JEPPIAAR INSTITUTE OF TECHNOLOGY

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DEPARTMENT

OF

COMPUTER SCIENCE AND ENGINEERING

LECTURE NOTES

CS8561-COMPUTER NETWORKS

Year/Semester: III/05 CSE

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FUNDAMENTALS & LINK LAYER

Building a network – Requirements - Layering and protocols - Internet Architecture – Network software – Performance ; Link layer Services - Framing - Error Detection - Flow control

1.0 Network

Network meant the set of serial lines used to attach dumb terminals to mainframe computers. To some, the term implies the voice telephone network. To others, the only interesting network is the cable network used to disseminate video signals.

- Network is an Collection or Group of computer system connected together.
- Series of nodes interconnected by communication line or path
- Connection between nodes using either cable media or wireless media
- It is an Data Communications
- Data is Transferred in the form of **Packets**

1.1 BUILDING A NETWORK

1.2 REQUIREMENTS

- *Why* Network are designed the way they are ?
- Identify set of constraints and Requirements
- Understand the Expectations
- Application Programmer (services – send message without error on time)
- Network Designer (cost effective)
- Network Provider (Administer and Manage)

1.2.1 Connectivity

- Providing connection between set of computer systems
- Links , Nodes and Clouds
- Physical Medium – Links
- Computer it connects as – Nodes
- Point to Point and Multiple Access
- Switched Network

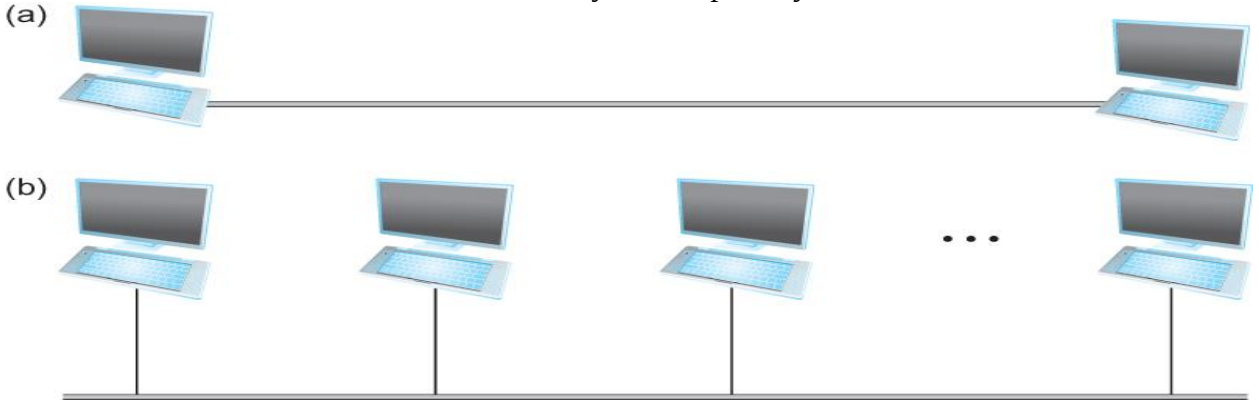
  Forward the data received on the one link to other

(a) **Point-to-point**

A point-to-point connection provides a dedicated link between two devices. The entire capacity of the link is reserved for transmission between those two devices.

(b) **Multiple access**

A multipoint connection is one in which more than two specific devices share a single link. In a multipoint environment, the capacity of the channel is shared, either spatially or temporally. If several devices can use the link simultaneously, it is a *spatially shared* connection.



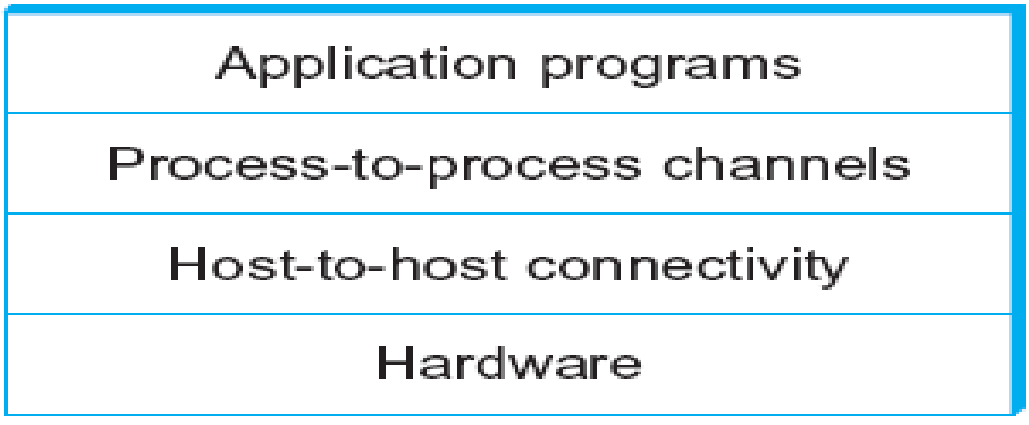
1.2.2 Switching Functions

- Store-and-forward
- Switches and host
- Connectivity and Address
- Network address

1.2.3 Cost-Effective Resource Sharing

- Need Multiplexing and DeMultiplexing
- FDM and STDM
- Switching using FIFO and Round Robin
- QoS
- Congestion

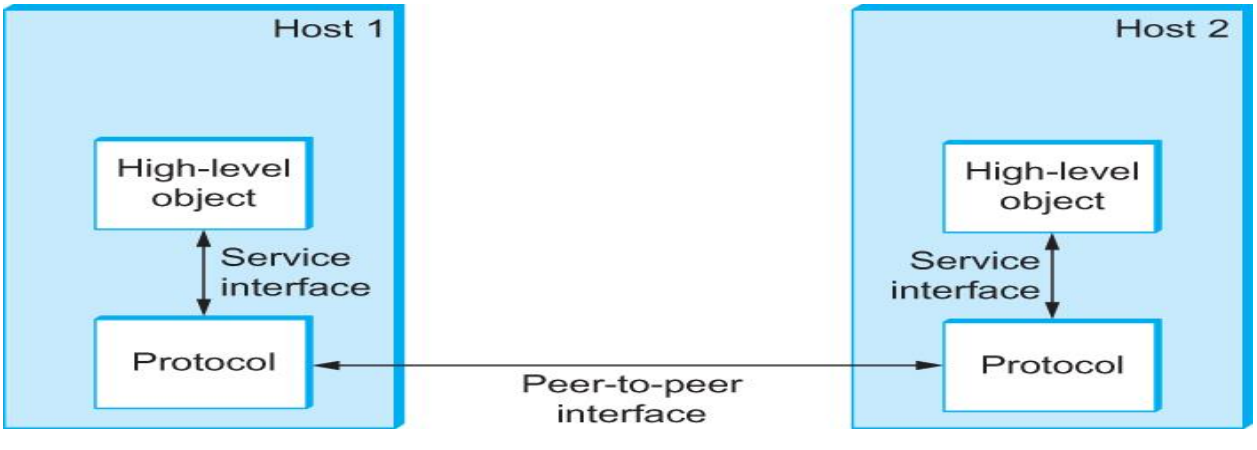
1.2.4 Network Architecture



1.3 LAYERING AND PROTOCOLS

- Protocol defines the interfaces between the layers in the same system and with the layers of peer system
- Each protocol object has two different interfaces
  - service interface: operations on this protocol
  - peer-to-peer interface: messages exchanged with peer

1.3.1 Interface



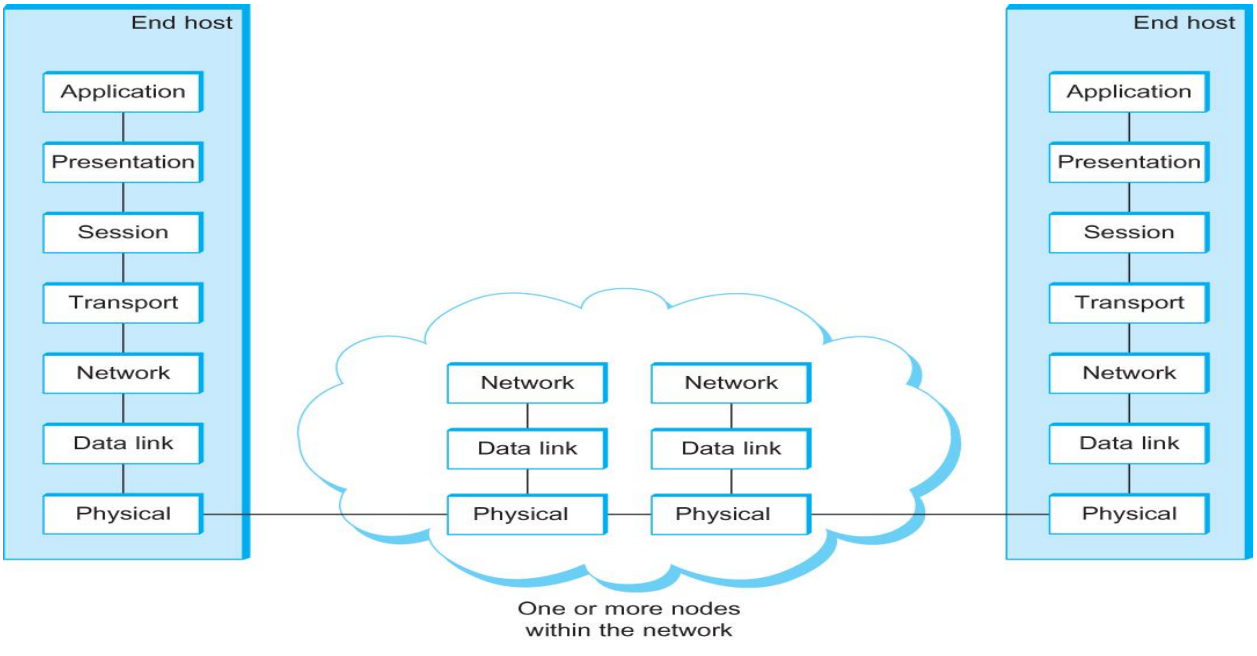
- HSPA – High Speed Packet Access (7 Mbps Downlink and 7 Mbps Uplink)
- UMTS – Universal Mobile Telecommunication System –WCDMA
- EDGE – Enhanced Data rates for GSM Evolution

  384 kbps to 10mbps
- GPRS – General Packet Radio Services
- 115 to 384 kbps

1.3.2 OSI Architecture

- OSI – Open System Interconnection
- Introduced by ISO – 1983.
- A Layer serves the layer above it and is served by the layer it.
- Systems are open for having communication with other systems.
- It characterizes and standardizes the internal functions of a communication system
- Hardware and Software work together

OSI Reference Model or Architecture



Physical Layer

The physical layer coordinates the functions required to transmit a bit stream over a physical medium. It deals with the mechanical and electrical specifications of the interface and the transmission medium.

Functions

i).Physical Characteristics of Interface & Media

ii).Representation of Bits

iii).Defining the Data Transmission Rate

iv).Transmission Mode

- Defining the direction of transmission between source and destination like
- 1. simplex 2. half duplex 3. full duplex

v).Synchronization of Bits - sender and receiver must be synchronized at bit level.

Data Link Layer

It is responsible for end to end delivery (node to node).

Functions of Data link layers are

i).Framing - Dividing the stream of bits into manageable data units called frames.

ii).Physical Addressing - Defines the physical address of the sender and the receiver.

iii).Flow Control

iv). Error Control (Error Detection & Correction)
v).Access Control

Network Layer

When the sender is in one network and the receiver is in some other network then the network layer has the responsibility for the source to destination delivery.

Function

i). Logical Addressing

ii).Routing

iii).Outgoing Messages into Packets & To assemble incoming messages

Transport Layer

The network layer is responsible for the end to end delivery of the entire message. It ensures that the whole message arrives in order and intact. It ensures the error control and flow control at source to destination level.

Functions

i).Port Addressing

ii).Segmentation & Reassembly

iii).Connection Control

iv).Error control

v).Flow Control

Session Layer

Session layer used to synchronize the interaction and communication services between two devices. It functions are

Functions

i)Synchronization

ii)Dialog Control

Presentation Layer

It is used to maintain the syntax and semantics of the data to be transferred between source and destinations.

Functions

i).Syntax and semantics

ii).Translation

iii).Encryption and Decryption

Protecting information encryption and decryption is used. Encryption is an to transform the original data into another form(encrypted form). Decryption means retrieve the original data from encrypted data.

iv).Compression

Application Layer

This layer enables the user to access the network. This allows the user to log on to remote services and allowing file transfer, mail transfer and other services.

Functions

i).Network Virtual Terminal

ii).E-Mail (SMTP & POP3)

iii).FTP

iv).TELNET

v).Distributed System

1.4 TCP / IP Architecture

- The *Internet* architecture is also known as TCP/IP architecture .
- This architecture evolved out of a packet-switched network ARPANET
- Applications are free to bypass transport layer and can directly use IP.

1.4.1 Internet Architecture

- Defined by IETF
- The application is free to bypass the defined transport layers and to directly use IP.
- In order for a new protocol to be officially included in the architecture, there needs to be both a protocol specification and at least one (and preferably two) representative implementations of the specification.

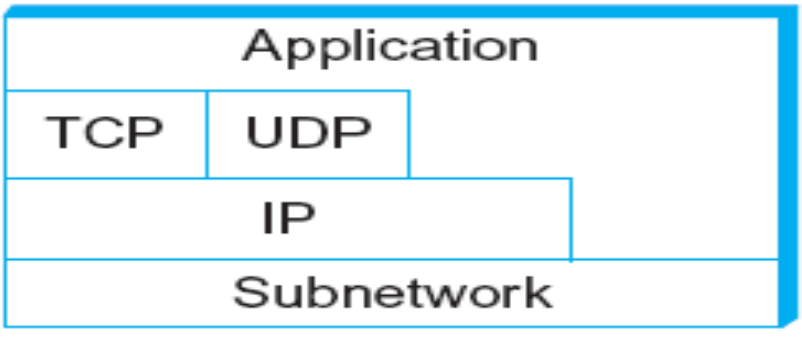
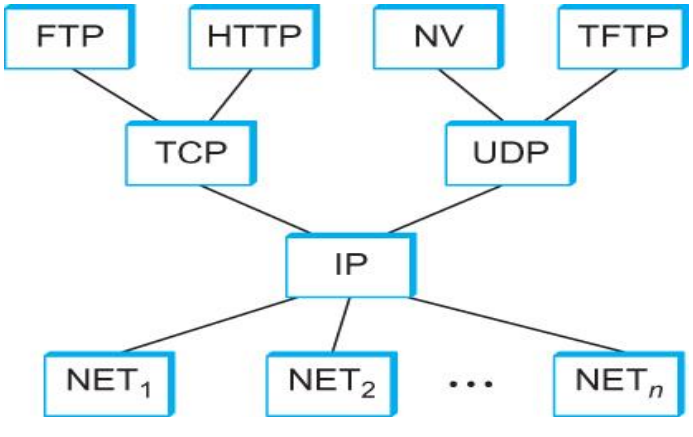


Figure : TCP / IP Internet Architecture

Host to Network Layer



- Accepting and Transmitting IP datagrams
- Finding Corresponding NIC
- Combination of Physical and Data Link Layer.

Difference between TCP and UDP

TCP	UDP
Connection Oriented	Connectionless
Connection is byte stream	Connection is message stream
It does not support multicasting and Broadcasting	It support Broadcasting and Multicasting
It Provide error control and flow Control	It does not provide error and Flow control
Full Duplex transmission	Does not support full duplex transmission
TCP is Reliable	Unreliable connections
TCP packet is called Segment	Packet is called user datagram

Network Layer

- Fragmentations
- It is an unreliable and connectionless protocol.
- IP sends data in packets called *datagram,* each of which is transported separately and independently.
- The other protocols supported in this layer are ARP, RARP, ICMP and IGMP.

Transport Layer

- *Transport* layer is responsible for delivery of a message from one process to another process.
- The two protocols supported in this layer are:
- Transmission Control Protocol (TCP) for connection-oriented reliable byte-stream channel.
- User Datagram Protocol (UDP) for connectionless unreliable datagram delivery channel.

Application Layer

- Application layer supports a wide range of protocols.
- FTP, TFTP, Telnet (remote login), SMTP, etc.,
- This layer is equivalent to combined session, presentation, and application layers in the OSI model.

Function

- Network Virtual Terminal
- Mail Services
- HTTP
- E-Mail
- FTP
- TELNET
- Distributed System

1.5 NETWORK SOFTWARE

- Used to implement network Protocols as part of OS
- It will Provide Interface services ie API
- Socket Interface was originally provided by the Berkeley distribution of Unix
- API provides a syntax by which those services can be invoked in this particular OS

Socket

- The point where a local application process attaches to the network
- An interface between an application and the network
- An application creates the socket

The interface defines operations for

- Creating a socket
- Attaching a socket to the network
- Sending and receiving messages through the socket

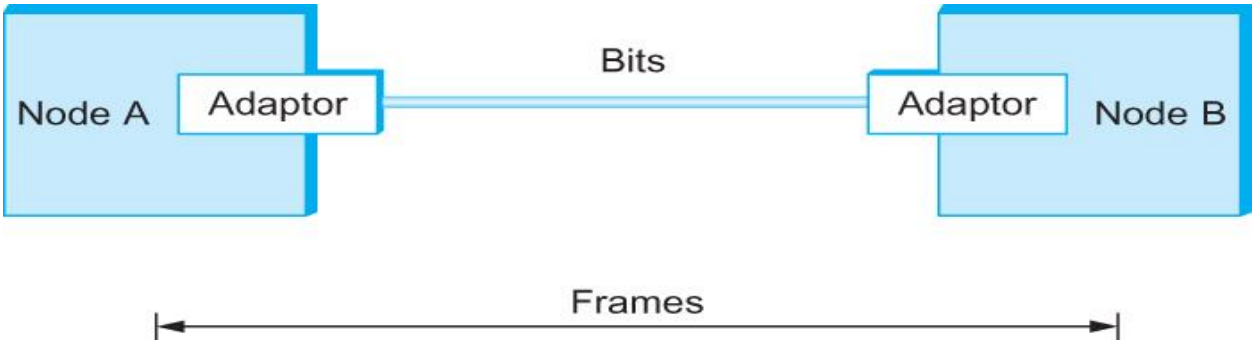
Socket Type

- SOCK_STREAM is used to denote a byte stream
- SOCK_DGRAM is an alternative that denotes a message oriented service, such as that provided by UDP

LINK LAYER SERVICES

1.7 FRAMING

- Packet-switched networks, which means that blocks of data (called *frames* at this level), not bit streams, are exchanged between nodes.
- It is the network adaptor that enables the nodes to exchange frames



1.7.1 Switching concept

- Switching – Collection of nodes connected with one or more point to point links.
- Circuit Switching :

  - Dedicated Path communication (Telephone System)

- Packet Switching :

  - Nodes transmit discrete blocks of data to each other.

  Blocks is an Packet or Messages.

- When node A wishes to transmit a frame to node B, it tells its adaptor to transmit a frame from the node's memory. This results in a sequence of bits being sent over the link.
- The adaptor on node B then collects together the sequence of bits arriving on the link and deposits the corresponding frame in B's memory.

1.7.2 Byte-oriented Protocols

BISYNC (Binary Synchronous Communication) Protocol

DDCMP (Digital Data Communication Protocol)

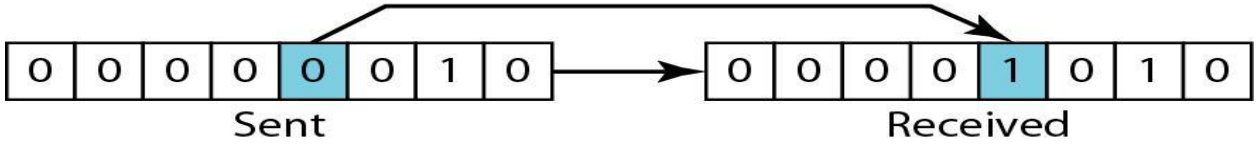
HDLC : High Level Data Link Control

1.8 ERROR DETECTION

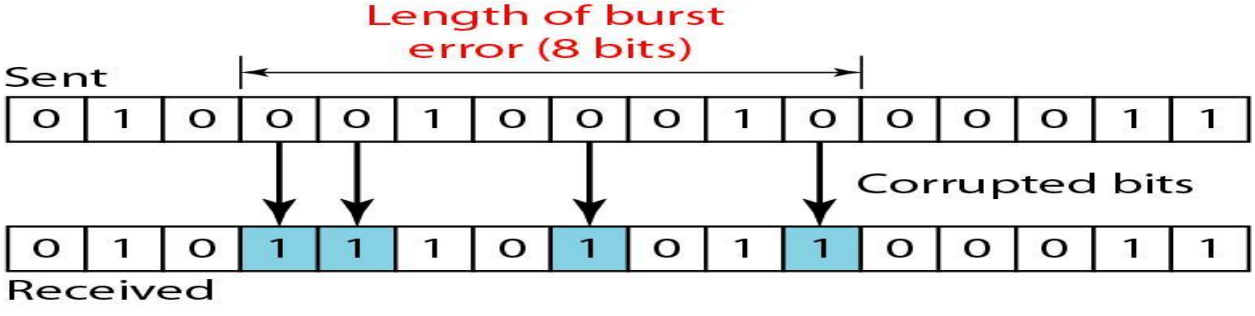
Error – Electrical Interference or thermal noise

- Types of Error

i) Single bit Error



ii) Burst Error



1.8.1 Error Detection

- Add redundant information to a frame that can be used to determine if errors have been introduced.

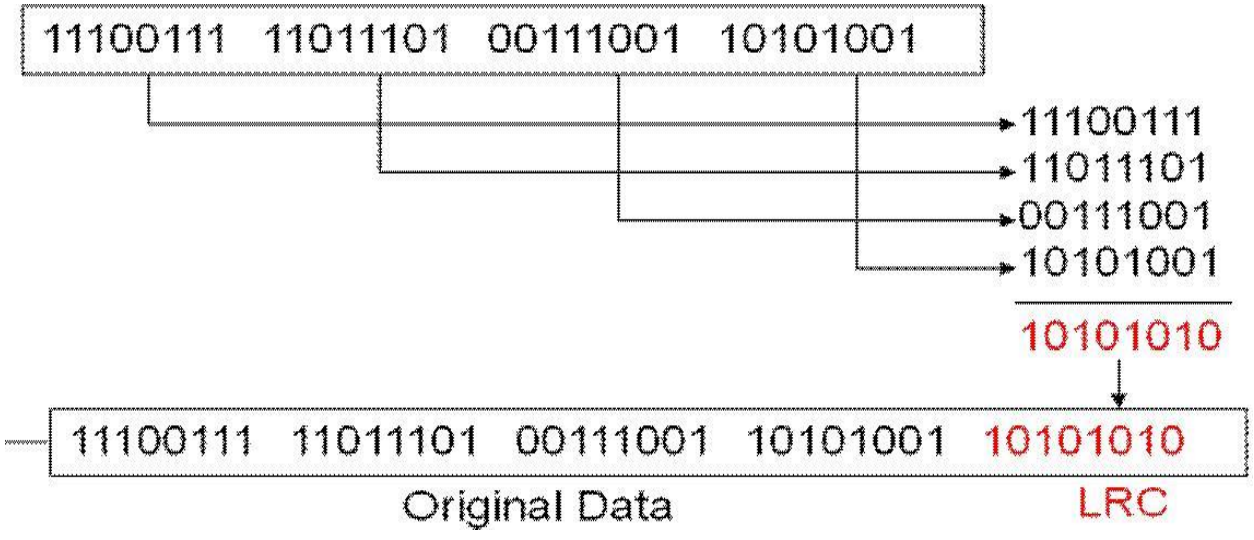
Simple Replication

- Transmit two copies of the data
- If the two copies are identical at the receiver, then it is correct ,else error occurred.
- Vertical Redundancy Check (VRC)

0110011 0110011**0** 0110001 0110001**1**

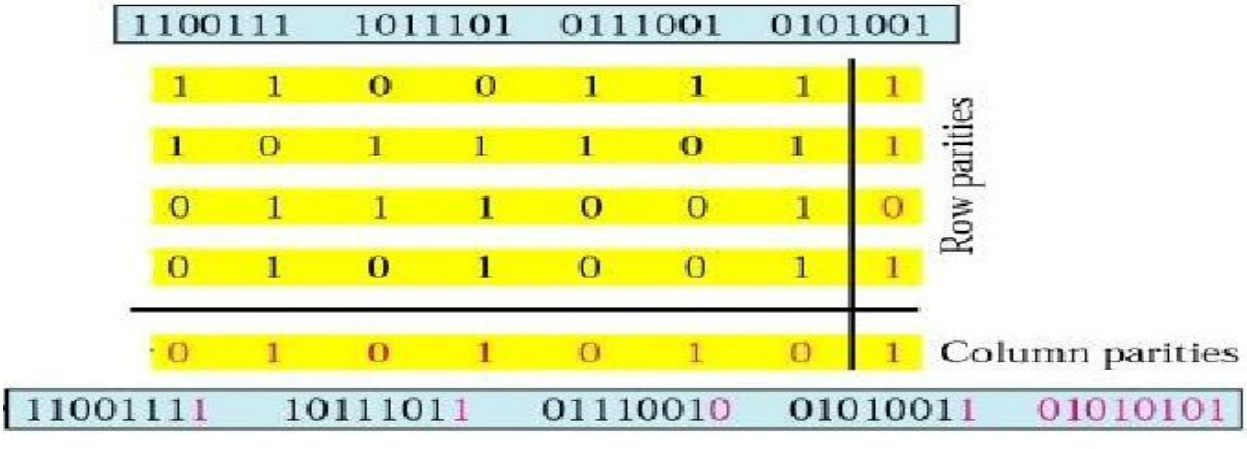
1.8.2 Longitudinal Redundancy Check (LRC)

The data bits are divided into equal segments and organized as a table. Parity bit is computed for each column.



1.8.3 Two-Dimensional Parity

- Data is divided into seven byte segments. Both VRC and LRC methods are applied. Even parity is computed for all bytes (VRC).

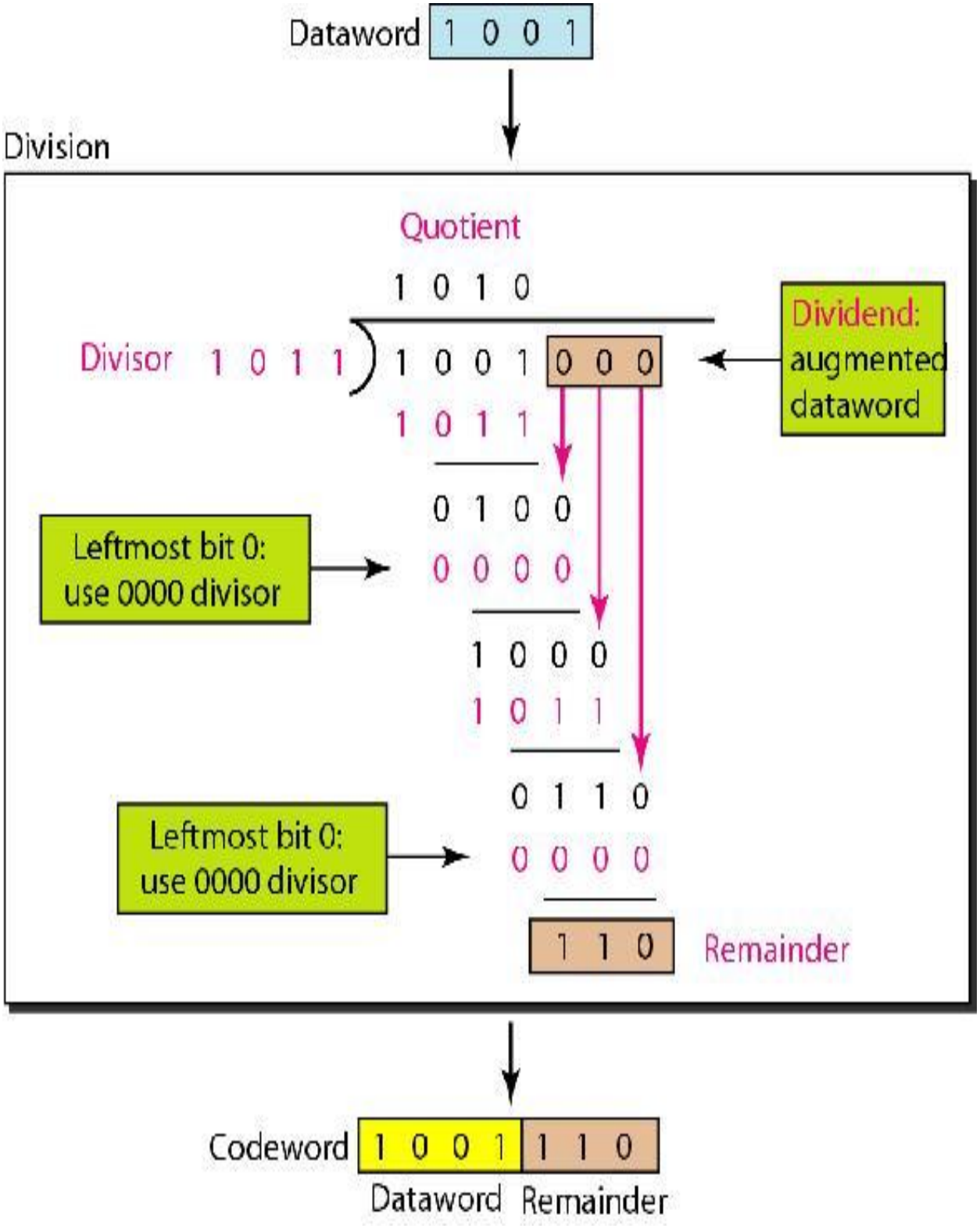


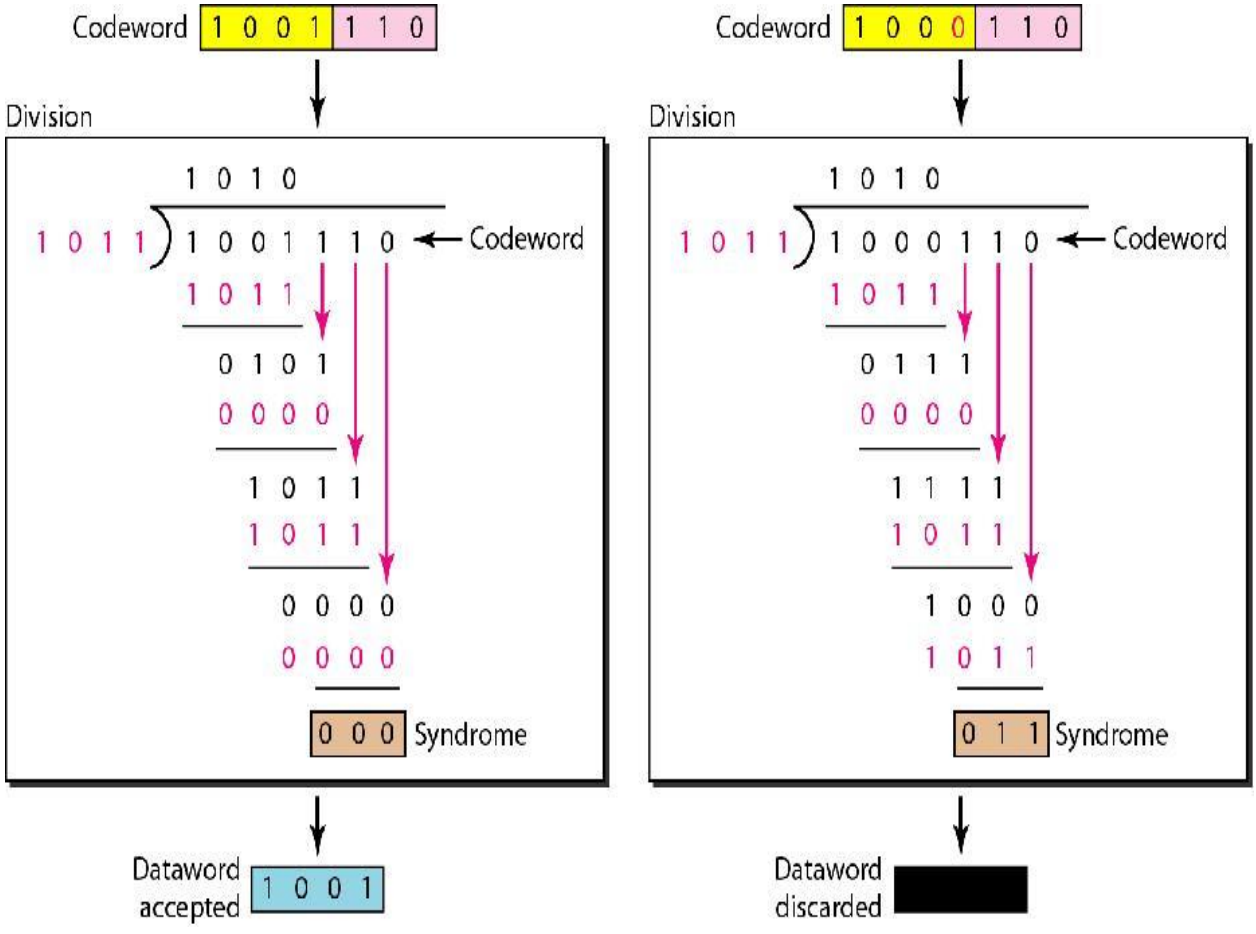
- The receiver re computes the row and column parities. If parity bits are correct, the frame is accepted else discarded.

1.8.3 Cyclic Redundancy Check

- A *n* bit message is represented as a polynomial of degree *n* - 1.
- The message M(*x*) is represented as a polynomial by using the value of each bit in the message as coefficient for each term.

- For eg., 10011010 represents $x^7 + x^4 + x^3 + x$





1.9 FLOW CONTROL

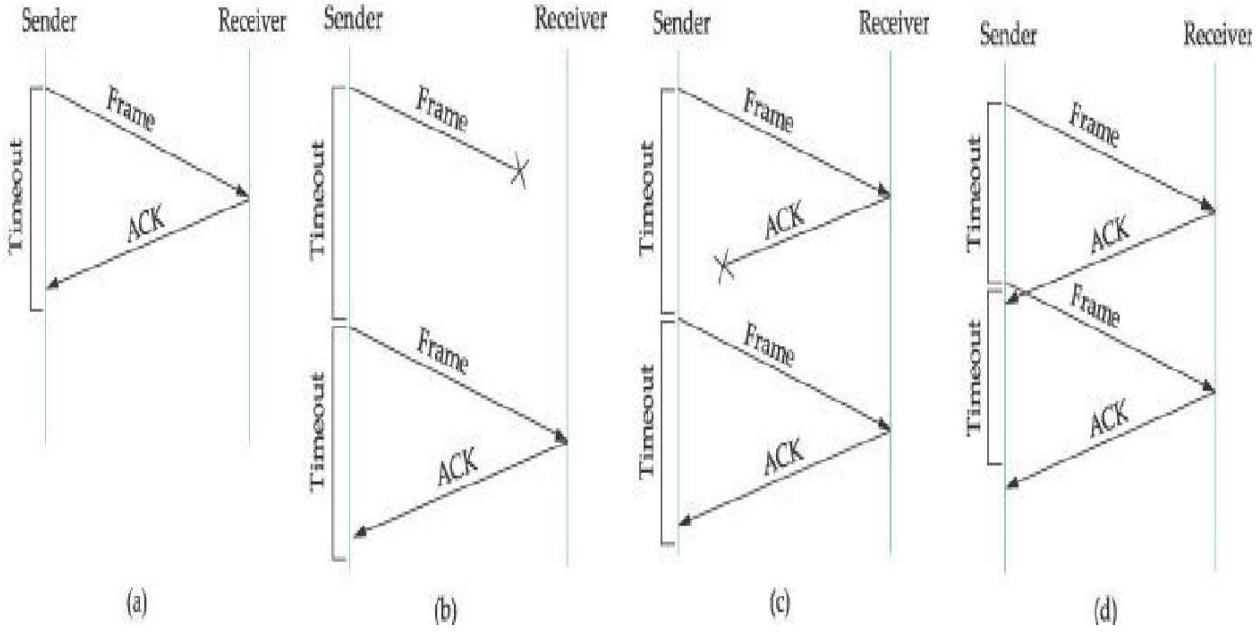
- Sender : Transmit single frame at a time
- Receiver : Transmit ACK as it receives a frame
- If sender does not receive an acknowledgment within a specified period (*timeout*), it retransmits the original frame. This is known as Automatic Repeat Request (*ARQ*).
- **The ARQ mechanism :**

  * Stop and Wait Protocol

  * Sliding Window Protocol

1.9.1 STOP-and-WAIT

- The sender keeps a copy of the frame and then transmits it.
- The sender waits for an Acknowledgment before transmitting the next frame.
- If acknowledgment does not arrive before timeout, the sender Retransmits the frame.

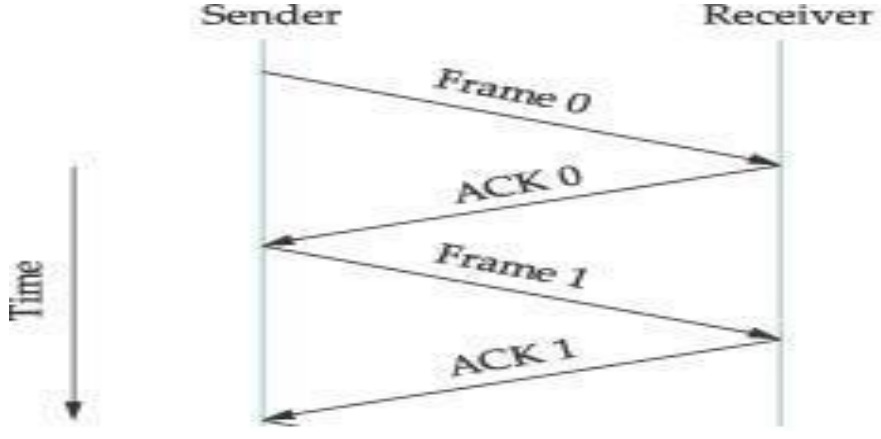


Scenarios

- ACK is received before the timer expires. The sender sends the next frame.
- The frame gets lost in transmission. Sender eventually times out and Retransmits frame.
- ACK frame gets lost. The sender eventually times out and retransmits the frame.
- The sender times out soon before ACK arrives and retransmits the frame.

1.9.2 Frame Sequence Number

- In scenarios (c) and (d), since the receiver has acknowledged the received frame, it treats the arriving frame as the next one. This leads to duplicate frames.



1.9.3 Sliding Window Protocol

- To improve efficiency, multiple frames must be in transition while waiting for an acknowledgment.

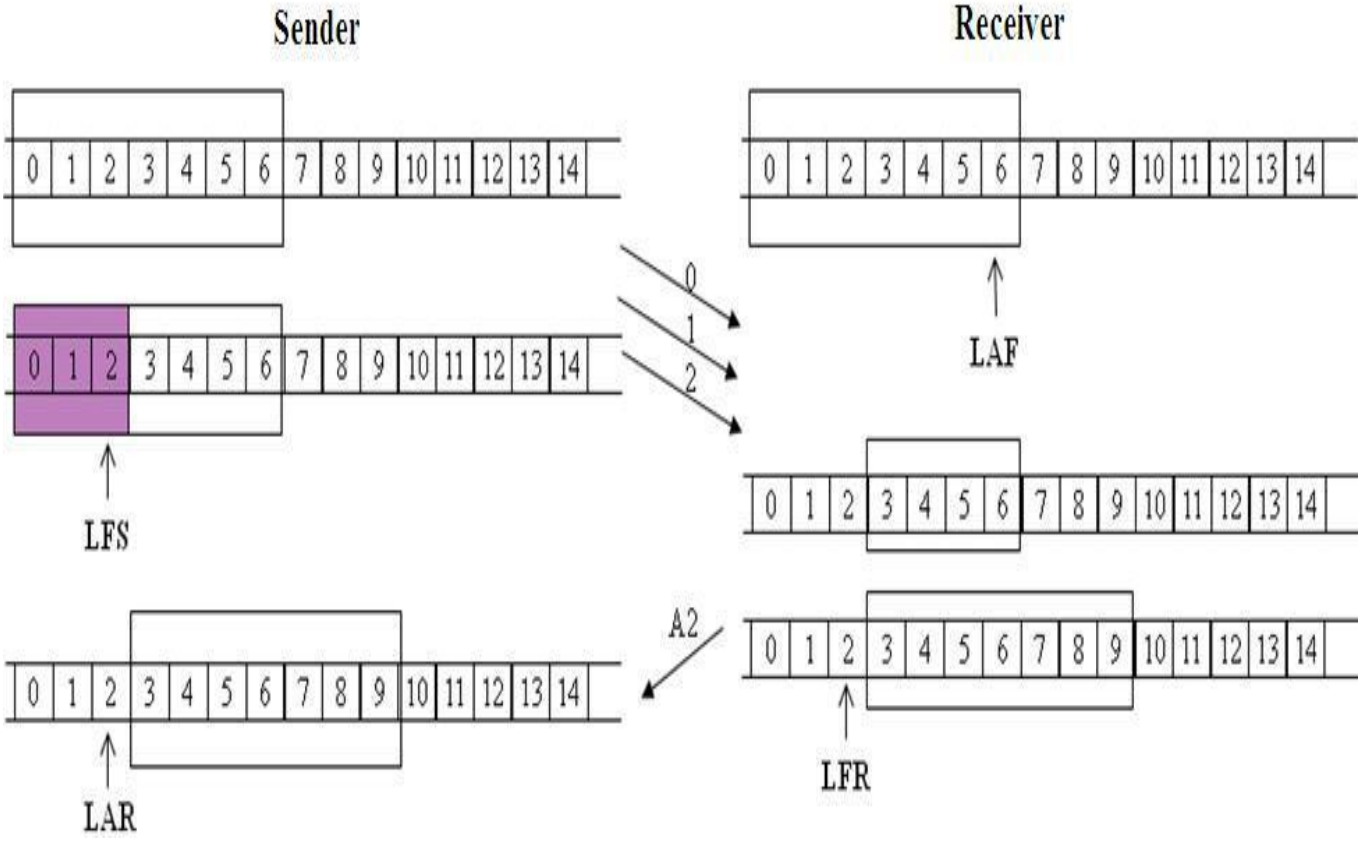
Sender :

- SWS – Sender Window Size : The number of outstanding frames that the sender can transmit.
- LAR - The sequence number of the Last Acknowledgment Received.
- LFS - The sequence number of the Last Frame Sent.

Receiver

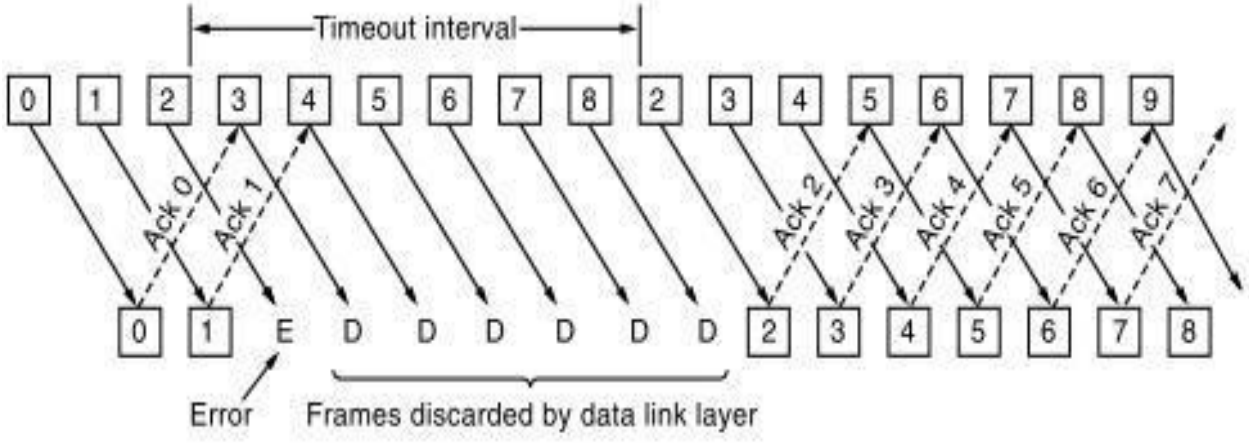
- Three state variables:
- RWS – Receiver Window Size : The number of outstanding frames that the Receiver can Receive
- LAF - The sequence number of the Largest Acceptable Frame.
- LFR - The sequence number of the Last Frame Received.

Example :



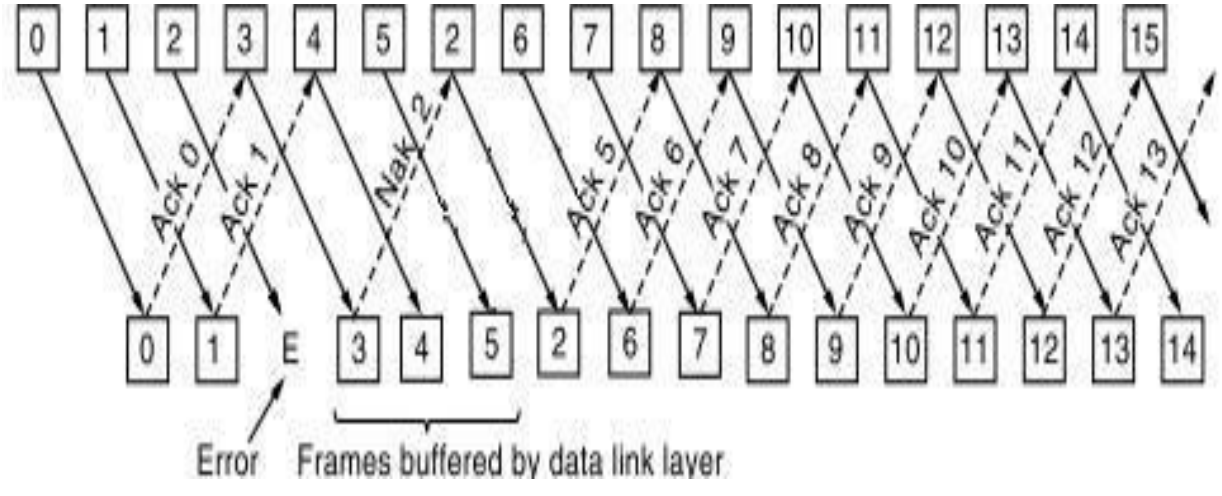
1.9.4Go Back N-ARQ

- The receiver only acknowledges SeqNumToAck, even if higher numbered frames arrive. Frames when arrive *out-of-order* are discarded by the receiver.



1.9.5 Selective Repeat

In selective repeat mechanism only selected or failure frame will be resend.



Issues with Sliding Window

- When timeout occurs, the amount of data in transit decreases
- When the packet loss occurs, this scheme is no longer keeping the pipe full
- The following method will help us to solve this issues
  - Negative Acknowledgement (NAK)
  - Additional Acknowledgement
  - Selective Acknowledgement