18ECC303J – Computer Communication Networks

Course Credit : 4

Theory : 9 Hours

1. Behrouz A. Fehrouzan, “Data communication & Networking”, Mc-Graw Hill, 5th Edition Reprint, 2014.

2. Andrew S. Tanenbaum, “Computer Networks”, Pearson Education India, 5th Edition, 2013.

3. William Stallings, “Data & Computer Communication”, Pearson Education India, 10th Edition, 2014.

Unit-2 : OSI Lower Layers

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- OSI Network models
- Layered Architecture
- Data Link Layer - Introduction
- Link Layer Addressing
- Error detection and Correction
- Data Link control – LLC
- Data Link control – MAC
- Flow and Error Control Protocol
- ARQ Schemes
- HDLC protocol

Unit 2 –Week 4

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Session 7

- Network models
- OSI layer Architecture

Session 8

- Data Link Layer
- Link Layer Addressing

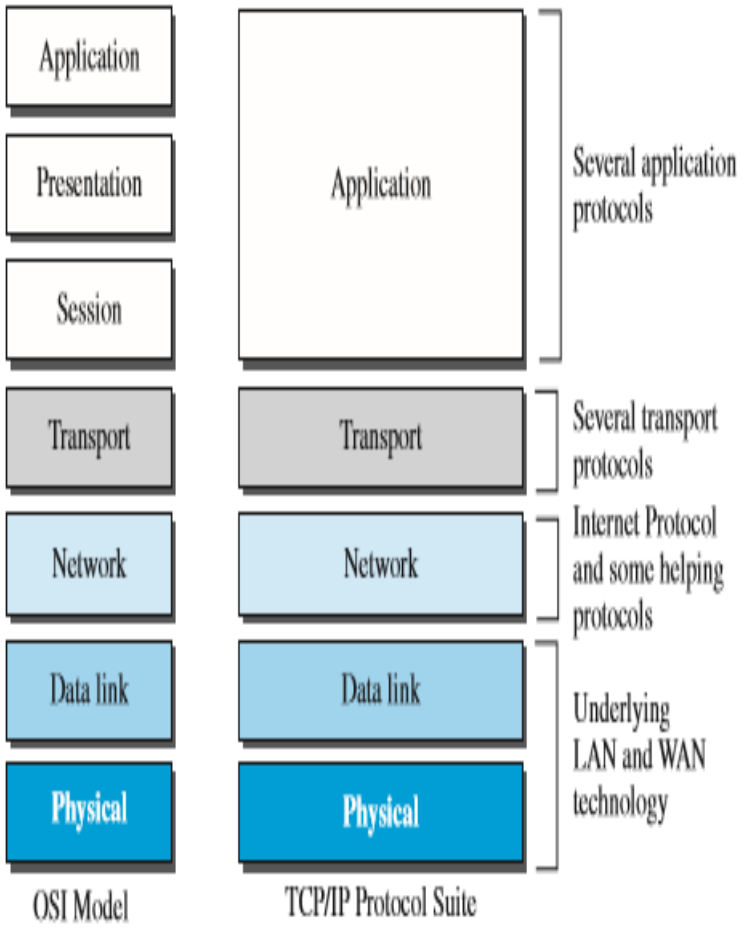
Session 9

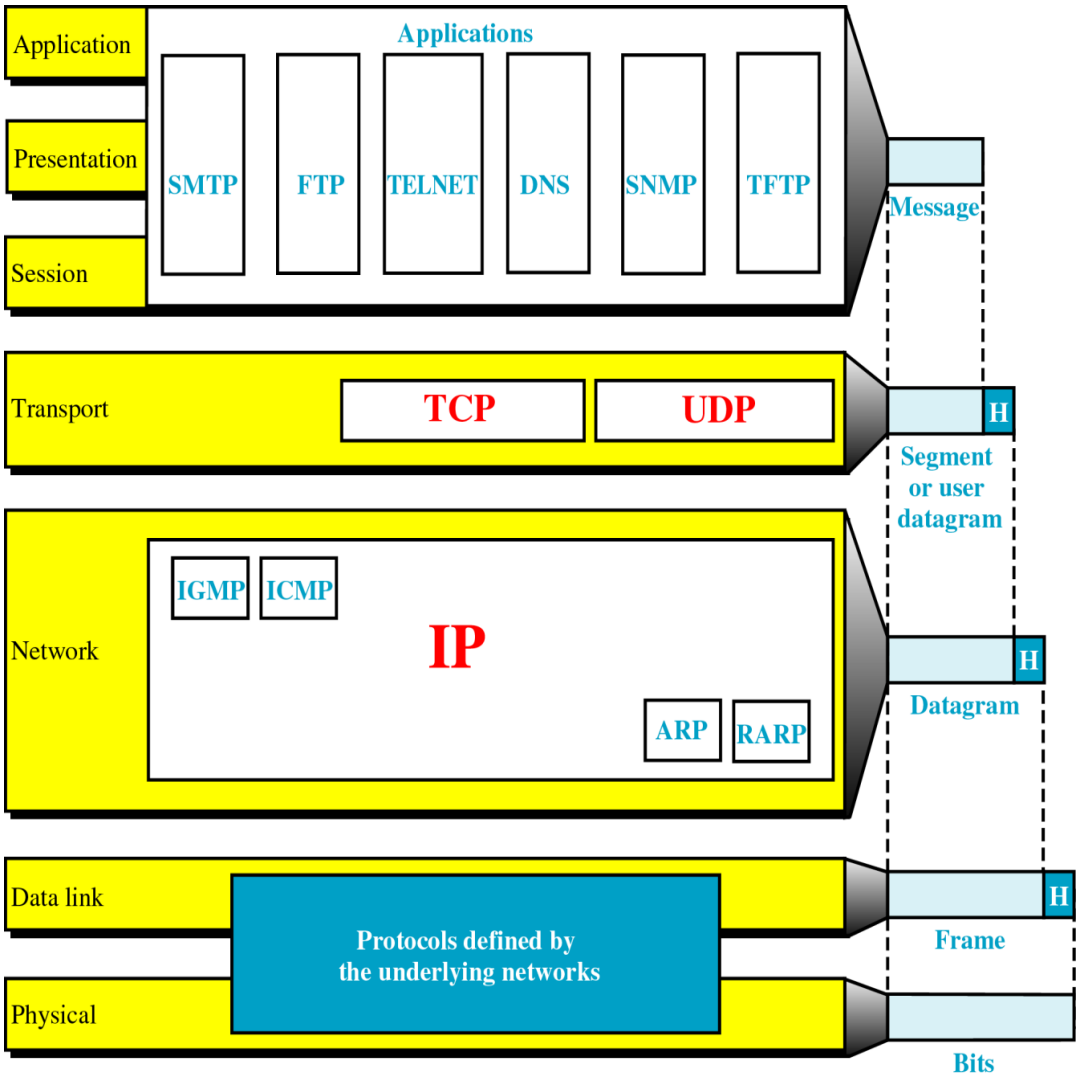
Error detection

Network Models

Two models have been devised to define computer network operations

- **OSI model**
- **TCP/IP model**





OSI Layered Architecture

OSI (Open Source Interconnection) 7 Layer Model

Layer	Application/Example		Central Device/ Protocols			DOD4 Model
Application (7) Serves as the window for users and application processes to access the network services.	**End User layer** Program that opens what was sent or creates what is to be sent Resource sharing • Remote file access • Remote printer access • Directory services • Network management		**User Applications** SMTP	GATEWAY Can be used on all layers		Process
Presentation (6) Formats the data to be presented to the Application layer. It can be viewed as the "Translator" for the network.	**Syntax layer** encrypt & decrypt (if needed) Character code translation • Data conversion • Data compression • Data encryption • **Character Set Translation**		JPEG/ASCII EBDIC/TIFF/GIF PICT			
Session (5) Allows session establishment between processes running on different stations.	**Synch & send to ports** (logical ports) Session establishment, maintenance and termination • Session support - perform security, name recognition, logging, etc.		**Logical Ports** RPC/SQL/NFS NetBIOS names			
Transport (4) Ensures that messages are delivered error-free, in sequence, and with no losses or duplications.	**TCP** Host to Host, Flow Control Message segmentation • Message acknowledgement • Message traffic control • Session multiplexing	PACKET FILTERING	TCP/SPX/UDP			Host to Host
Network (3) Controls the operations of the subnet, deciding which physical path the data takes.	**Packets** ("letter", contains IP address) Routing • Subnet traffic control • Frame fragmentation • Logical-physical address mapping • Subnet usage accounting		**Routers** IP/IPX/ICMP			Internet
Data Link (2) Provides error-free transfer of data frames from one node to another over the Physical layer.	**Frames** ("envelopes", contains MAC address) [NIC card —— Switch —— NIC card] (end to end) Establishes & terminates the logical link between nodes • Frame traffic control • Frame sequencing • Frame acknowledgment • Frame delimiting • Frame error checking • Media access control		**Switch Bridge WAP** PPP/SLIP	Land Based Layers		Network
Physical (1) Concerned with the transmission and reception of the unstructured raw bit stream over the physical medium.	**Physical structure** Cables, hubs, etc. Data Encoding • Physical medium attachment • Transmission technique - Baseband or Broadband • Physical medium transmission Bits & Volts		**Hub**			

Layer communication & Interfaces

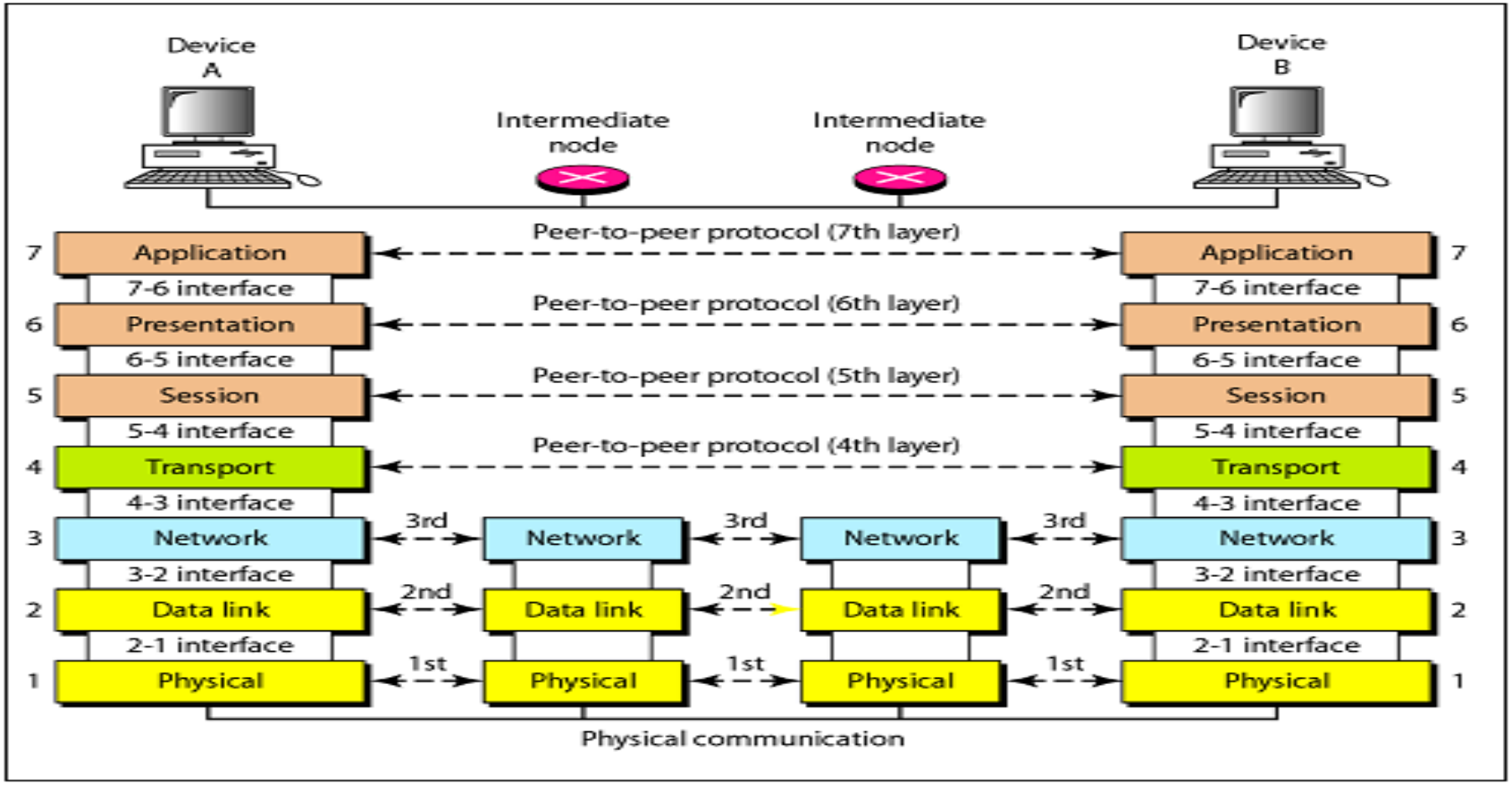


Fig: Communication & Interfaces in the OSI model

Layer communication & Interfaces

The processes on each machine that communicate at a given layer are called peer-to-peer processes.

Organization of Layers

The seven layers can be thought of as belonging to **three subgroups.**

Layers 1, 2, and 3 (Physical, Data link, and Network) are ***Network support layers***

It deals with the physical aspects of moving data from one device to another.

Layers 5, 6, and 7 (Session, Presentation, and Application) are ***User support layers*** that allows interoperability among unrelated software systems.

Layer 4, **Transport layer**, links the two subgroups and ensures that what the lower layers have transmitted is in a form that the upper layers can use.

If you are a sender, the layer operates from Layer 7 to Layer 1, if you are a receiver, the layer operated from Layer 1 to Layer 7.

At each layer, a *header*, and possibly a *trailer*, is *added* to the data unit. This is called *encapsulation*.

When the data unit passes through the physical layer, it is changed into an electromagnetic signal and transmitted across a physical link.

Physical layer

The main functions of this layer are to transmit a bit stream over a physical medium.

It deals with the mechanical and electrical specifications of the interface and transmission medium.

It also defines the procedures and functions that physical devices and interfaces have to perform for transmission to occur. Other responsibilities include:

- *Physical characteristics of interfaces and medium*

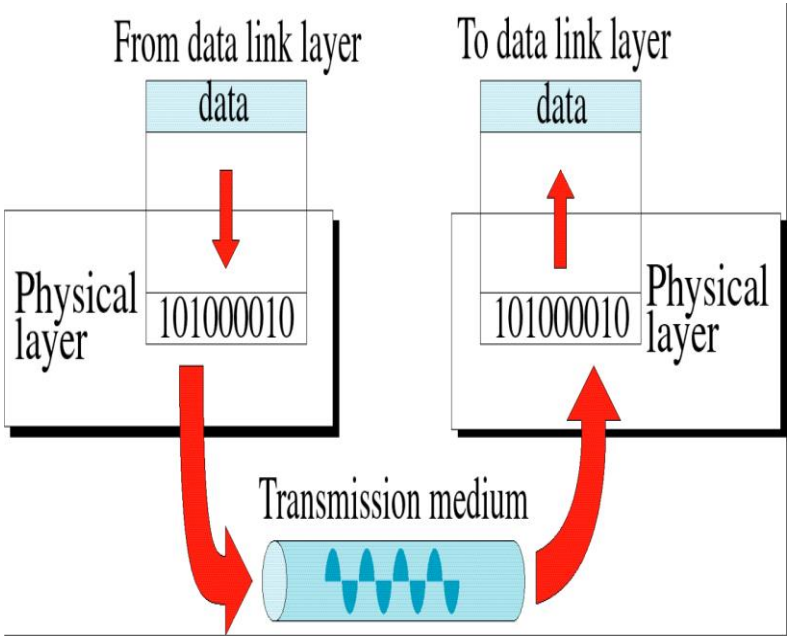
It defines the

- characteristics of the interface between devices and transmission medium, Type of medium.

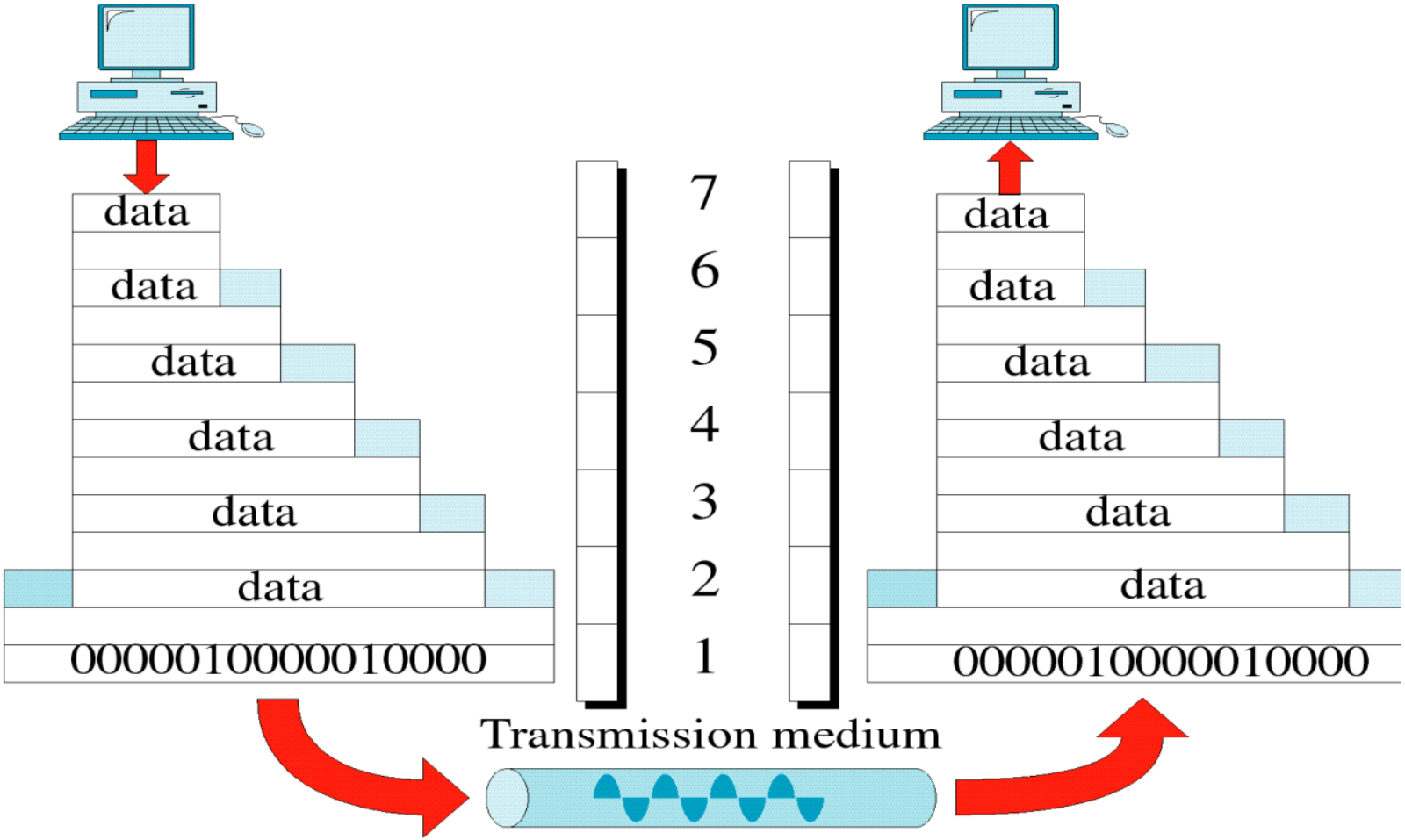
- *Representation of bits*—

  To be transmitted, bits must be encoded into signals - electrical or optical.

  The physical layer defines the type of encoding.



Physical Layer



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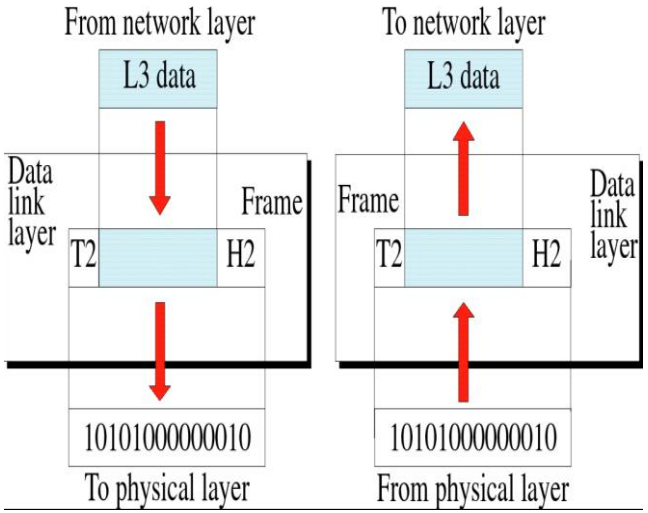
- ***Data rate***
  - It defines the transmission rate (number of bits sent per second).
- ***Synchronization of bits***
  - The sender and receiver must be synchronized at the bit level.
- ***Line configuration***
  - The physical layer is concerned with the connection of devices to the media (point-to-point or multipoint configuration).
- ***Physical topology***
  - It defines how devices are connected (mesh, star, ring, bus or hybrid) to make a network.
- ***Transmission mode***
  - The physical layer also defines the direction of transmission between two devices: simplex, half-duplex, or full-duplex

Data Link Layer

- The data link layer transforms a raw transmission facility to a reliable link.
- It is responsible for node to node delivery
- It makes the data appear error-free to the upper layer (network layer).

Other responsibilities include:

- Framing
  - The data link layer divides the stream of bits received from the network layer into manageable data units called frames.
- Physical addressing
  - If frames are to be distributed to different systems on the network



Continued…

- If destination is outside the sender's network, the receiver address is the address of the device that connects the network to the next one.

➢ ***Flow control***

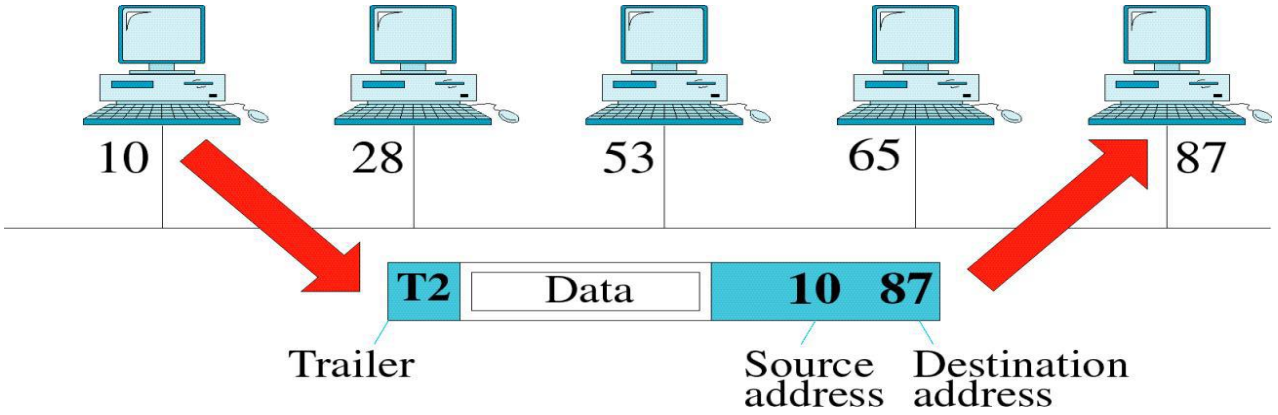
If the receiving rate is less than the transmission rate, the data link layer imposes a flow control mechanism to avoid overwhelming the receiver.

➢ ***Error control***

The data link layer adds reliability to the physical layer by adding a trailer to detect and retransmit damaged/lost frames and to recognize duplicate frames.

➢ ***Access control***

When two or more devices are connected to the same link, a data link layer protocol determines which device has control over the link at any given time.



Network Layer

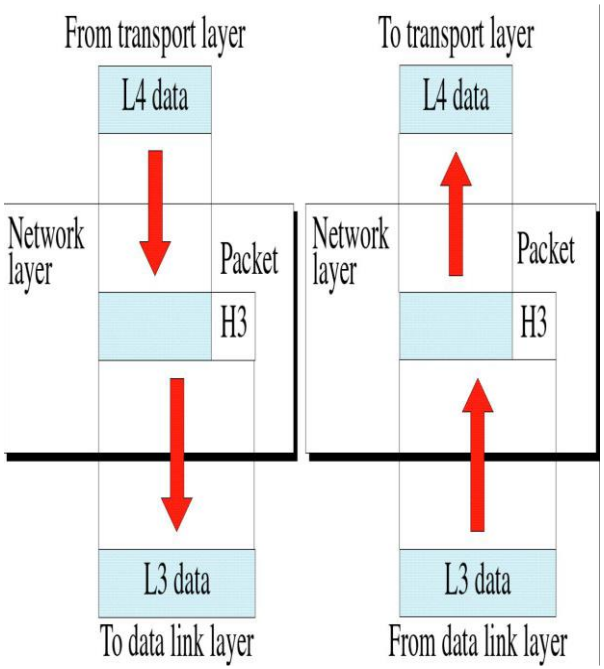
- The network layer is responsible for the source-to-destination delivery of a packet.
- If the two systems are attached to different networks with connecting devices between the networks, there is often a need for the network layer to accomplish source-to-destination delivery.

➢ ***Logical addressing***

- The physical addressing given by the data link layer handles the addressing problem locally.
- If a packet passes the network boundary, then logical addressing system is required to help distinguish the source and destination systems.

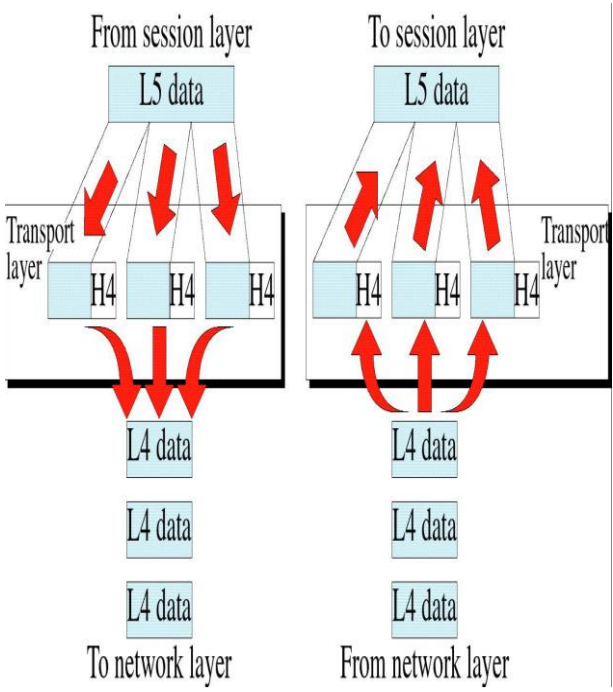
➢ ***Routing***

- When independent networks or links are connected to create *internetworks* (network of networks) or a large network, the connecting devices (called routers or *switches)* route or switch the packets to destination.



Transport Layer

- The transport layer is responsible for source to destination **(process-*to-process)* delivery of the entire message.**
- A process is an application program running on a host.
- It treats each one independently, as though each piece belonged to a separate message, whether or not it does.
- The transport layer, on the other hand, **ensures that the whole message arrives intact and in order, overseeing both error control and flow control at the source-to-destination level.**



Other responsibilities of the transport layer include:

➢ ***Service-point addressing***

A source-to-destination delivery means delivery not only from one computer to the next but also from a specific processon one comput er to a specific process on the other.

Transport layer

- ***Segmentation and reassembly***
  - A message is divided into transmittable segments, with each segment containing a sequence number.
  - These numbers enable the transport layer to reassemble the message correctly upon arriving at the destination and to identify and replace packets that were lost in transmission.
- ***Connection control***
  - A connectionless transport layer treats each segment as an independent packet and delivers it to the transport layer at the destination machine.
  - A connection oriented transport layer makes a connection with the transport layer at the destination machine first before delivering the packets. After all the data are transferred, the connection is terminated.
- ***Flow control***
  - The flow control at this layer is performed end to end.
- ***Error control***
  - The error control at this layer is performed process-to-process.
  - The sending transport layer makes sure that the entire message arrives at the receiving transport layer without error (damage, loss, or duplication).

Session Layer

The session layer is the network dialog controller.

- **It establishes, maintains, and synchronizes the interaction among communicating systems.**

Specific responsibilities of the session layer include the following:

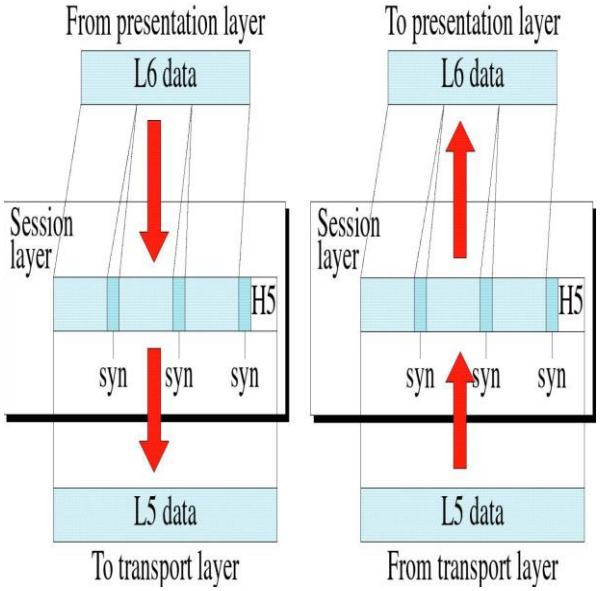
- ***Dialog control***

  It allows two systems to enter into a dialog and communication between two processes to take place in either half-duplex / full-duplex mode.

- ***Synchronization***

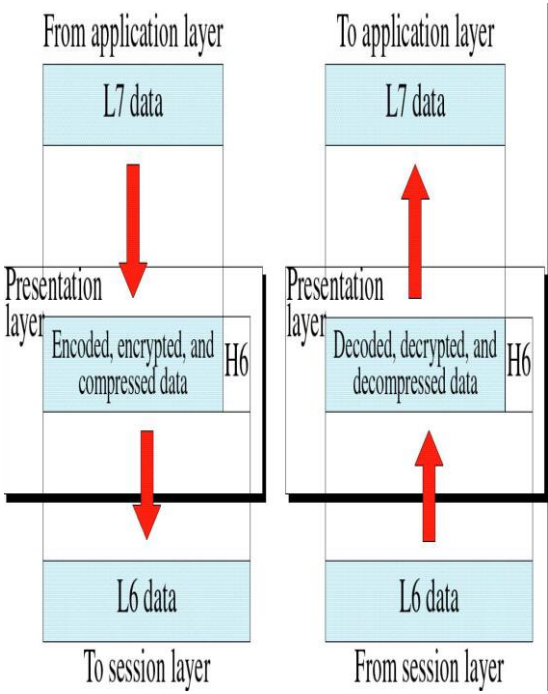
  The session layer allows a process to add checkpoints, or synchronization points, to a stream of data.

- For example, if a system is sending a file of 2000 pages, it is advisable to insert checkpoints after every 100 pages to ensure that each 100-page unit is received and acknowledged independently.
- If a crash happens during the transmission of page 523, the pages 501 to 523 will be resent.



Presentation layer

- The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems.
- Syntax means- the format and the coding scheme used for the information exchange between peer layers
- Semantics – the interpretation of control information for synchronization, coordination and error handling
- The main functions of this layer is translation, encryption/decryption and compression/decompression
- Specific responsibilities of the presentation layer include:
- ***Translation***
  - Different computers use different encoding systems, the presentation layer is responsible for interoperability between these different encoding methods.
  - The presentation layer at the sender changes the information from its sender-dependent format into a common format. The presentation layer at the receiving machine changes the common format into its receiver-dependent format.



Presentation layer

Encryption

- To carry sensitive information, a system must ensure privacy.
- The sender transforms the information into another form (encryption) before sending.
- The receiver transforms the encrypted message back to its original form (decryption).

Compression

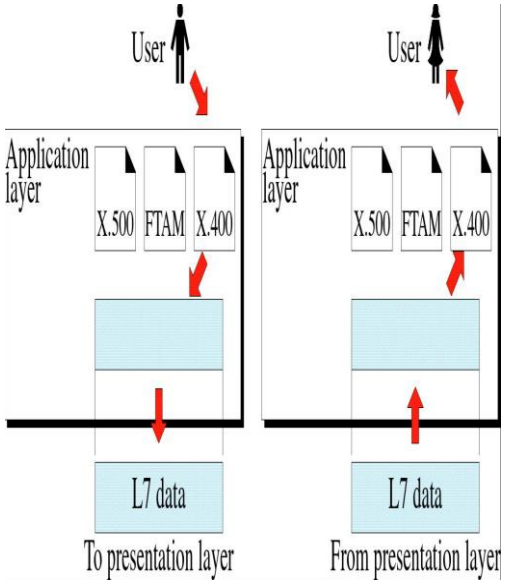
- Data compression reduces the number of bits contained in the information.
- It is particularly important in multimedia transmission.

Application Layer

- The application layer enables the user, whether human or software, to access the network.
- It provides user interfaces and support for services such as electronic mail, remote file access and transfer, shared database management, and other types of distributed information services.

Specific services provided by the application layer include:

- *Network virtual terminal—*
  - A **network virtual terminal** is a software version of a physical terminal, and it allows a user to log on to a remote host.
  - To do so, the application creates a software emulation of a terminal at the remote host.
  - The user's computer talks to the software terminal which in turn, talks to the host, and vice versa.



Review Questions

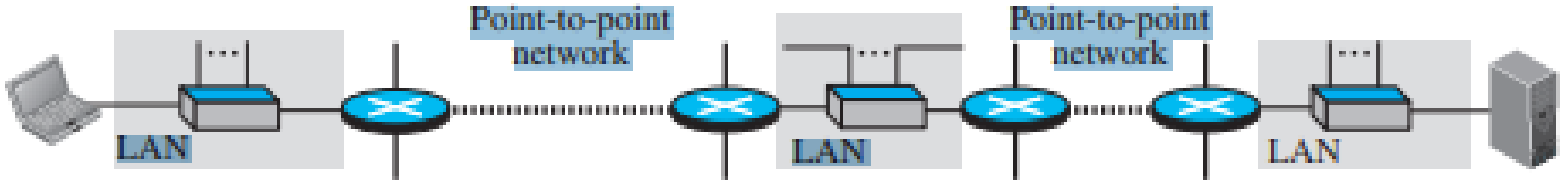
1. When the communication is complex, we may need to divide the task between different layers, in which case we need____.
2. The network layer is responsible for the _____ delivery of a packet.
3. A ____is a software version of a physical terminal, and it allows a user to log on to a remote host.
4. A ___ is an application program running on a host.

Answers

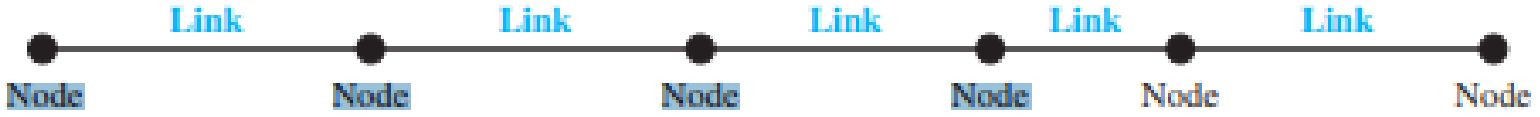
1. Protocol Layering
2. Source to destination
3. Network virtual Terminal
4. Process

Data Link Layer

- The data-link layer is located between the physical and the network layers.
- The data-link layer provides services to the network layer; it receives services from the physical layer
- Communication at the data-link layer is node-to-node.
- A data unit from one point in the Internet needs to pass through many networks (LANs and WANs) to reach another point.
- These LAN and WAN are connected by routers.
- **Two end hosts and the routers as nodes** and **the networks in between as links**



a. A small part of the Internet



b. Nodes and links

Services of Data-link layer

Framing

Link layer addressing

Flow Control

Error Control

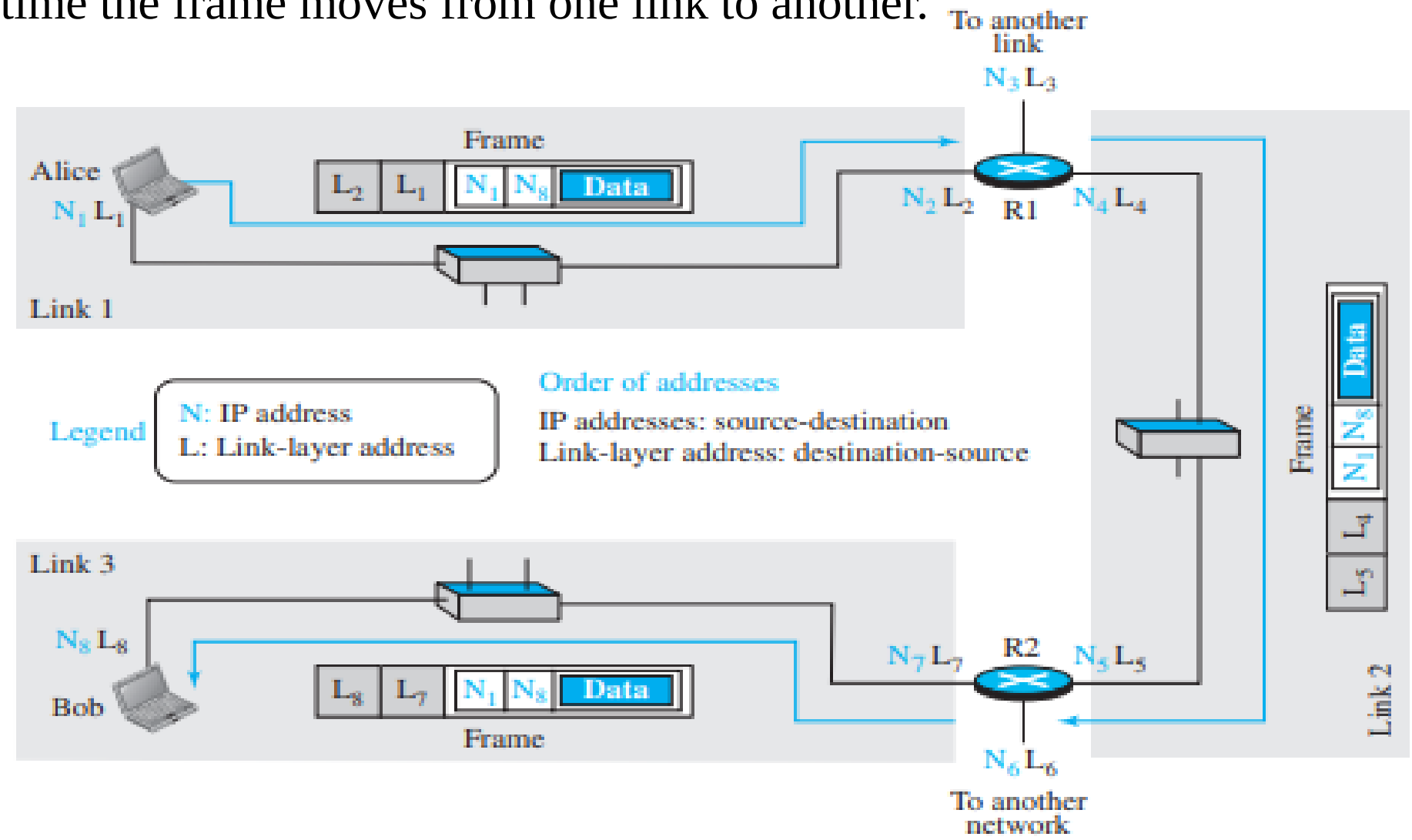
Framing : First service provided by the data-link layer is framing

- When a packet is travelling in the Internet, the data-link layer of a node (host or router) is responsible for delivering a datagram to the next node in the path.
- Data-link layer of the sending node needs to encapsulate the datagram received from the network in a frame. Data-link layer of the receiving node needs to decapsulate the datagram from the frame.
- Encapsulation and Decapsulation is needed at each intermediate node.
- Reason: Each link may be using a different protocol with a different frame format. Even if one link and the next are using the same protocol, encapsulation and decapsulation are needed because the link-layer addresses are normally different.

Link Layer Addressing

- **In a connectionless internetwork such as the Internet** we cannot make a datagram reach its destination using only IP addresses.
- The reason is that each datagram in the Internet, from the same source host to the same destination host, may take a different path.
- The source and destination IP addresses define the two ends but cannot define which links the datagram should pass through.
- We need to remember that the IP addresses in a datagram should not be changed. If the destination IP address in a datagram changes, the packet never reaches its destination; if the source IP address in a datagram changes, the destination host or a router can never communicate with the source if a response needs to be sent back or an error needs to be reported back to the source
- We need another addressing mechanism in a connectionless internetwork: the link-layer addresses of the two nodes.
- A link-layer address is sometimes called **a link address, sometimes a physical address, and sometimes a MAC address.**
- Since a link is controlled at the data-link layer, the addresses need to belong to the data-link layer.

When a datagram passes from the network layer to the data-link layer, the datagram will be encapsulated in a frame and two data-link addresses are added to the frame header. These two addresses are changed every time the frame moves from one link to another.



Consider the figure shown in previous slide:

- We have three links and two routers.
- Two hosts: **Alice as source and Bob as destination**.
- For each host, we have shown two addresses, the IP addresses (N) and the link-layer addresses (L).
- A router has as many pairs of addresses as the number of links the router is connected to.
- In the figure in the previous slide, it is shown three frames, one in each link.
- Each frame carries the same datagram with the same source and destination addresses (N1 and N8), but the link-layer addresses of the frame change from link to link.
  - **In link 1, the link-layer addresses are L1 and L2.**
  - **In link 2, they are L4 and L5.**
  - **In link 3, they are L7 and L8.**

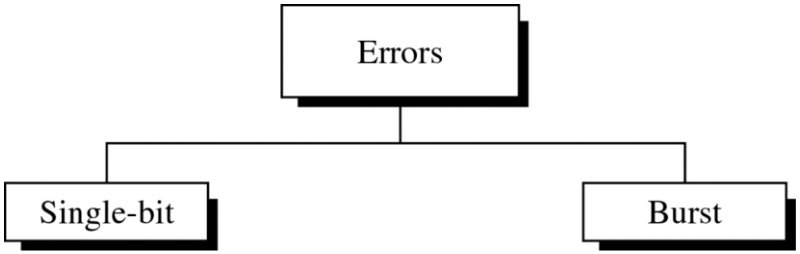
Note that the IP addresses and the link-layer addresses are not in the same order.

For IP addresses, the source address comes before the destination address;

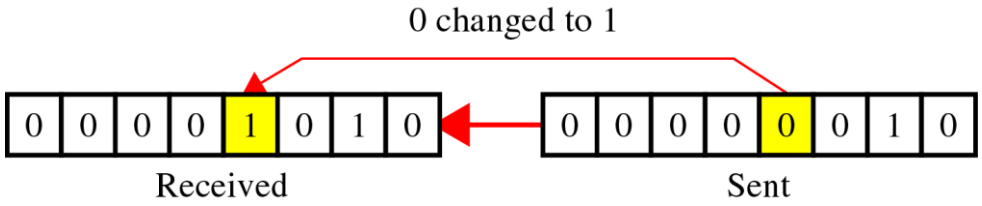
For link-layer addresses, the destination address comes before the source

Error Detection and Correction

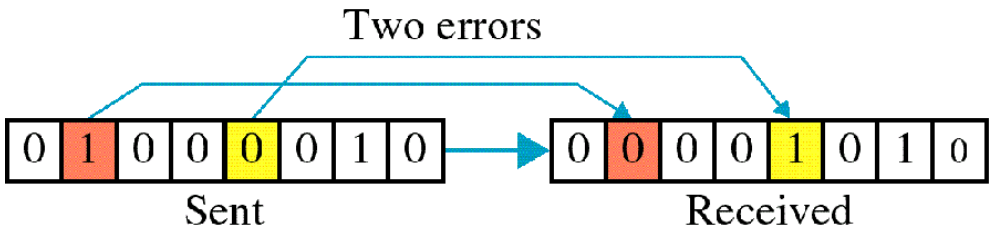
- Data can be corrupted during transmission.
- For reliable communication, error must be detected and corrected
- Implemented either at the data link layer or the transport layer of the OSI model



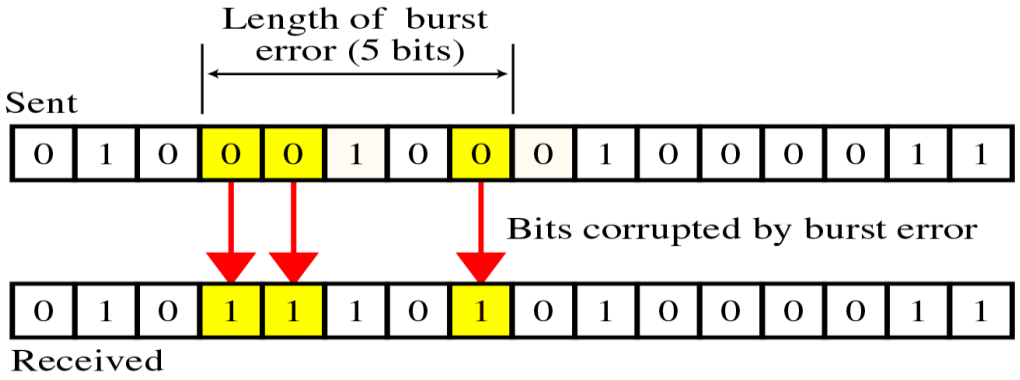
- **Single-Bit Error:** When only one bit in the bit in the data unit has changed



- **Multiple-Bit Error:** When two or more nonconsecutive bits in the data unit have changed

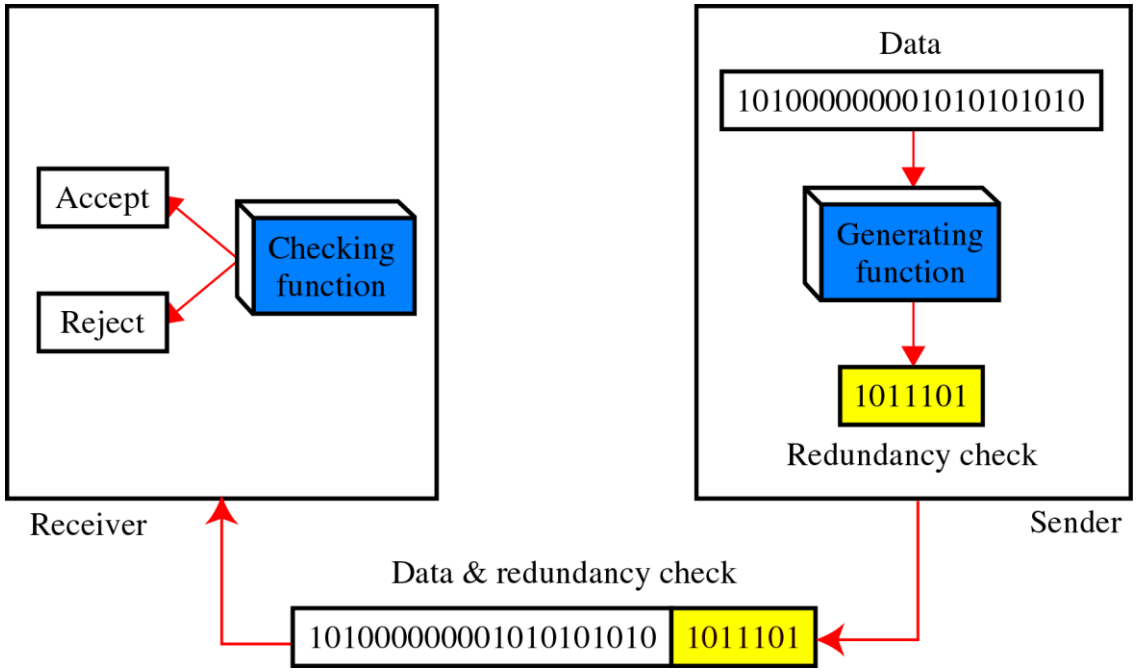


- **Burst Error:** Two or more consecutive bits in the data unit have changed

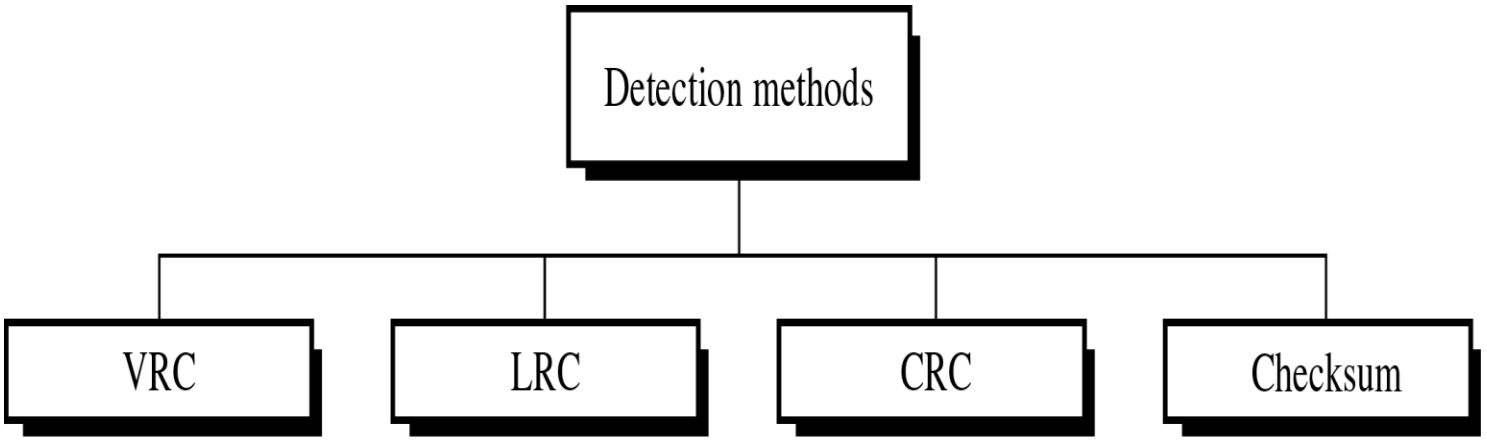


Error Detection

- Error detection uses the concept of redundancy, which means adding extra bits for detecting errors at the destination

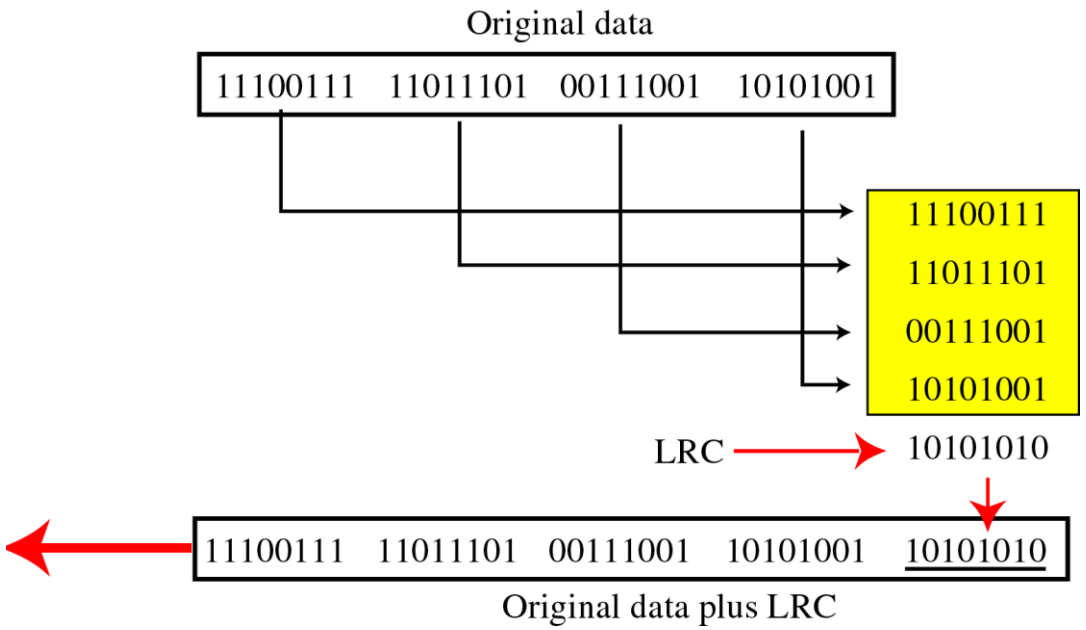


Detection methods



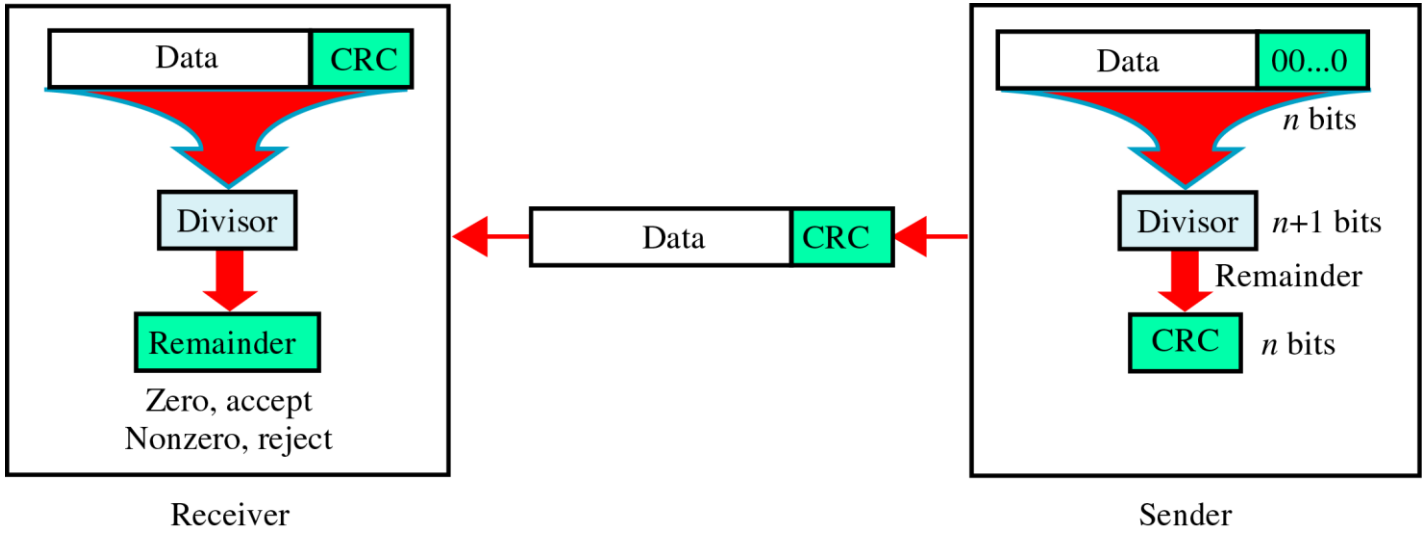
Vertical Redundancy Check (LRC)

- A parity bit is added to every data unit so that the total number of 1s(including the parity bit) becomes even for even-parity check or odd for odd-parity check
- VRC can detect all single-bit errors.
- It can detect multiple-bit or burst errors only the total number of errors is odd.



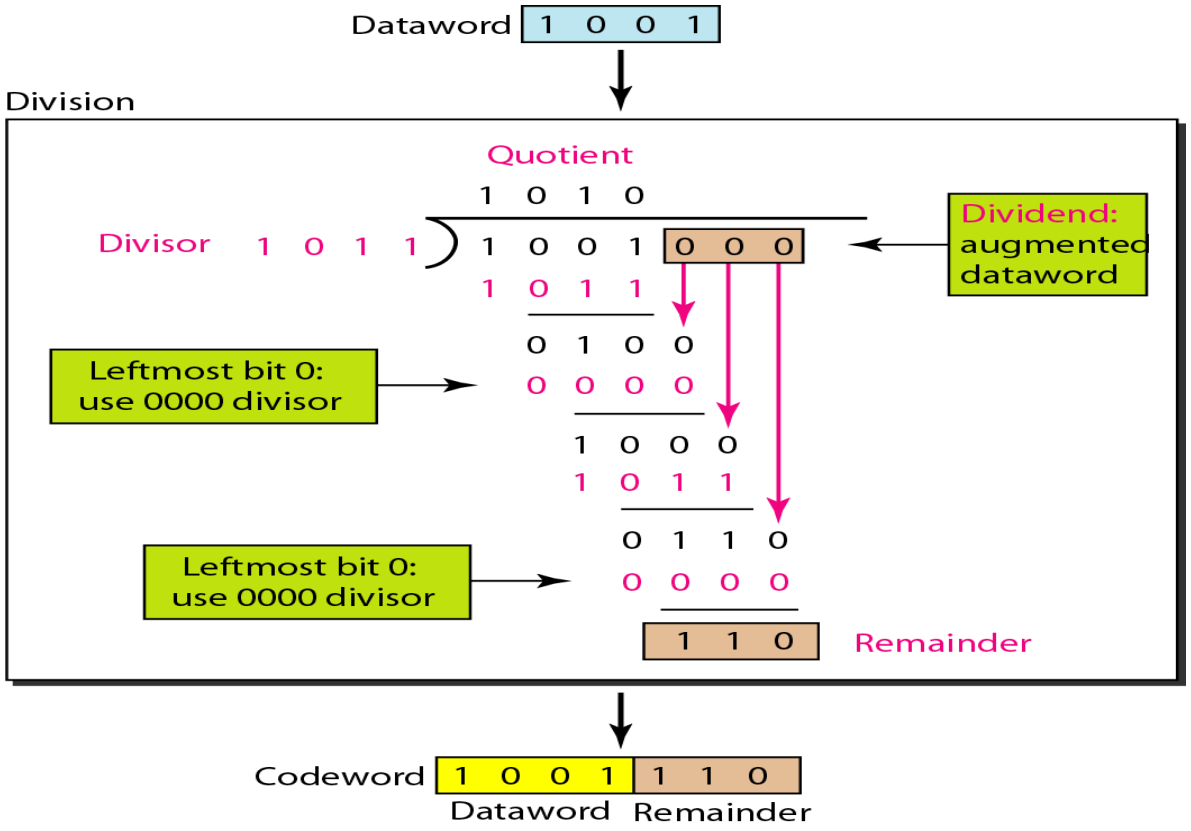
Cyclic Redundancy Check (CRC)

Based on Binary Division



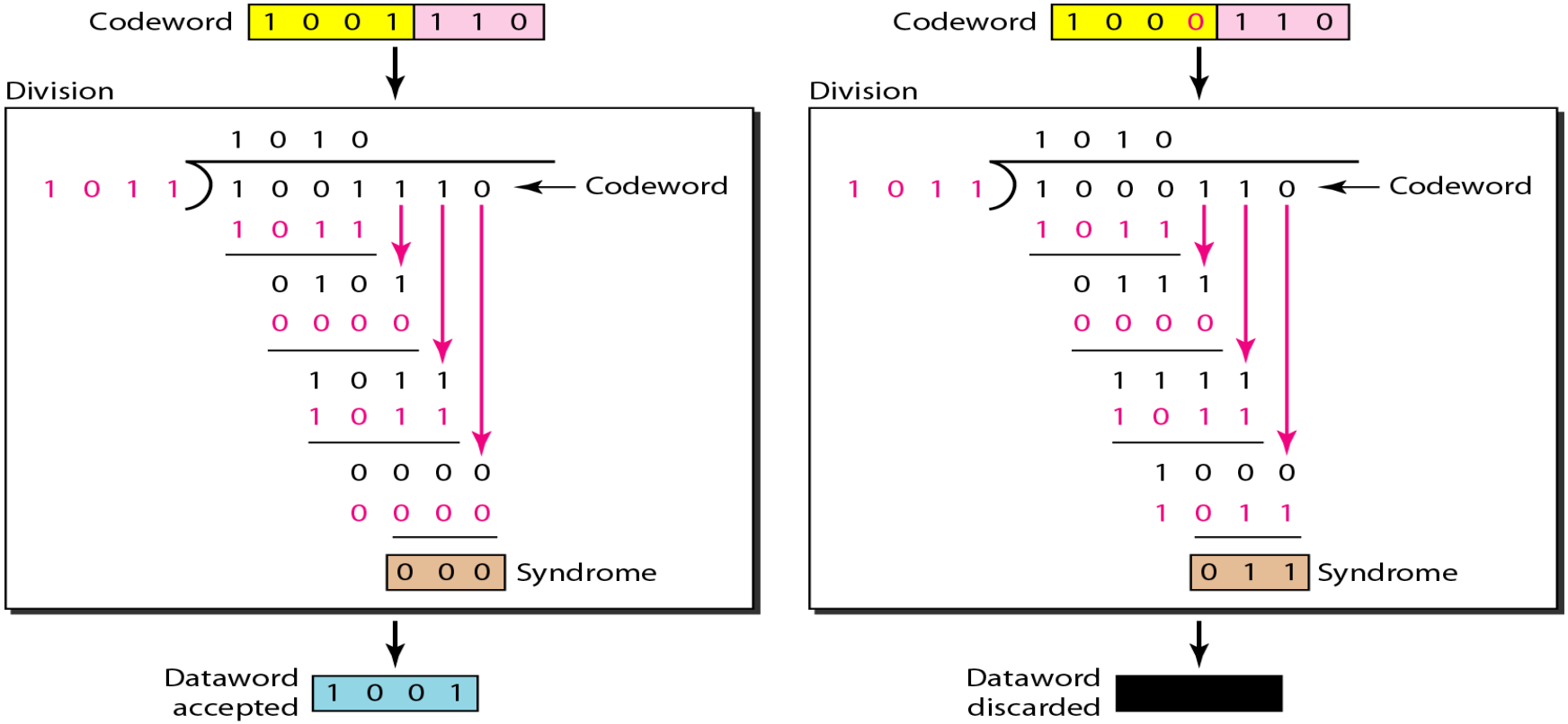
CRC generator

Uses Modulo-2 Division



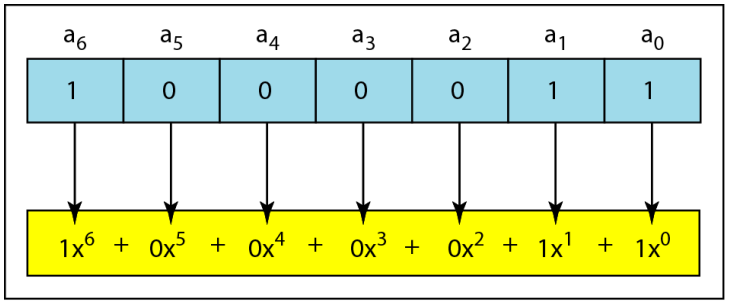
CRC Checker

Uses Modulo-2 Division

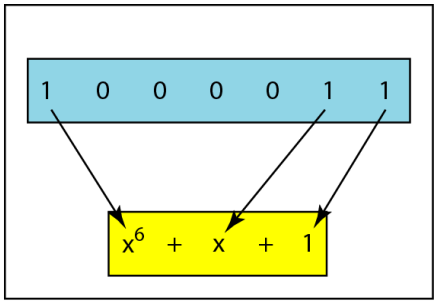


Polynomial representation of a binary word

- We can use a polynomial to represent a binary word.
- Each bit from right to left is mapped onto a power term.
- The rightmost bit represents the “0” power term.
- The bit next to it the “1” power term, etc.
- If the bit is of value zero, the power term is deleted from the expression.

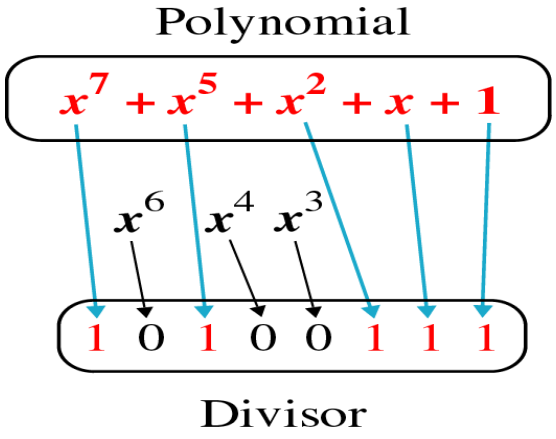


a. Binary pattern and polynomial



b. Short form

- CRC generator(divisor) is most often represented not as a string of 1s and 0s, but as an algebraic polynomial



CRC-12

$x^{12} + x^{11} + x^3 + x + 1$

CRC-16

$x^{16} + x^{15} + x^2 + 1$

CRC-ITU-T

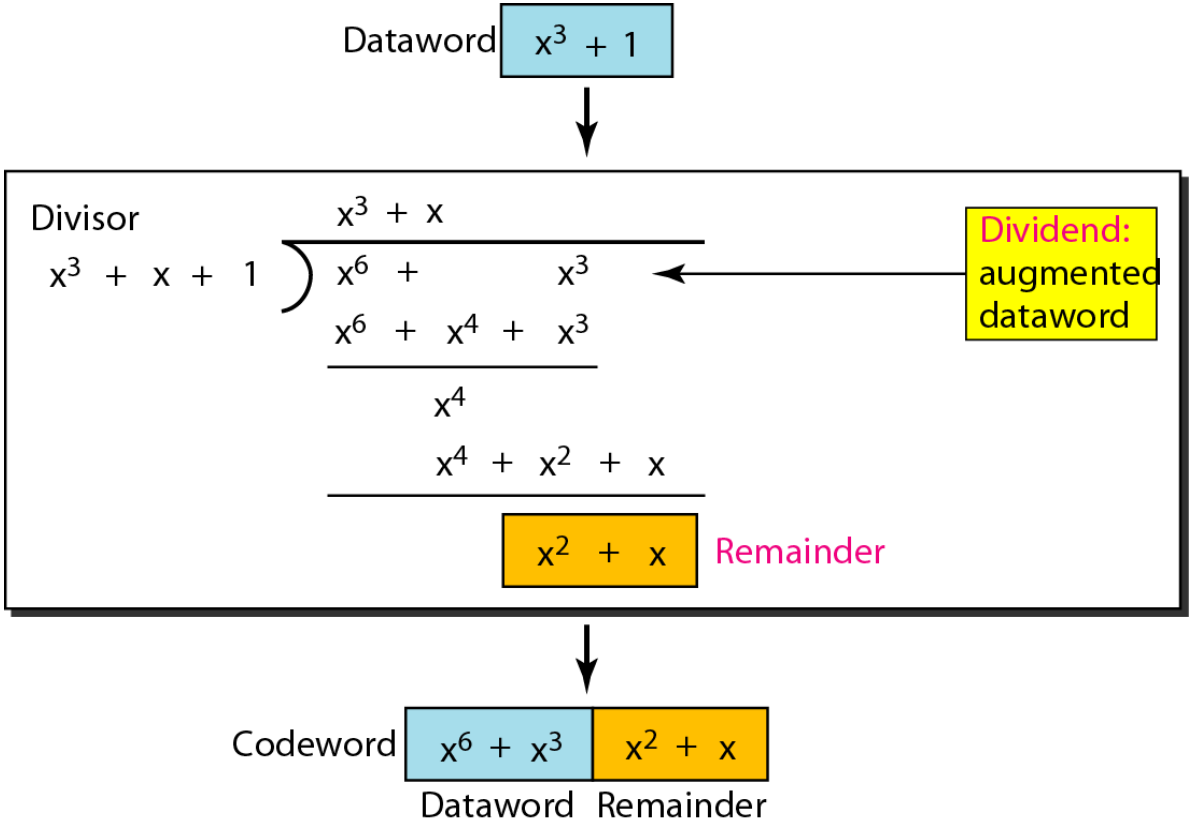
$x^{16} + x^{12} + x^5 + 1$

CRC-32

$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$

CRC division using polynomials

For a (n , k) Cyclic Code, multiply x^{n-k} with the Polynomial representation of the data word, where n is the length of the codeword and k is the information bits



Checksum: Used by Higher layer protocols

Sender site:

1. The message is divided into 16-bit words.
2. The value of the checksum word is set to 0.
3. All words including the checksum are added using one's complement addition.
4. The sum is complemented and becomes the checksum.

Receiver site:

1. The message (including checksum) is divided into 16-bit words.
2. All words are added using one's complement addition.
3. The sum is complemented and becomes the new checksum.
4. If the value of checksum is 0, the message is accepted; otherwise, it is rejected.

Review Questions

1. ___ uses the concept of redundancy.
2. VRC can detect multiple errors only when number of errors is ___.
3. In CRC checker syndrome is not equal to zero indicates an ___ in the codeword.

Answers

1. Error correction
2. Odd
3. Error