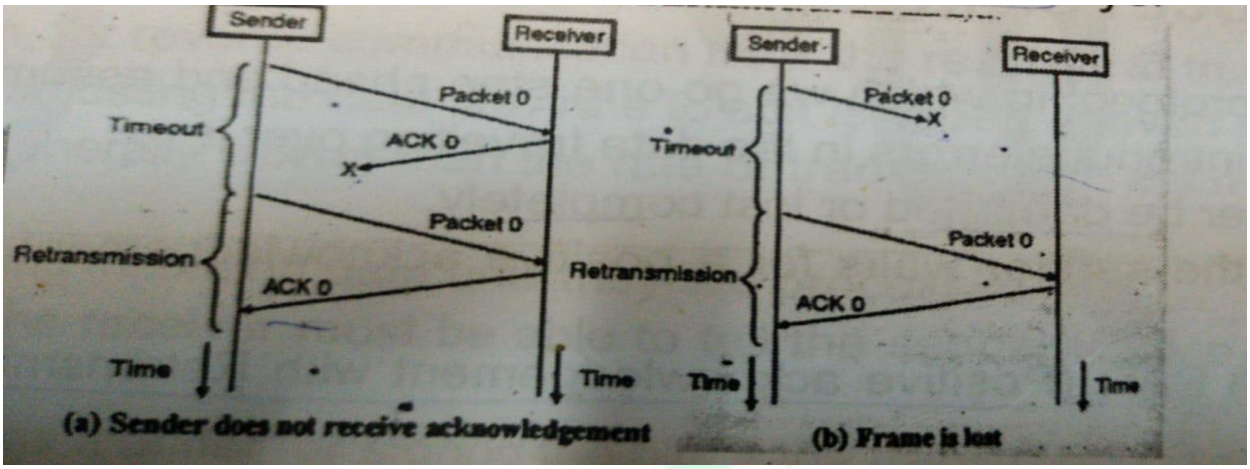


- Also , to avoid confusion caused by delayed or duplicate AcK’s “stop-and-wait” sends each packet with unique sequence number and receives that the number in each ACK’s

Time Out

- If the sender does not receive ACK for previous sent packet after a certain period of time , the sender times out and retransmit that packet again
- There are two cases when the sender does not receive ACK ; one is when the ACK is lost and the other is when the frame itself is not transmitted

- To support this feature , the sender keeps time for each packet
- We have already discussed that a timer is introduced in the data link layer



Piggy Backing:

- In all the practical situations , the transmission of data needs to be bi-directional . This is called as full duplex transmission
- One way of achieving full duplex transmission is to have two separate channels one for forward data transfer and the other for reverse transfer(for acknowledgement)
- But this will waster the bandwidth of the reverse channel almost entirely
- A better solution would be to use each channel (forward and reverse) to transmit frames bothways , with both channels having same capacity
- Let A and B be the users. Then the data frames from A to B are intermixed with the acknowledgement from A to B.
- One more improvement can be made. When a data frame arrives , the receiver waits , does not send the control frame (acknowledgement) back immediately
- Receiver waits until its network layer passes in the next data packet
- The acknowledgement is then attached to this outgoing data frame.
- This technique in which the outgoing acknowledgment is delayed temporarily is called as piggybacking

Advantages of Piggy Backing

The main advantage of piggybacking is better use of available channel bandwidth

Disadvantages :

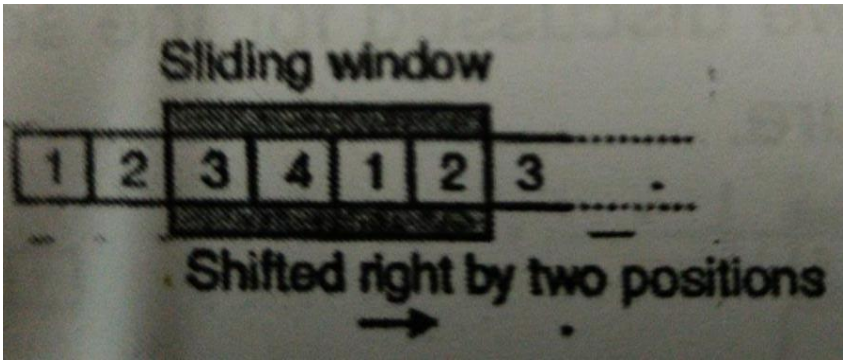
- The disadvantage of piggybacking is the additional complexity
- If the DLL waits too long before transmitting acknowledgement , then retransmission of frame would take place

Sliding Window Protocols :

- The next three protocols are more robust and bi-directional protocols
- All these protocols belong to a special class of protocol called the sliding window protocols
- They show a different performance in terms of their efficiency , complexity and buffer requirements

Sender And Receiver Sliding Windows:

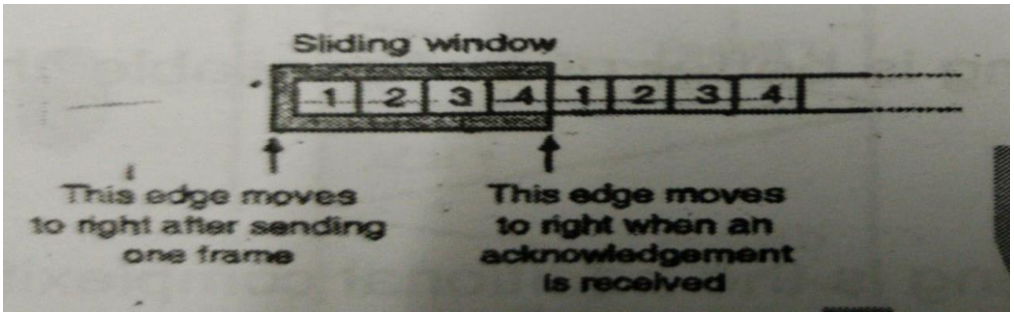
- The sender as well as receiver maintain their own sliding windows
- The sender sends the number of frames allowed by the size of its own sliding window and then wait for an acknowledgement from the receiver
- The receiver sends an acknowledgement which includes the number of the next frame that the sender should send
- For example , if the sender has sent frames 1 and 2 to the receiver and if receiver receives them correctly , then the acknowledgement send by the receiver will include number-3 indicating the sender to sender frame number-3
- Now if the sender transmits the first 4 frames as per size of its own window and receiver an acknowledgement for the first two frames , the sender will slide its window two frames to the right as shown below and sends the 5^{th} and 6^{th} frames (i.e. 1 and 2 of the next slot)



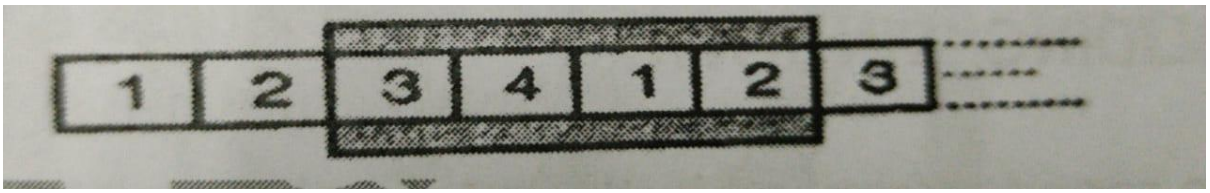
- The receiver now has four frames again , so if check frames 3,4,1,2 by checking their CRC . If it finds the frame 3 faulty then it will send an acknowledgement which including number 3 . The sender will send 4-frames starting from frame 3 onwards
- The sliding window mechanism then uses two buffers and one window so as to exercise the flow control
- The application program on the sender side will create the data to be transmitted and loads into the sender buffer
- Then sender's sliding window is imposed on this buffer . these frames are then sent till all the frames have been sent
- The receiver receives these data frames and carriers out checks such as CRC , missing or duplicate frames etc . and stores and correct frames in the receiver buffer
- The application program at the receiver then the takes this data

Movement of Sender's Window :

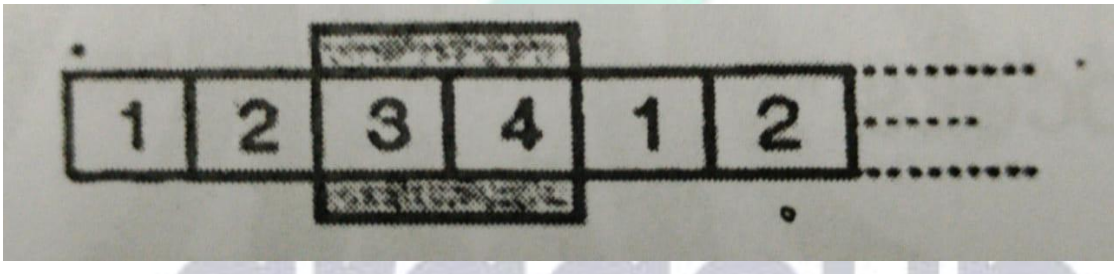
- Below figure shows the sender's window:



- If the senders window size is 4 frames 1 and 2 sent but acknowledgment has not been received so far , then shown below , the sender's windows will only contain two frames i.e. 3 and 4

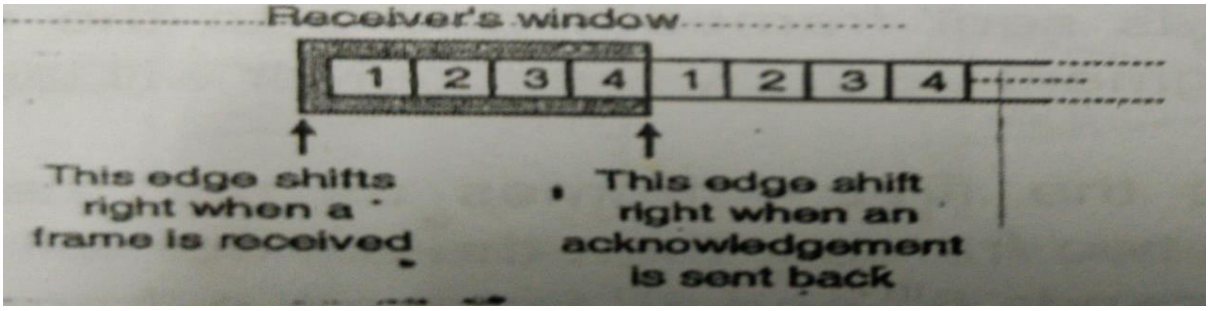


- Now if the sender receives acknowledgement bearing number , then it understands that the receiver has correctly received frame 1 and 2
- The senders window now expands and include the next two frames as shown below

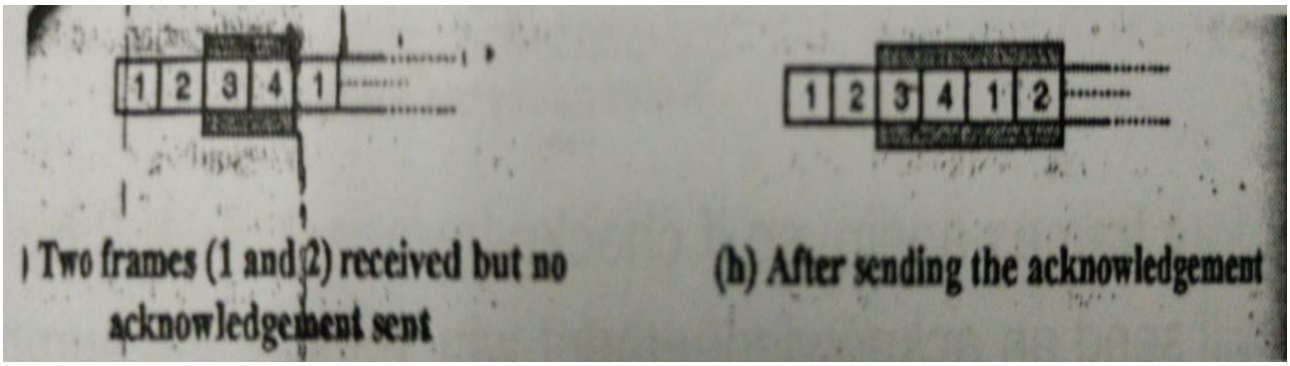


Movement of Receiver' Windows :

- Below figure shows the receiver's window . Its left edge shifts right on receiving each data frame , where as its right edge shifts right when and acknowledgement is sent



- It we take the same example that we discussed for the sender's window then the position of receivers



One Bit Sliding Window Protocol (Stop and Wait ARQ):

- This protocol is called 1 bit protocol because the maximum window size here i.e. n is equal 1.
- It uses the stop-and-wait technique . The sender sends one frame and wait to get its acknowledgement
- Only after receiving acknowledgement , does it transmit the next frames.
- So one bit sliding window protocol is also called stop and wait protocol
- The sequence of events taking place when a frame is transmitted and received is as follows :
  1. The data link layer of sending machine fetches the first packet frame its network layer
  2. It builds the frame for it sends it to receiver
  3. The receiver data link layer checks the received frame for duplication
  4. If ok, it passes the frame to its network layer.

Features Added For Retransmission:

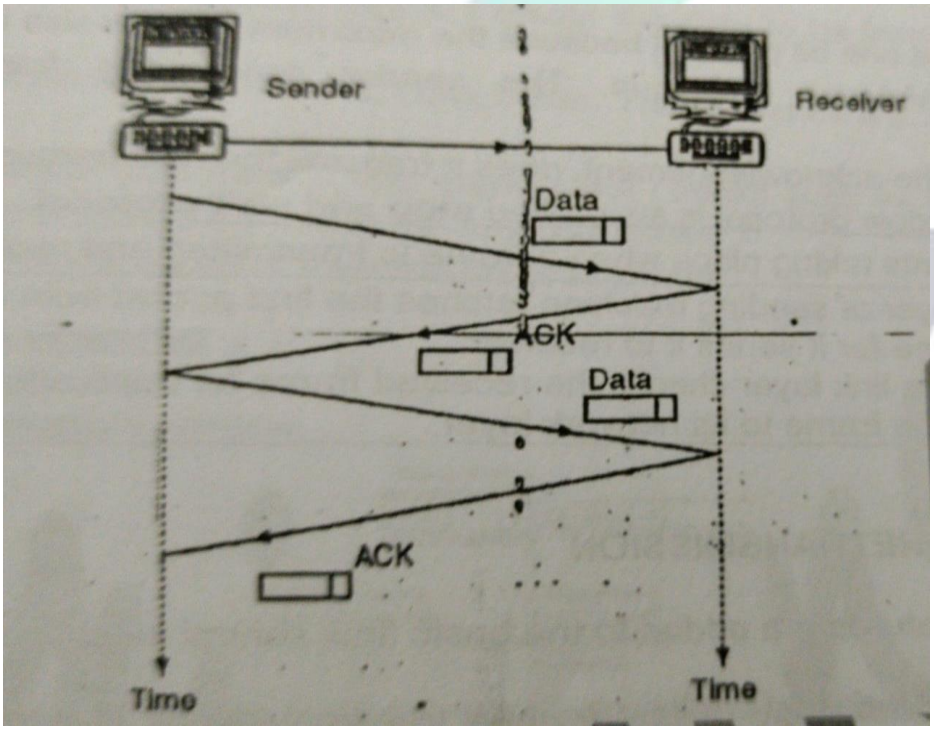
For retransmission , four features are added to the basic flow control mechanism

- The transmitter stores the copy of last frames transmitted unit it receives an acknowledgement for those frames

- For identification purpose both data and ACK frames are numbered alternately 0 and 1 . A data 0 frame is acknowledged by an ACK 1 frame indicating that the received data 0 and is expecting the next data frame numbered 1 .
- In an error occurs while transmission , the receiver sends a NAK frame back to the transmitter for retransmission of the corrupted frame . NAK frames which are not numbered tell the transmitter to retransmit the last frame transmitted
- The transmitter has a timer to take care of the frame ACK which are lost. After a specific time if the transmitter does not receive a ACK or NAK frame it retransmits the last frame

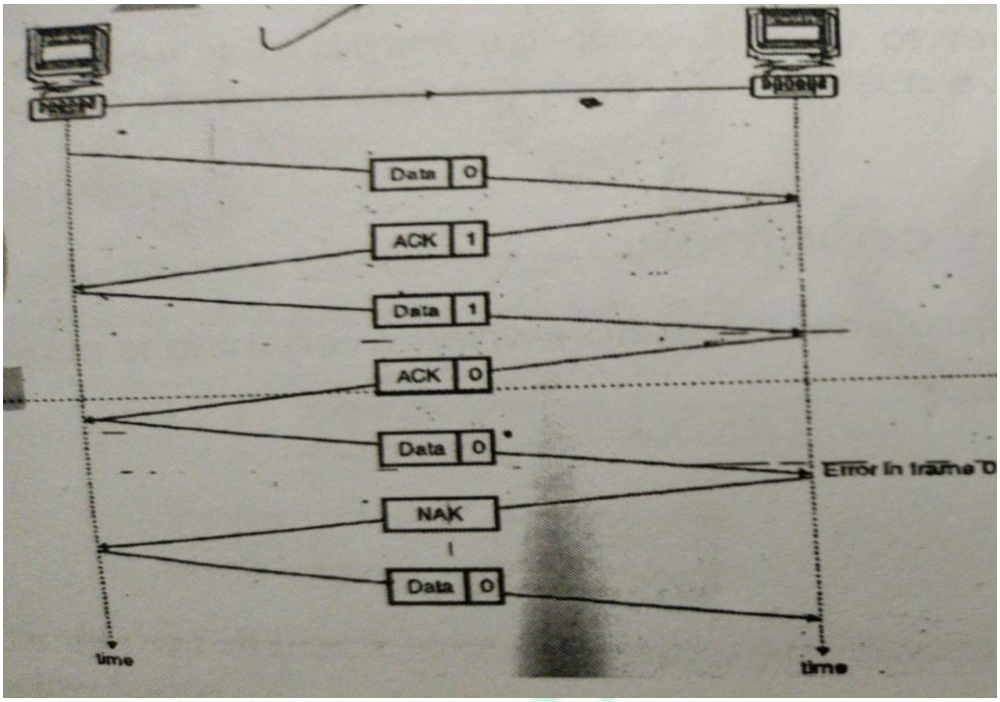
Operation Under Normal Condition

- Below shows the protocol operation when everything is normal :



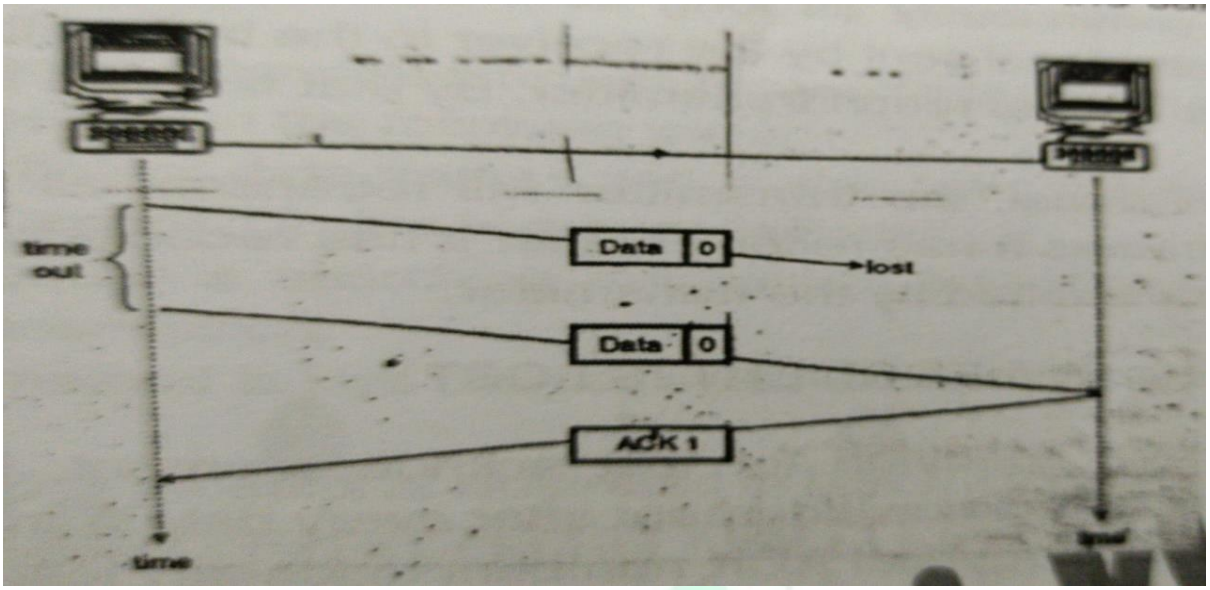
- No frame is lost so retransmission is not necessary

Stop and wait ARQ for damage frames



- As shown in above diagram the transmitter transmits data frame numbered 0. The receiver returns an ACK 1 indicating that the data frame numbered 0 is received without error
- The process goes on this way but if an error occurs the receiver sends a NAK requesting retransmission of the corrupted data frame

Stop and wait ARQ for lost data frame : Below figure show that if a data frame is lost and if the transmitter does not receive any type of acknowledgement from the receiver with a specified time it retransmits the same again



Disadvantage of Stop and wait Protocols :

- The problem with stop and wait protocol is that it is very inefficient . At any one moment , only one frame is in transition
- The sender will have to wait at least one round trip time before sending next The waiting can be long for slow network such as satellite link .

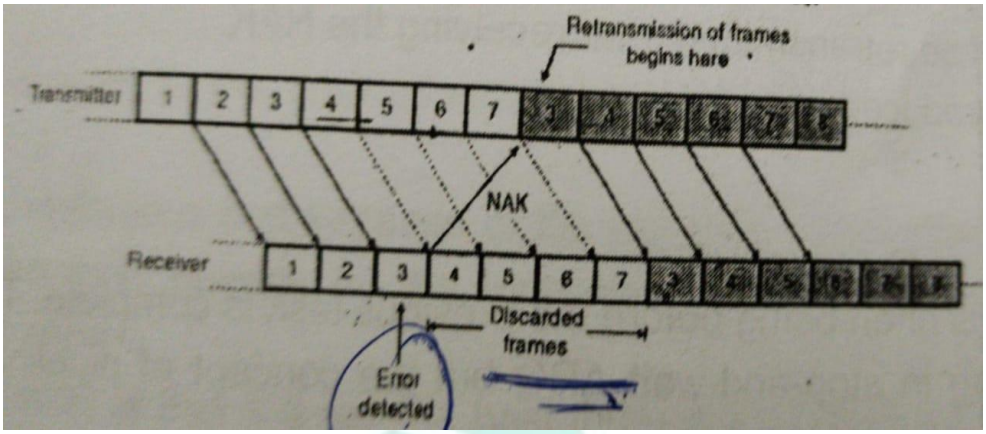
A Protocol Using Go Back 'n' :

- In this stop and wait protocol it was assumed that the transmission time required for a frame to arrive at the receiver plus the transmission time for the acknowledgement to come back is negligible
- But in some practical situations , this assumption is not correct
- In the systems like satellite system the round trip time can be as long as 500ms(propagation delay)
- This protocol is also known as Go-Back-n ARQ
- It is a method used to overcome the inefficiency of the stop and wait ARQ by allowing the transmitter to continue sending enough frames so that the channel is kept busy while the transmitter waits for acknowledgement

- In this method if one frame is damaged or lost , all frames are sent since the last frame acknowledged are retransmitted

Principle of Go-Back-n ARQ

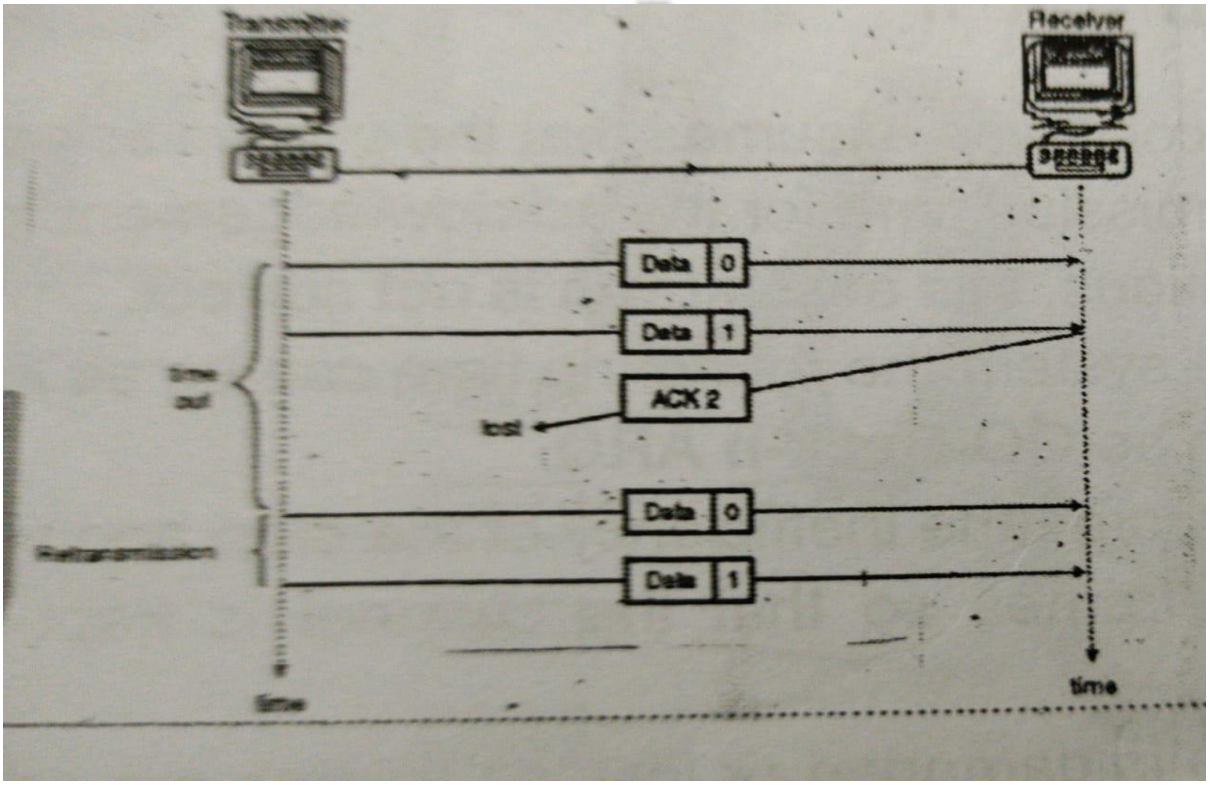
- Refer below diagram to understand the principle of Go-Back-n ARQ



- The major difference between this and the previous system is that the sender does not wait for ACK signal for transmission of next frame
- It transmits the frames continuously as long as it does not receive the “NAK” signal . NAK is the negative acknowledgement signal sent by the receiver to the transmitter
- But this signal takes some time to reach transmitter . By that time the transmitter has transmitted frames upto frame ?
- On reception of the NAK signal , the transmitter will retransmit all the frames from 3 onwards . the receiver discards all the frames it has received after 3 i.e. to 7 . It will receive all the frames that are retransmitted by the transmitter

Operation When the Acknowledgement is lost :

- Below figure shows the condition for lost acknowledgement . In case of go-back-n method for transmitter does not except an acknowledgement after every data frame
- It cannot use the absence of sequential ACK numbers to identify lost ACK or NAK frame instead it uses a timer
- The transmitter can send as many frame as the window allows before waiting for an acknowledgement
- Once the limit has been reached or the transmitter has no more frames to transmit it must wait till timer goes off and retransmit all the data frames again
- The disadvantage of Go-Back-n ARQ protocol is that in noisy channels it has poor efficiency because of the need to retransmit the frame in error and all the subsequent frames



Disadvantage of Go-Back-n

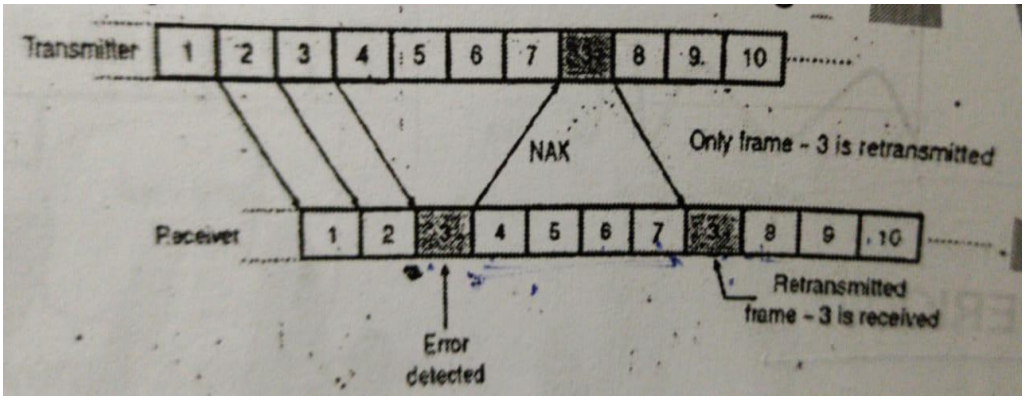
- It transmits all the frames if one frame is damaged or lost
- It transmit frames continuously as long as it does not receive NAK signal
- The NAK signal takes some time to reach the sender . Till that time the sender has already sent some frames . All those will be retransmitted after receiving the NAK
- The error can get introduced if the NAK is lost .

Pipelining :

- In networking a task is often being before the previous task is complete . this called pipelining
- There is no pipelining in stop-and-wait ARQ but the concept of pipelining does apply to Go-Back-n ARQ and the selective repeat ARQ
- Pipelining improves the efficiency of transmission

Selective Repeat ARQ:

- In this method only the specified damaged or lost frame is retransmitted . A selective repeat systems differs from the go-back-n method in the following ways
  1. The receiver can do sorting of data frames and is also able to store frames received after NAK has been sent until the damaged frame has been replaced
  2. The transmitter must contain a searching mechanism that allows it to find and select only the requested frame for retransmission
  3. The window size in this method is less than or equal to (n+1)/2 , whereas in case of go-back-n it is n-1
- The principle of operation of this protocol is illustrated below :



- In this system as well , the transmitter does not wait for the ACK signal for the transmission of the next code word. If transmits the code words continuously till it receive the “NAK” signal from the receiver
- The receiver sends the “NAK” signal back to the transmitter as soon as it detects an error in the received frame. For example , the receiver detects an error in the third frame
- By the time this “NAK” signal reaches the transmitter , it had transmitted the frames upto 7 as shown above
- On reception of “NAK” signal , the transmitter will retransmit only the frame -3 and then continues with the sequence 8,9,..... as above
- The frames 4,5,6 and 7 received by the receiver are not discarded by the receiver . The receiver receives the retransmitted frames in between regular frames. Therefore the receiver will have to maintain the frame sequence
- Thus in selective repeat ARQ only the frame which is damaged or lost is retransmitted by the transmitter
- The lost ACK or NAK frames are treated in the same manner as of the go-back-n method
- When the transmitter reaches either the capacity of its window [(n-1)/2] or the end of its transmission it set as a time r.
- If no acknowledgement arrives in the time allotted , all the frames the remain unacknowledged are retransmitted
- This disadvantage of this method is that because of the complexity of sorting and storage required by the receiver and extra logic needed by the transmitter to select frames for retransmission , the system become more expensive
- The advantage of this system is that it gives the best throughput efficiency . This is due to the use of pipelining in selective repeat ARQ

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