Types of Networks

cost, error rate, Maintenance, speed of transmission

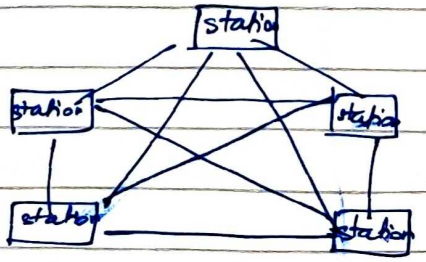
PAN	e.g. Bluetooth, zigbee, IrDA.	1-100 metres	Private ownership
WLAN, LAN	e.g. Ethernet and wiFi	upto 2KM	Private ownership
MAN	e.g. FDDI, CDDI, ATM	5-50KM	Public or private
WAN	e.g. Leased line, Dial-up	>50 KM	public or private

Computer Networks
- Hardware - adapters, cables
- Software - protocols

Topologies
- Mesh - Each device connected to every other device
- Star - Nodes are individually connected to a station.
- Bus - multipoint - one long cable acts as a backbone
- Ring - point to point with only two devices on either side of it.

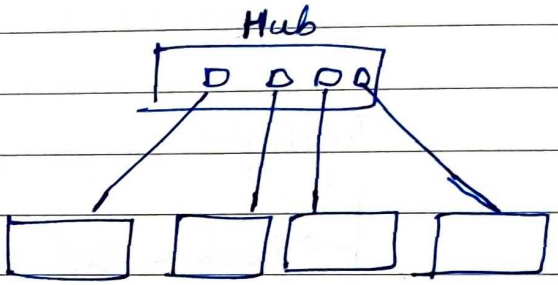
Mesh → guaranteed dedicated link
eliminate traffic
privacy and security
fault identification easy

disadv → Cabling and no. of io ports required
wiring is greater than available space
hardware is required for each link expensive



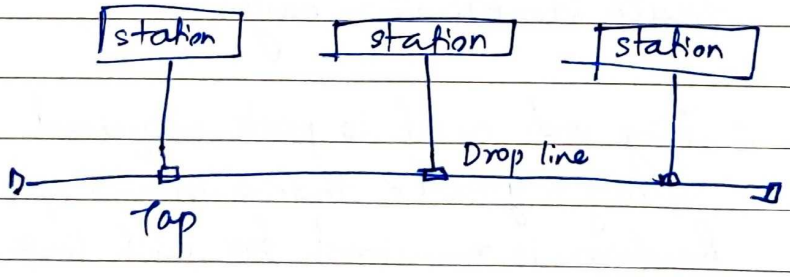
Star → less expensive
robustness - if one link fails only that link is affected, other links remain active.

Disadv → dependency of whole topology on one single point
star requires less than mesh, each node is linked to hub. So more cabling is required.



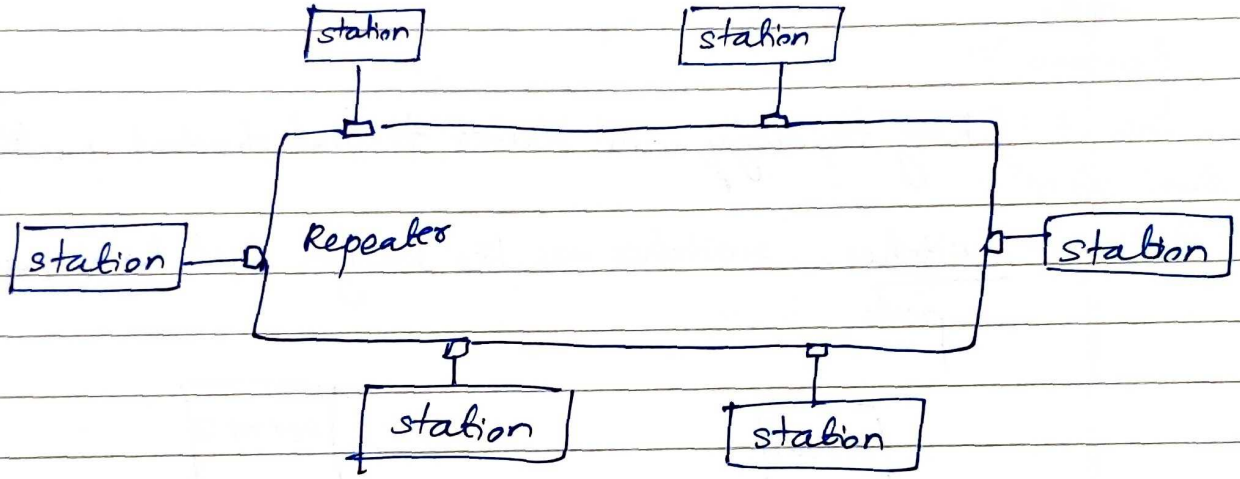
Bus → easy of installation

Disadv → difficult reconnection
addition of new devices require modification or replacement of the backbone.

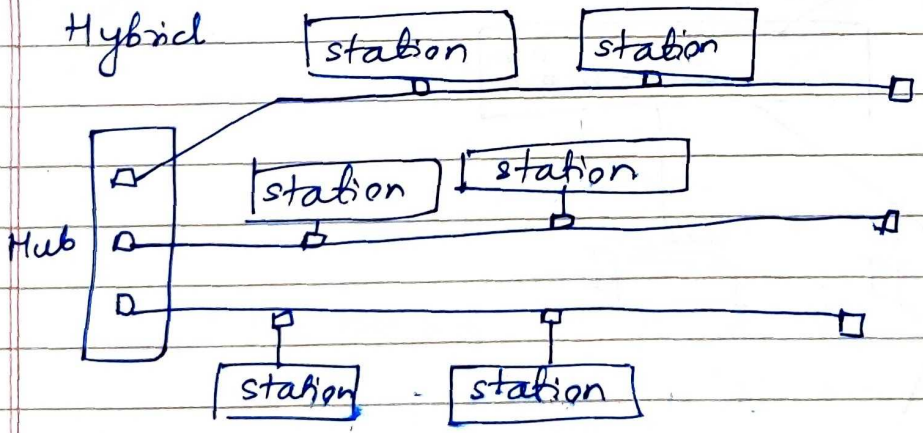


Ring Topology

→ easy to install and reconfigure
→ to add or delete a device requires changing only two connections. The only constraints are media and traffic.



Hybrid



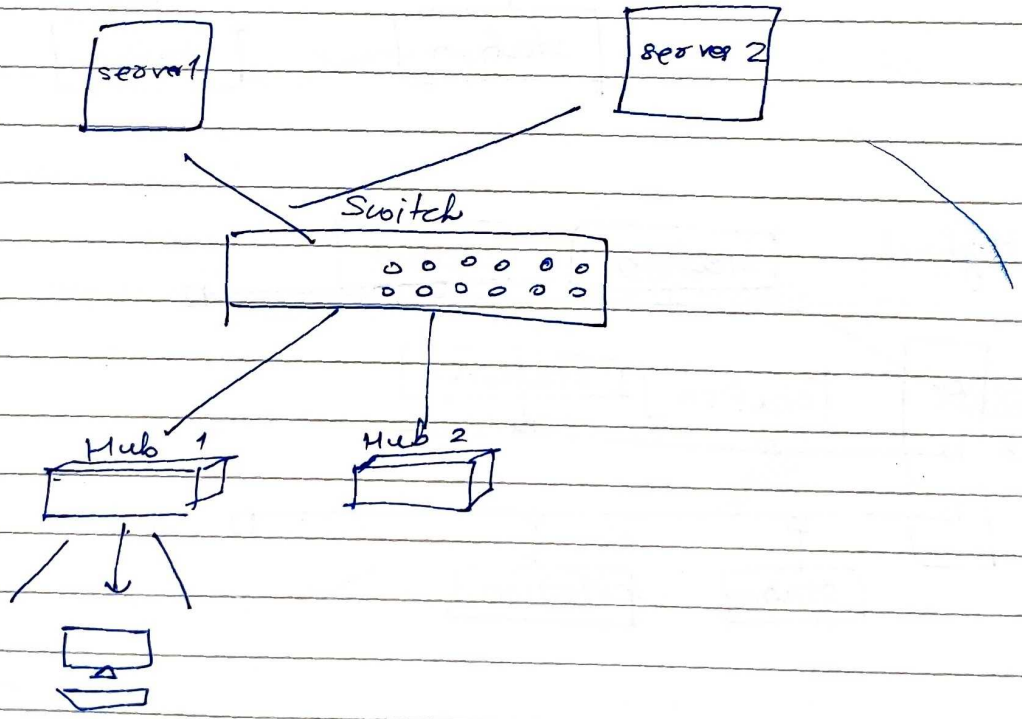
Computer Network - Set of computers which are connected together.

→ enables users to share hardware like scanners, printers, this reduces costs by reducing the number of hardware items bought

Interprocessor Distance	Example		
1m	square meter	PAN	Bluetooth zigbee
10m	Room	LAN	wireless WLAN
100 m	Building	LAN	
1km	Campus	LAN	
10 km	City	MAN	
100 km	Country	WAN	
1000 km	Continent	WAN	
10,000 km	Planet	The internet	

Ring topology uses router to find shortest path

Switches - switches are like bridges but have many ports

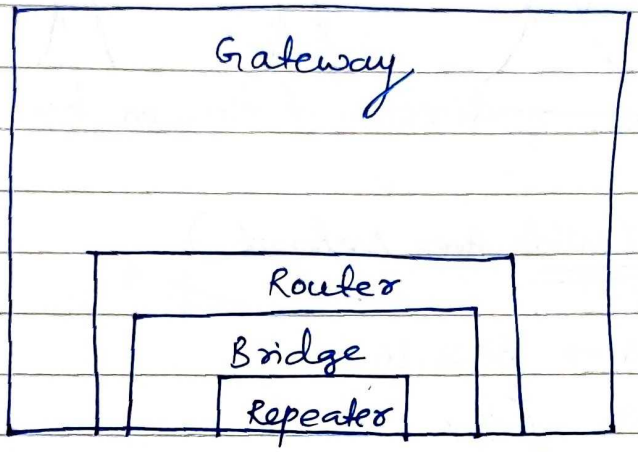


WLAN · IEEE 802.11
Standard · ↳ wireless ↳ LAN

PAN → 802.15.1 → Bluetooth
wireless ↳ PAN 802.15.4 → zigbee

Open System Interconnection

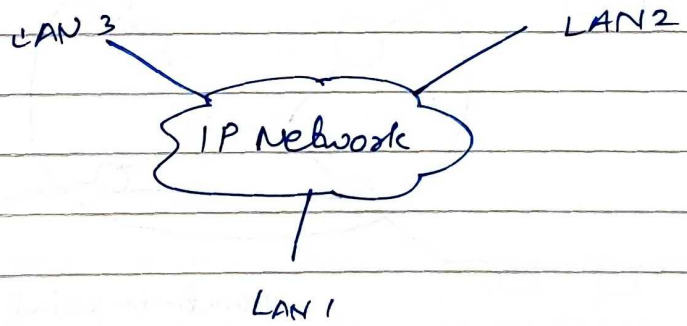
Gateways - primary use for gateways is to handle email.
link all seven layers of OSI
Uses SMTP, POP3 protocols.



Application
Presentation
Session
Transport
Network
Data Link
Physical

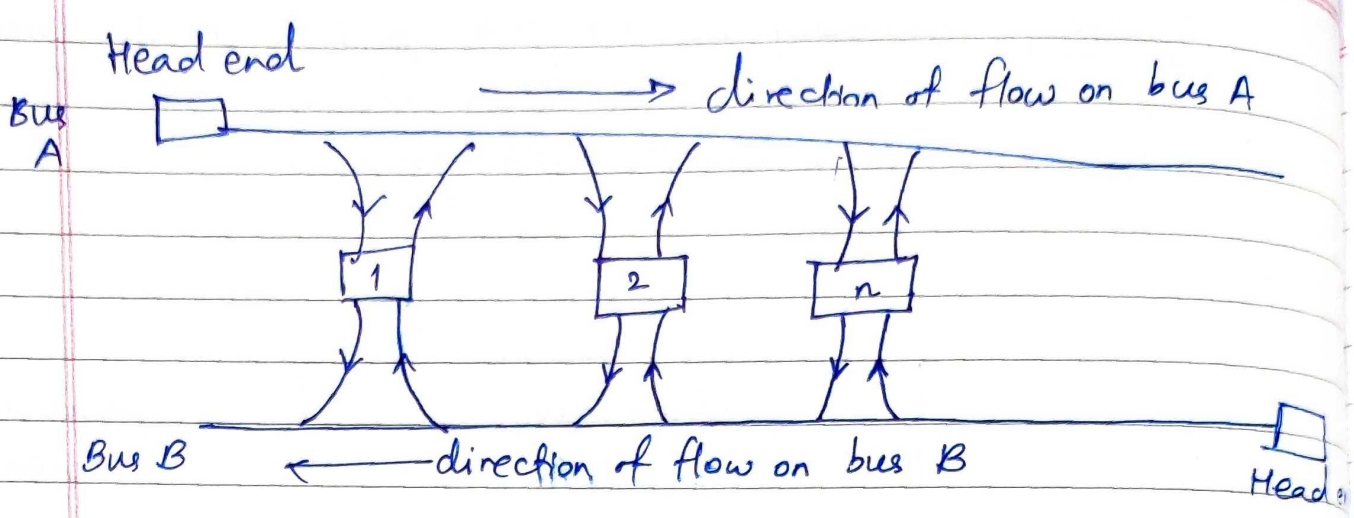
Devices and OSI model.

MAN



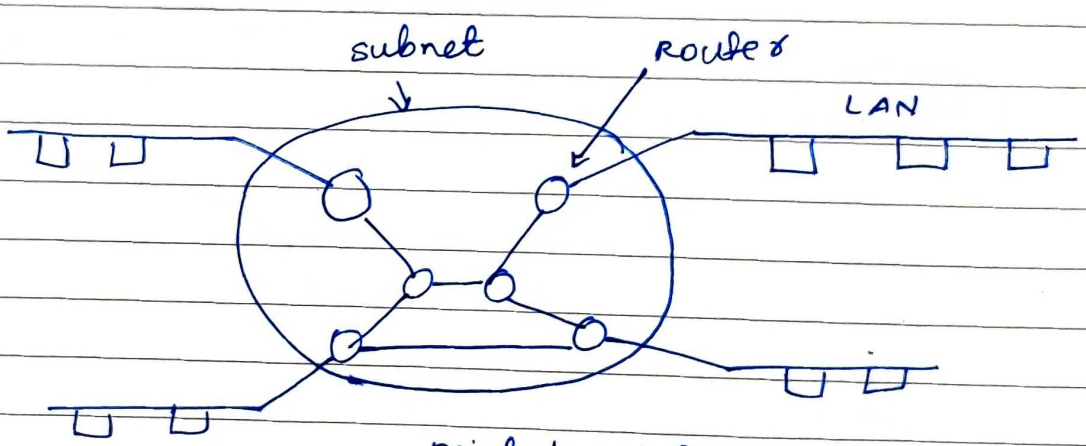
LAN → Bus topology → Ethernet 802.3 (10 mbps or 100)
Ring topology → IBM token ring 802.5 (4 and 16)

MAN → DQDB → 802.6
↳ two unidirectional buses to which all computers are connected.
Each bus has a head end. A device that initiates transmission activity.

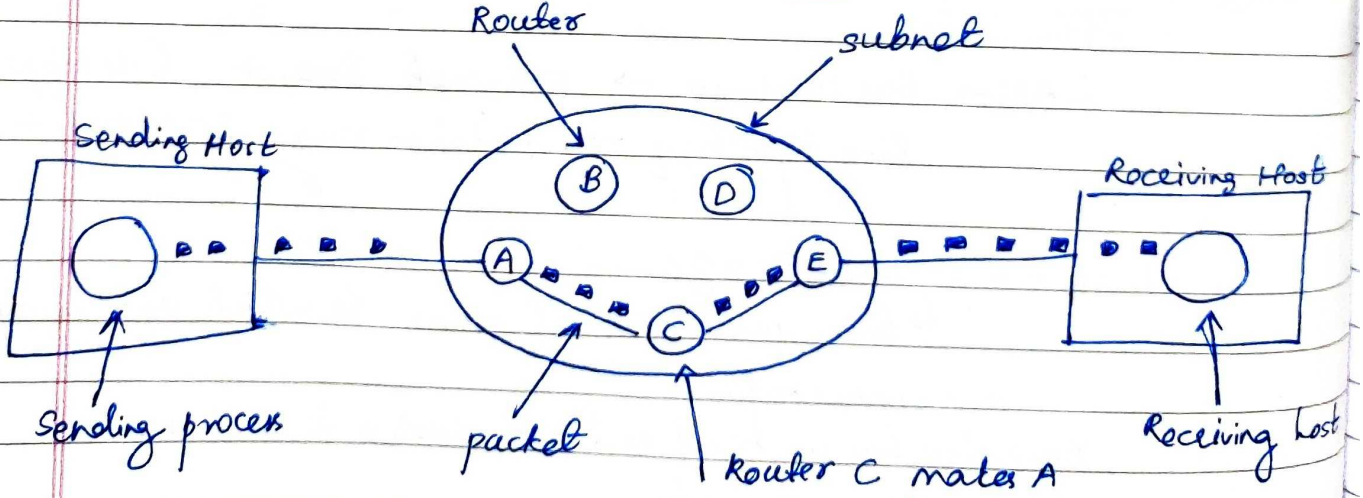


WAN (Wide Area Network).

YMAX → 802.16
(wireless)



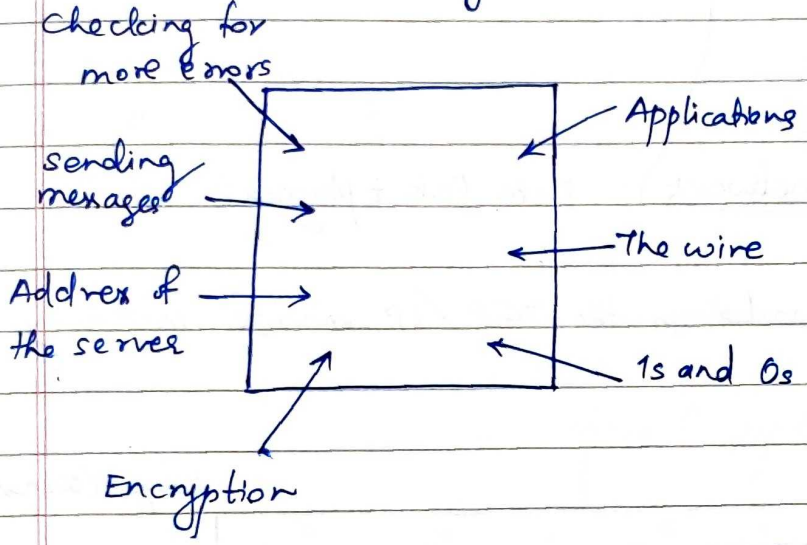
point-to-point



Delay in Virtual Circuit switching

Network software

Chaos networking



Networking OSI seven-layer model.

All ppl Seem to need data processing

7. Application
6. Presentation
5. Session
4. Transport
3. Network
2. Data link
1. Physical

Mostly software ↑

↓ mostly Hardware

Protocol Hierarchies

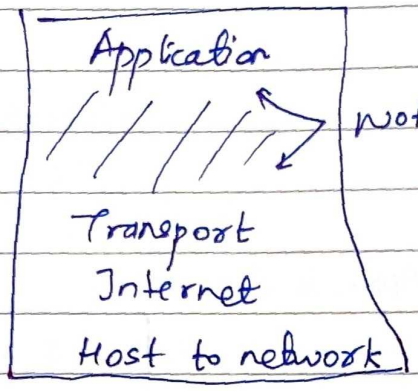
Session Layer :

Sessions offer various services, including dialog control (keeping track of whose turn it is to transmit), token management, synchronization.

Interaction between layers in the OSI model.

TCP/IP reference model

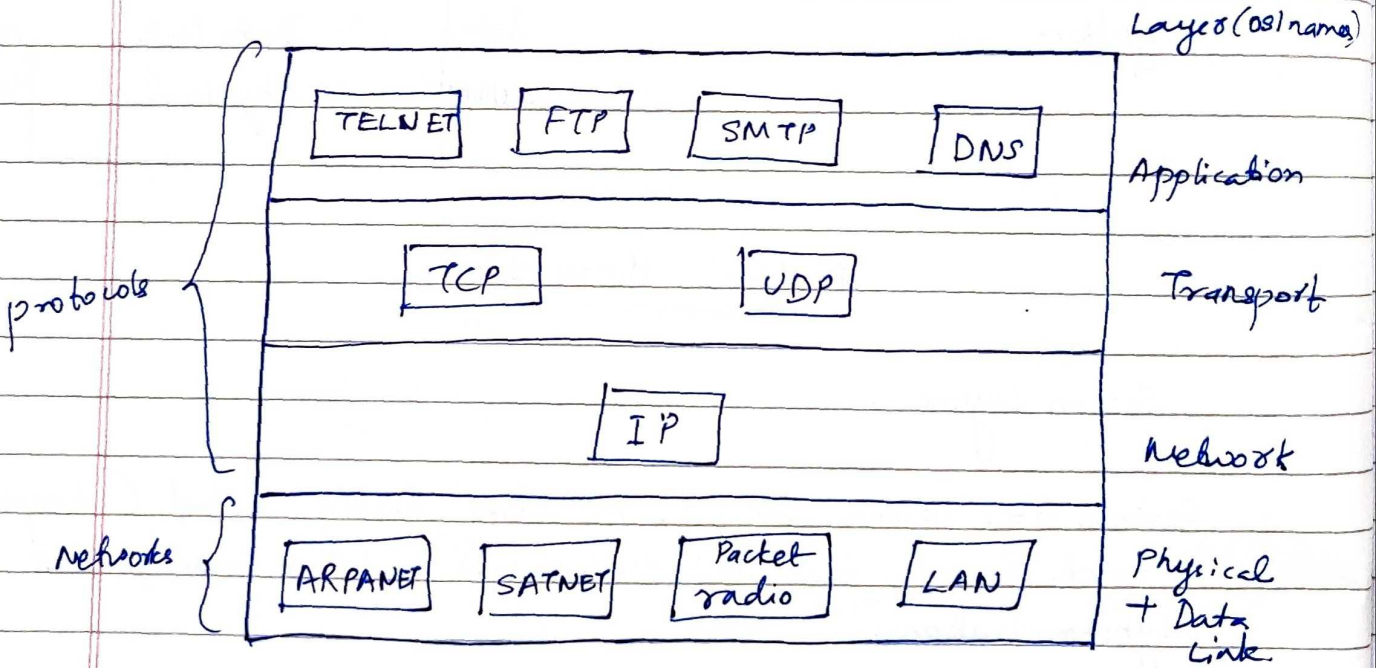
TCP/IP



not present in model

Data link + physical

protocols and Networks in the TCP/IP model initially.



Module 2 — 30 marks

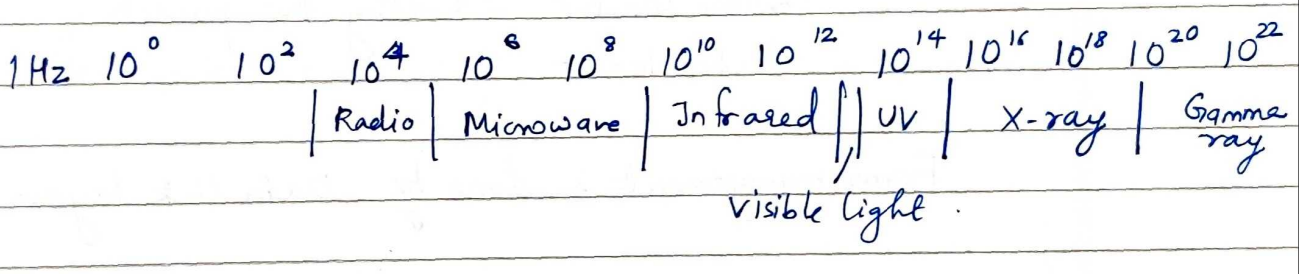
Physical Link / DataLink

Electromagnetic spectrum

When electrons move, they create electromagnetic waves that can propagate through space (even in vacuum).

$$\lambda f = c$$

$\lambda \rightarrow$ wavelength
$f \rightarrow$ frequency
$c \rightarrow$ speed of light



Comparison of Twisted pair, coaxial and optical fiber

Twisted pair cable	Coaxial Cable	optical fiber

Chapter 2: Data Link Layer

Physical layer to Network layer.

Error correction

CRC - Cyclic Redundancy Check

form of Frames (whole units of information)

Errors like distortion, delay

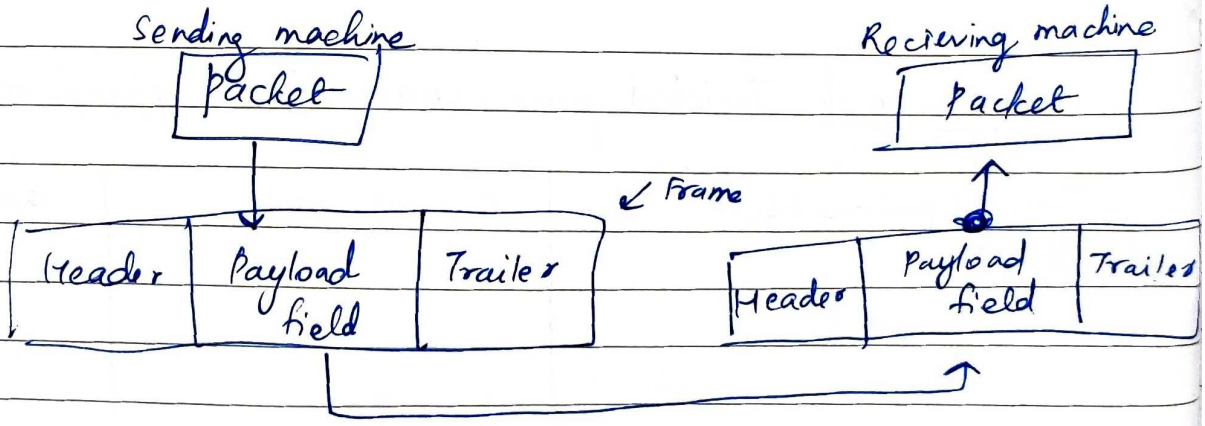
Functions of Data Link layer are

Each frame has a

frame header - holding the packet

trailer -

Frame management is done by Data Link layer



Services provided to network layer

7 Oct
8 22

Possible Services offered.

Unacknowledged conectionless service
Acknowledged connectionless service.
Acknowledged connection-oriented service.

Data Link Layer Issues

Framing Methods :-

1. Byte count
2. Flag bytes with byte stuffing
3. Flag bits with bit stuffing
4.

Byte count Framing method.

Byte Count → One byte.

5 1 2 3 4 5 6 7 8 9 8 0 1 2 3 . . . . .

frame 1 Frame 2

→ error

5 1 2 3 4 7 8 9 8 0

Frame 1 frame 2

Flag Bytes with byte stuffing framing method

To identify the boundary of the frame, (To reduce interference, distortion) we add some beginning and ending byte in the frame. They are called flag bytes.

original frame

Framing Method 3: Flag Bits with Bit Stuffing Framing Method

0 1 1 0 1 1 1 1 1 0 0 1 0

0 1 1 0 1 0 1 1 1 1 1 0 0 0 1 0

stuffed bits.

Error Control

Unacknowledged connectionless services
Reliable connection-oriented service

Flow Control

Important design issue for the cases when the sender is running on a fast powerful

Error detection and Correction Code

$n \rightarrow$ total length of block $(n = m + r)$

(n, m) - code

n - bit codeword containg n bits.

m/n - code rate

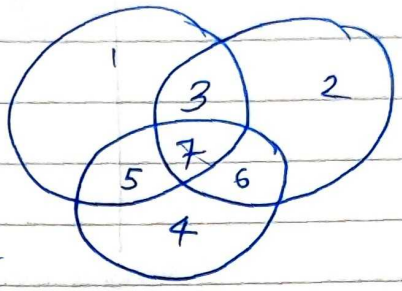
1 - board

Hamming Code

codeword : b1 b2 b3 b4 ...

Parity - 1, 2, 4

Data bits - 3, 5, 6, 7



36 — ~~00~~ 0100 → 6

10 → 4

0110 → 6

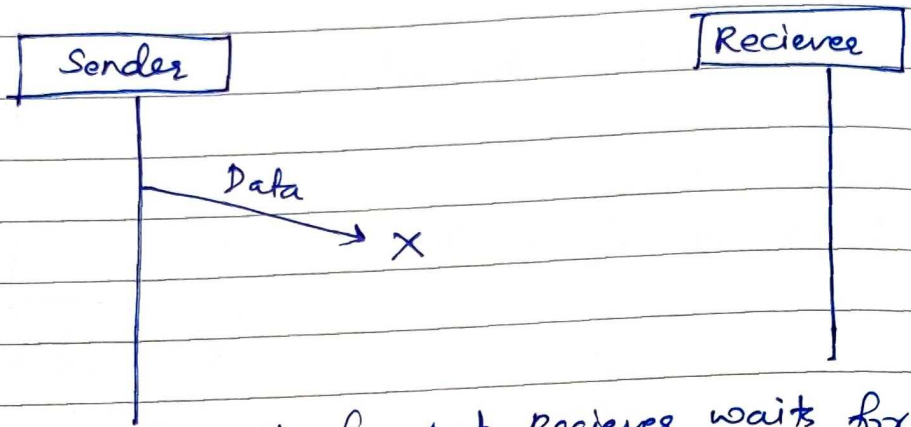
2	36
2	18

is comple. 1001 → 9

~~7,6,0,0~~

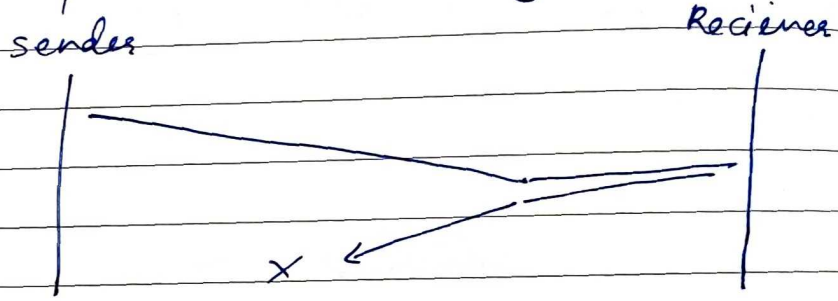
466F

1011) 100100

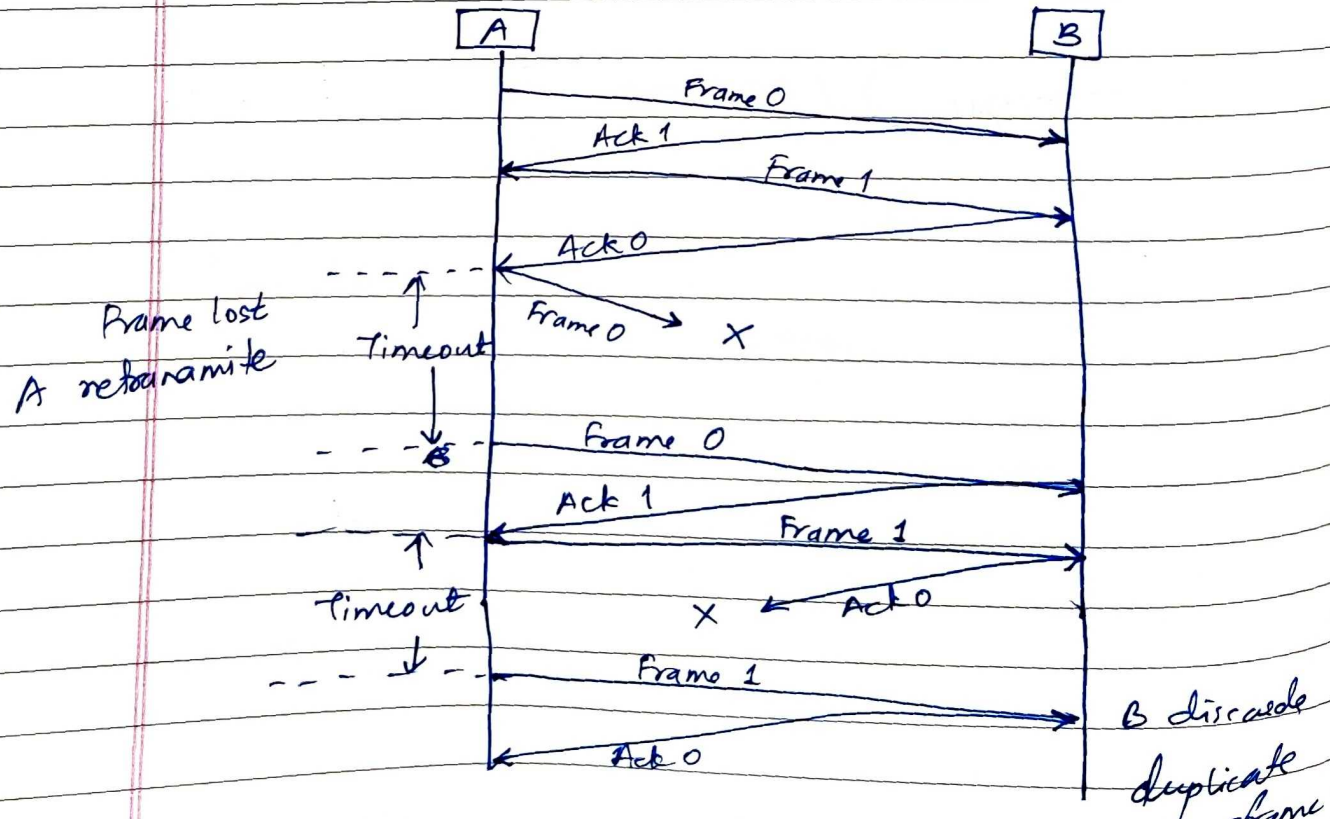


sender waits for Ack Reciever waits for data for infinite amount of time

1. Stop and wait protocol scenario (Noisy Channel).



2 Automatic Repeat request Protocol (ARQ)



Assignment - 2

Q11- CRC (Cyclic Redundancy Check) with example

→ • Based on binary division

total bits = $(m+r)$

append highest degree

$x^4 + x^3 + 1$) 10101010 (

polynomial

- Polynomial should not be divisible by x and $(x+1)$
- Can detect all odd errors, single bit, burst errors of length equal to polynomial degree

$m \rightarrow$ no. of bits in the message

$r \rightarrow$ no. of redundant bits

11001) 10101010 0000 (

1. Convert polynomial to binary

$\therefore x^4 + x^3 + 1$ will be converted as :-

$1.x^4 + 1.x^3 + 0x^2 + 0x^1 + 1.x^0$

$\therefore$ divisor will be :- 11001

In case, the polynomial is not given i.e. only the divisor is given, we append the number of bits in the divisor - 1 no. of 0's.

i.e. if divisor = 1010

$\Rightarrow$ append 4-1 = 3 0s.

↓ XOR operation → start with leading 1

same values → 0

diff values → 1

Data word — augmented

```
11001 ) 1010101010 0000
        11001↓
        -----
        01100 0
         11001
         -----
         000011010
             11001
             -----
             00011000
                11001
                -----
                00010
```

append the remainder (or the last few bits of remainder) to the dividend

In this case, 4 bits will be appended. (0010)

∴ Valid data code word becomes 1010101010 0010

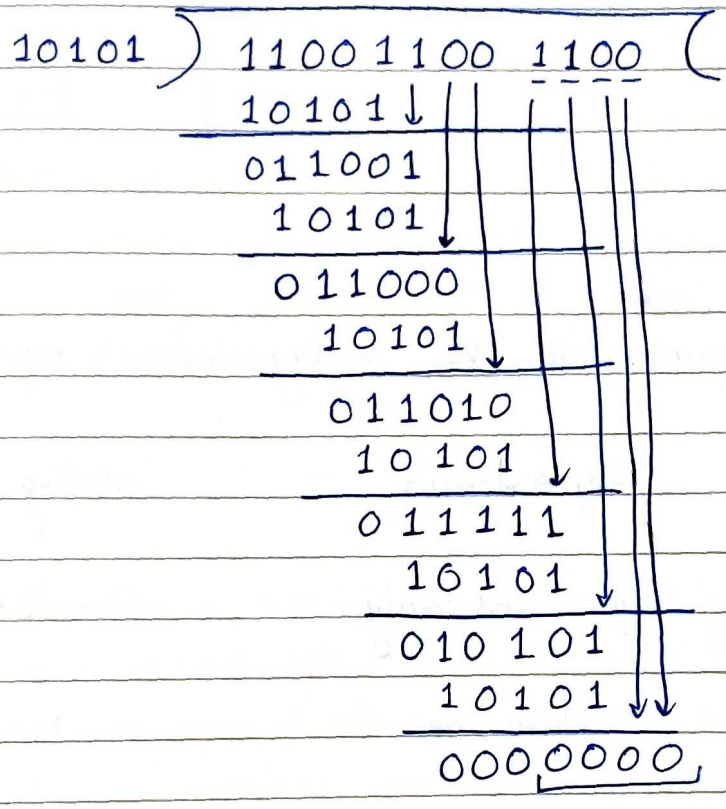
when the reciever recieves the message, it will divide it by the divisor and if he gets all 0s ∴ The message is error free

$$\text{Efficiency} \rightarrow \frac{\text{Data bits}}{\text{Total bits}} \times 100$$

$$= \frac{10}{14} \times 100$$

$$= 71.42\ \%$$

Q5- Recieved string : 110011001100
Data bit sequence = ?
Divisor : 10101



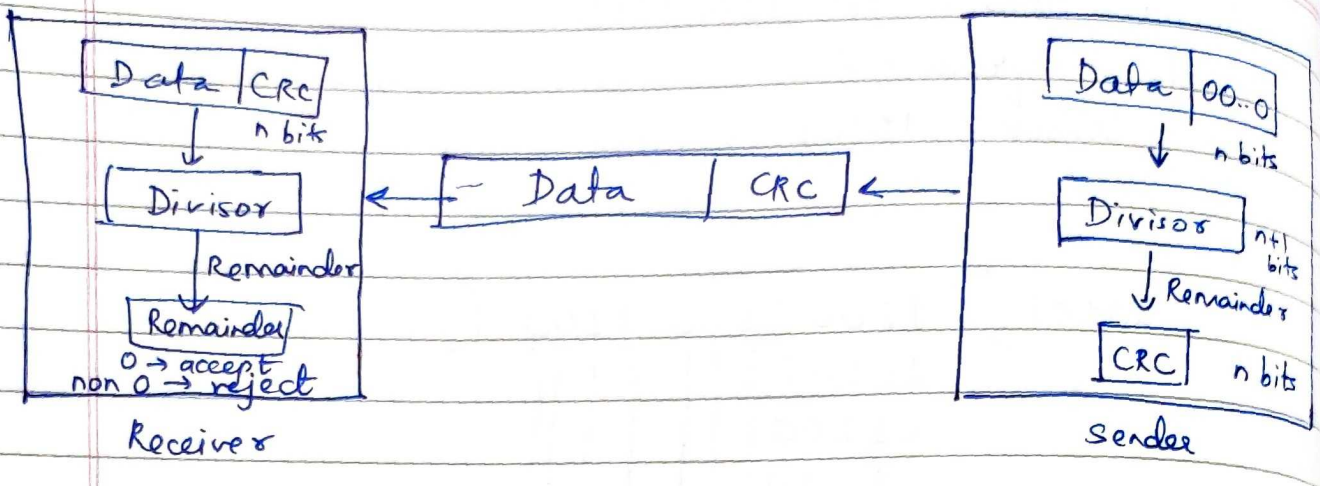
Since the remainder is 0, the message is error free.
∴ It is acceptable
and the data bit sequence is → 11001100

CRCs theory :-

Cyclic codes are special linear block code
if a codeword is cyclically shifted, the result is another codeword

e.x. 1011000 is a codeword and if cyclically rotated.
0110000 is also a codeword.

CRC : The use of cyclic codes to detect and correct error.



Q10 - Difference : Stop and wait Vs Sliding window's repeat

Basis	stop-and-wait	sliding window
Behaviour	Request and reply	Simultaneous transm
No. of transferable frames	Only one	Multiple
Efficiency	Less	More comparatively
Acknowledgement	sent after each arriving packet	window of acknowledg is maintained.
Type of transmission	Half duplex	Full duplex
Propagation delay	Long	Short
Link utilization	Poor	Better

Data Link → Node to Node
Flow control
Error control
Access Control
Physical Address (MAC)

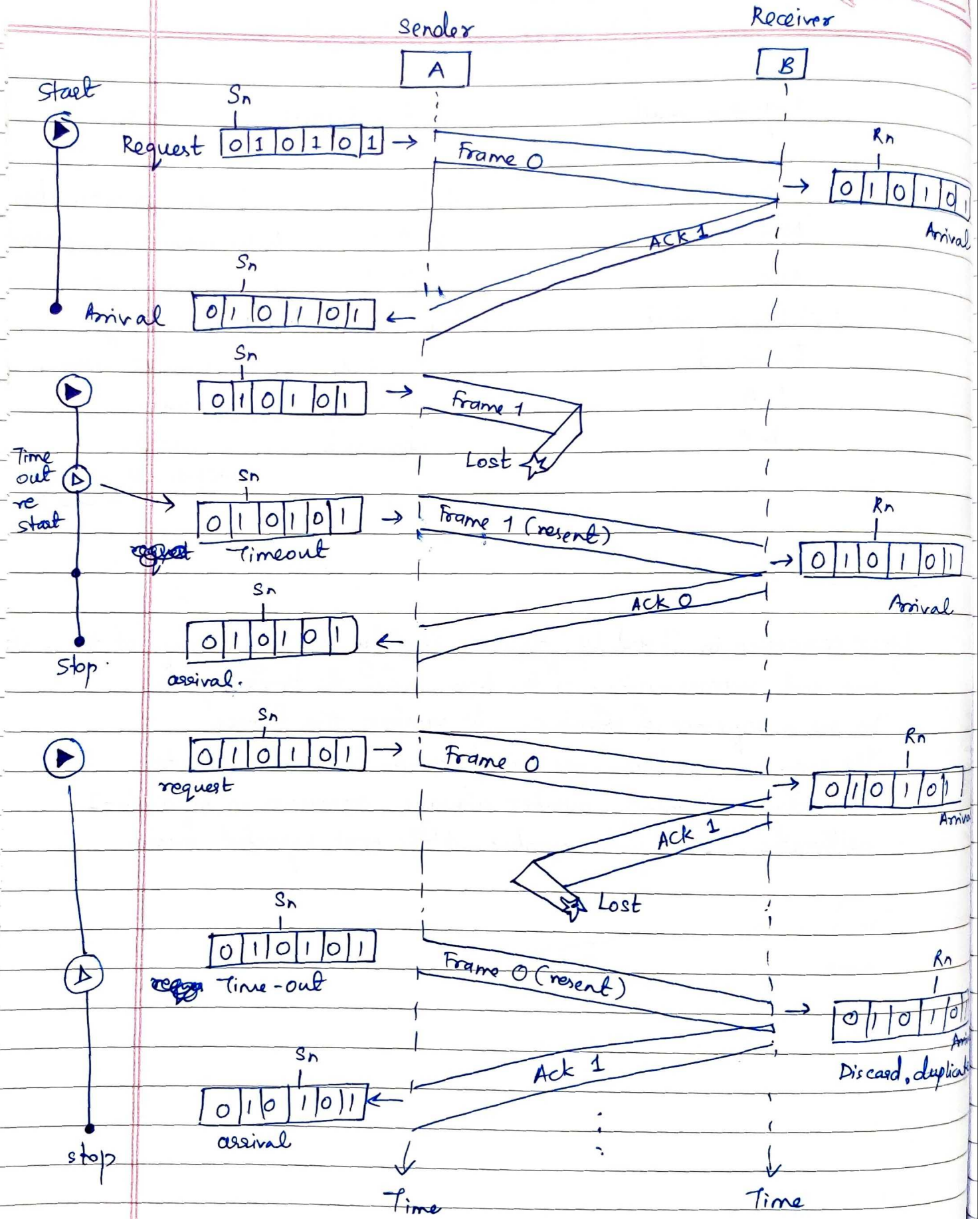
Network
Data Link
Physical

Protocol :-	Selective Repeat	Stop and wait
Bandwidth utilization	High	Low
Max. sender size window	$2^{(m-1)}$	N.A.
Max. reciever size window	$2^{(m-1)}$	N.A.
Pipelining	Implemented	Not implemented
Out of order frames	Accepted	Discarded
Cumulative ACK	applicable	N.A.
NAK (Negative Acknowledgement)	applicable	N.A.

Stop and wait

Error correction in S and W ARQ is done by keeping a copy of the sent frame and retransmitting of the frame when the timer expires.
We use a sequence of numbers to number the frames.
The sequence numbers are based on modulo-2 arithmetic.
The acknowledgement number always announces, in modulo-2 arithmetic, the sequence number of the next expected frame

STOP & WAIT.


Sender
Receiver
A
B
Start
Sn
Request
0 1 0 1 0 1
Frame 0
Rn
0 1 0 1 0 1
Arrival
ACK 1
Arrival
0 1 0 1 0 1
Frame 1
Lost
Time out re start
Timeout
Frame 1 (resent)
ACK 0
Stop
arrival.
request
Frame 0
ACK 1
Lost
Time-out
Frame 0 (resent)
Ack 1
Discard, duplicate
stop
Time
Time

SLIDING WINDOW.

Go-back-N.

In Go-Back-N Protocol, the sequence numbers are modulo 2^m, where m is the size of the sequence number field in bits.

The send window is an abstract concept defining an imaginary box of size $2^m - 1$ with three variables: Sf, Sn, and Ssize

The send window can slide one or more slots when a valid acknowledgement arrives

The receive window is an abstract concept defining imaginary box of size 1 with one single variable Rn.
The window slides when a correct frame has arrived!
sliding occurs one slide at a time.

m → no. of bits representing sequence number.

if m = 2,
$2^m - 1 = 2^2 - 1 = 3$

Flow Control in Data Link Layer

k = no. of bits to represent window size

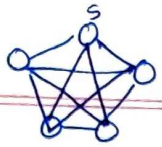
Stop and wait	Go-back-N	Selective Repeat
Only 1 frame transmit	Multiple frames	Multiple frames
sender window = 1	sender window = $2^k - 1$	Sender window = 2^{k-1}
Receiver window = 1	receiver window = 1	Receiver window = 2^{k-1}
$\eta = \frac{1}{1+2x}$	$\eta = (2^k - 1) * \frac{1}{1+2x}$	$\eta = 2^{k-1} * \frac{1}{1+2x}$
$\because x = \frac{T_p}{T_t}$ (Propagation delay / Transmission time)		
Retransmission = 1	Retransmission = $2^k - 1$	Retransmission = 1
	Cumulative Ack	Cumulative and Independent Acknow. Negative Ack. (NAK)

Available sequence no.

$= W_S + W_R$

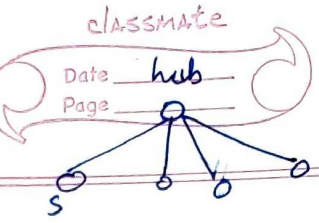
$= 1 + 1$

$= 2$



Mesh

- dedicated p-to-p link to every other device
- traffic between two devices conn
- duplex mode
- Adv: eliminate traffic, privacy, fault identification easy
- Disadv: cabling and IO ports reqd. is more. hardware for each link - expensive

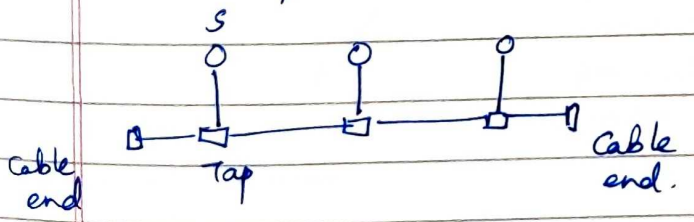


Star

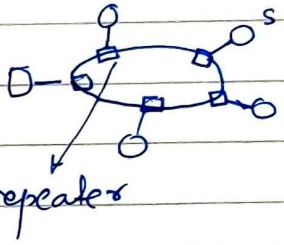
- dedicated p-to-p link to only hub
- Controller acts as exchange: device sends data to controller, from there sent to another connected device.
- Adv: less expensive
  robust - one link does not affect other active links
- Disadv: dependent on a single pt. Each node linked to hub, so more cabling reqd.

Bus

- One long cable acts as backbone to link all devices in network.
- Nodes connected to bus cable by drop lines and taps
  drop line: connection between device and main cable
  tap: connector that either splices or punctures.
- Adv: ease of installation
- Disadv: difficult reconnection
  addition of new devices require modification or replacement of backbone



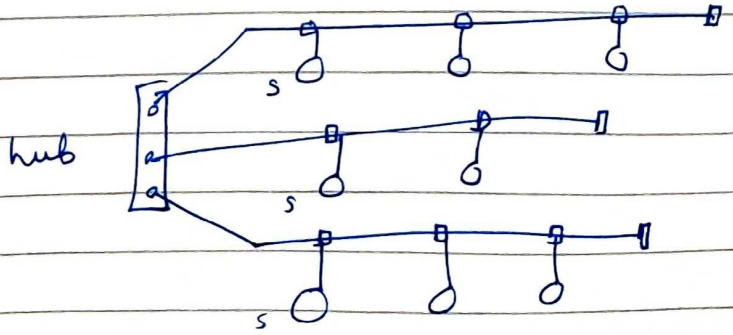
Ring



p-to-p link to only 2 devices on either side.
Signal passed along in one direction from device to device until it reaches its destination

- Adv: Easy to install and reconfigure
  adding or deleting requires only two connection changes.
- Disadv: unidirectional
  break in ring can disable the entire network

Hybrid :-



Types of transmission Tech.:-

- Broadcast

single communication channel shared by all machines on network sending same packets to all stations within network.
multicasting - data packets sent to specific group of stations.

- P-to-P

unicasting : dedicated link between any two stations.

Networking

Repeaters

physical layer

same type of media

boosts signal

↓

send to next node

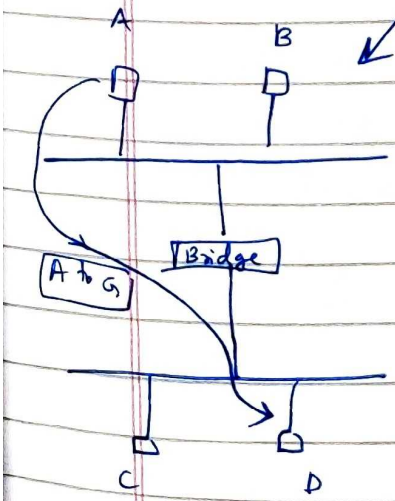
Bridges

data-link layer

don't care about protocols

intelligent repeaters.

Examine MAC and forms table



switch → Lot like bridges

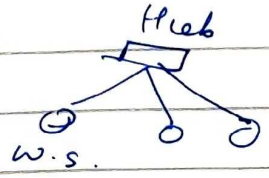
Hub

physical layer

concentrator

prevents collision

automatic partitioning property



Internetworking

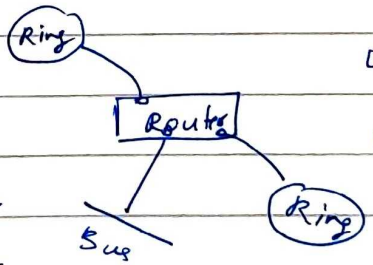
Routers

Intelligent bridges

processor and memory

similar and diff networks

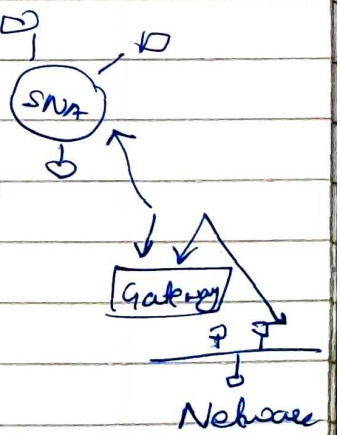
shortest route

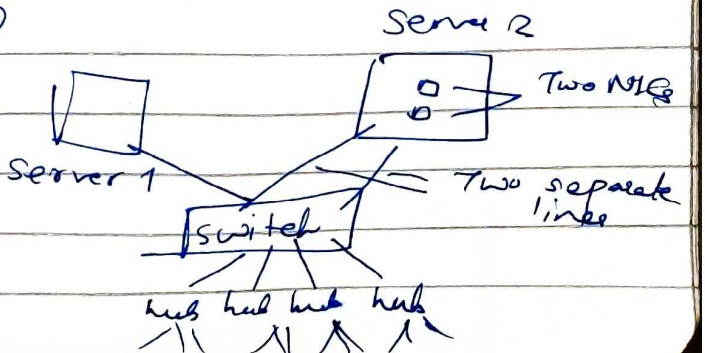


Gateways.

application specific interfaces that link all 7 layers of OSI model

primary use for handling emails.





MAC sublayer → Module 2 done.

Module 3: Network Layer (21 marks).

INTRODUCTION

IP is the transmission mechanism used by TCP/IP protocols at the network layer.

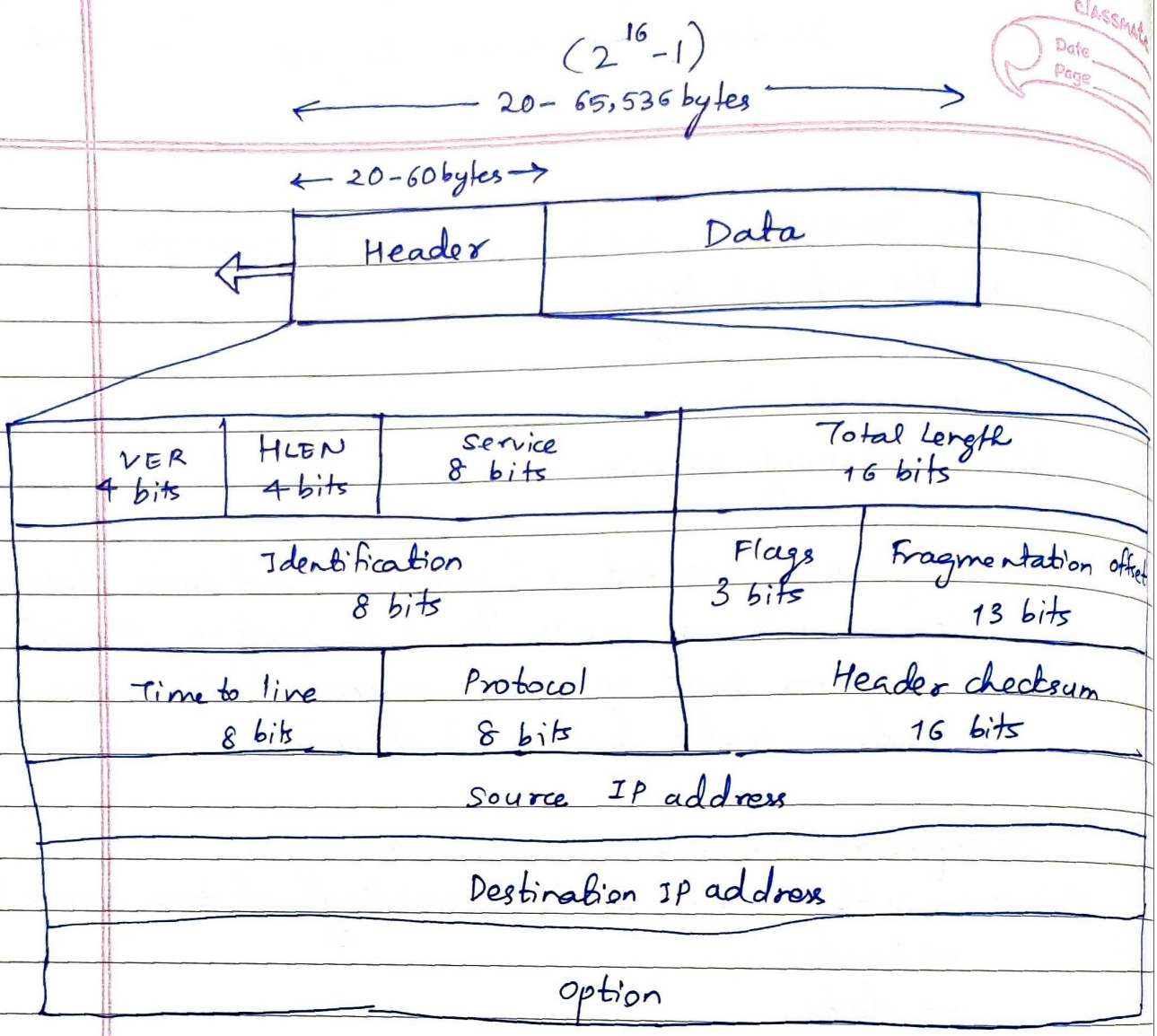
IP is an unreliable, connectionless datagram protocol - best effort delivery service

Each datagram is handled independently and each datagram can follow a different route to the destination this implies that datagram sent by same source to the same destination could arrive out of order.

Datagram: Packets in the network layer
It is a variable length packet consisting of two parts :-
- → header
- → data

Header :-
- → 20 to 60 bytes in length
- → contains info essential to routing and delivery
- → In TCP/IP it is customary to show header in 4 byte section.

IP V4 DATAGRAM FORMAT



VER (version):
4 bit field defines version.

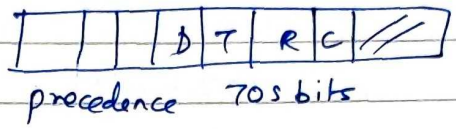
HLEN Header length:
20-60 bytes
defines total length of datagram header in 4 byte words

Service type:
Types of service required for communication
Defines how packets in network should be handled

HLEN.
1000
8 X 4 = ~~20~~ 32.

IETF (Internet Engineering Task Force)

Types of service
D T R C

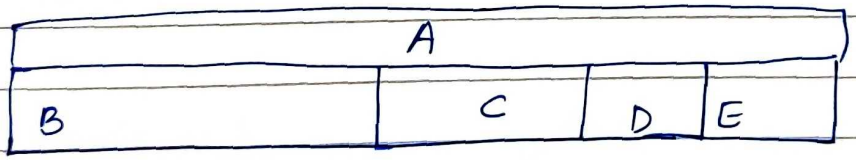


D- Minimize delay
T- Maximum throughput
R- Maximize reliability
C- Minimize cost

Using IPV4 → 2^{32}
Using IPV6 → 2^{128}

Classful Addressing

Address space



Class A → First byte 0
B 10
C 110
D 1110
E 1111

Example 1 → a. A 000
b. C 11000
c. B 10100
d. E 111100

Example :- Decimals.

A - 0-127

B - 128 - 191

C - 192 - 223

D - 224 - 239

E - 240 - 255

a. 227.12 → D

b. 193.14 → C

c. 14.23 → A

d. 252.5 → E

e. 134.11 → B

MANET - Mobile adhoc network.
↳ failures occur frequently

TCP - Transmission Control Protocol

Reliable, connection-oriented, byte-stream service
keeps track of individual units of data transmission, called segments

Wireless and hoc network

Autonomous and infrastructure less
self creating, organizing, administrating

Problems of TCP in wireless network :-

Lossy channels → signal attenuation
→ Doppler shift
→ Multipath fading

Path asymmetry → Bandwidth
→ Loss rate
→ Route
} asymmetry

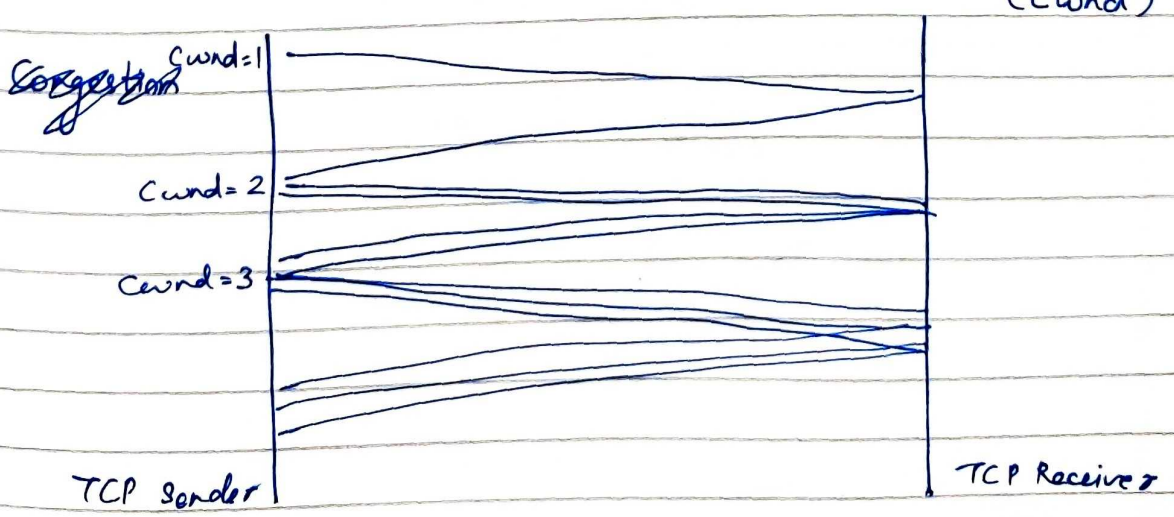
Cause: Node mobility ← Route failures

limited power ← power constraints

supply, processing power is limited.

TCP Algorithms :

slow start : Every ack increases sender window size by 1 (cwnd)



Congestion avoidance :- Reducing sender window size by half at experience of loss and Increase the sender's window at rate of one packet per RTT (ReTransmit Time) (Round-trip time)

Fast Retransmit :- Don't wait for retransmit timer to go off, retransmit packet if 3 duplicate acks recieved.

Fast Recovery :- Perform congestion avoidance, don't jump down to slow start

Routing Protocols

1. Reactive Protocol
   - → AODV (Ad Hoc On-demand Distance Vector routing protocol)
   - → DSR (Dynamic Source Routing)
   - → AOMDV (Ad Hoc On-demand Multipath Distance Vector Routing protocol)

2. Proactive Protocol
   - → DSDV (Destination Sequenced Distance Vector routing protocol)
   - → OLSR (Optimized Linked state Routing protocol)

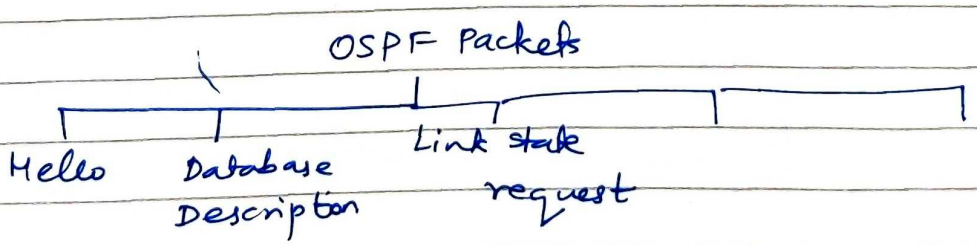
Link State Routing

1. Discover its neighbours.
   HELLO is sent

Broadcast routing : Sending a packet to all destinations simultaneously is called broadcasting

Multicast routing : Send message to well-defined groups.

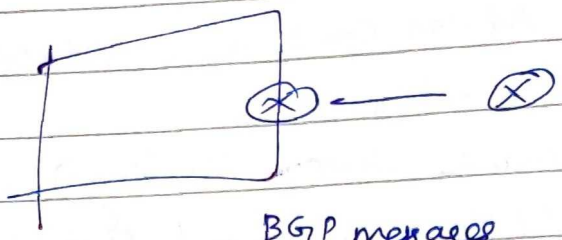
Anycast Routing : As per requirement



1, 2, 3, 4

20

Border Gateway - Inter-domain routing protocol.



BGP messages

open update keepalive Notification

Chapter - 6 - ~~Module~~ 1 question 10 marks.

Question Bank Module : 5

1. Three phases of evolving to an intelligent information network.

→ Phase 1 : Integrated Transport

- Everything (Data, voice, and video) consolidates onto an IP network for secure network convergence
- By integrating everything into a single standards-based modular network, organizations can simplify network management and generate enterprise wide efficiencies.
- Network convergence also lays the foundation for a new class of IP-enabled applications, now known as Cisco Unified Communications Sol (call control, conferencing, customer contract, video telephony, etc)

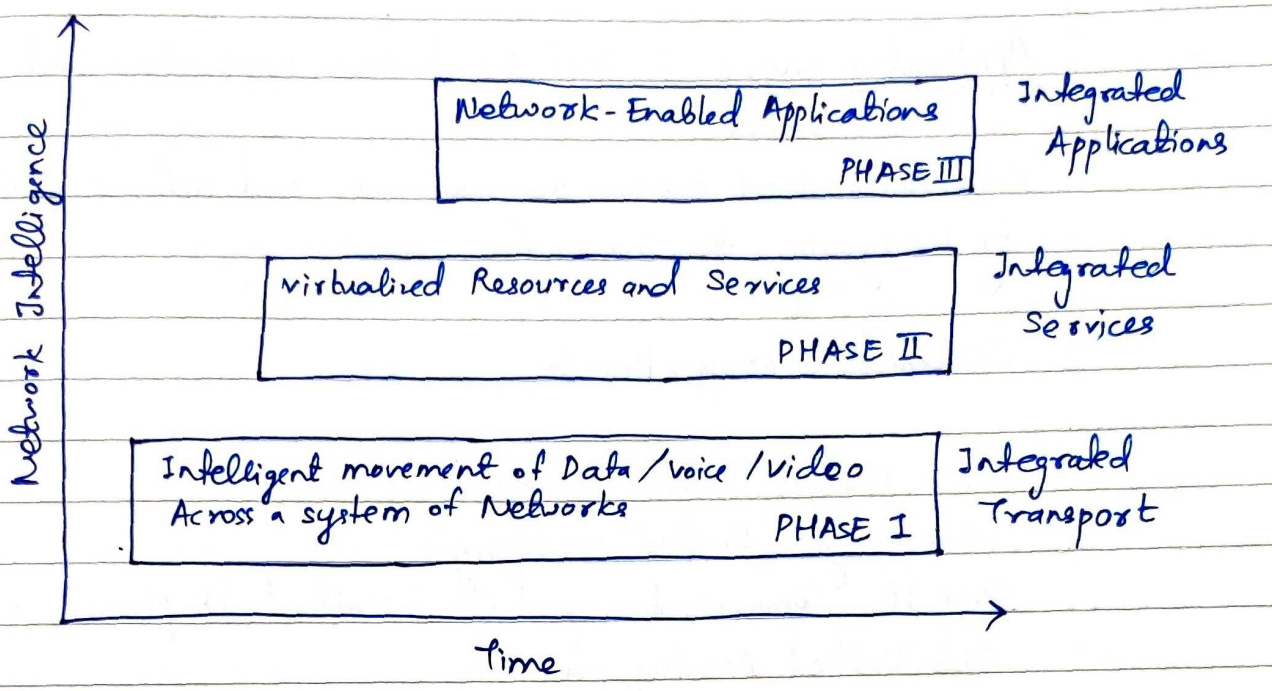
Phase 2 : Integrated Services

- When network infrastructure is converged, IT resources can be pooled or shared, or virtualized, to flexibly address the changing needs of the orgⁿ
- By extending this virtualizⁿ concept to encompass servers, storage and network elements, an organizⁿ can transparently use all its resources more efficiently
- Business continuity is also enhanced because in the event of a local systems failure, shared resources across the intelligent network can provide needed services.

Phase 3 : Integrated Applications

- Focuses on making the network application aware so that it can optimize application performance and more efficiently deliver networked applications to users.
- Application Network services make it possible for the network to simplify the application infrastructure by integrating intelligent application message handling, optimization and security into the existing network.

* consolidate – combine into a single coherent whole.
* Network Convergence - When one network provider delivers networking services for voice, data, and video in a single network offering, instead of separate network for each of these services.



2. Three Layers of SONA framework :

→ Networked Infrastructure Layer : All IT resources interconnected across converged network foundation. (servers, storage and clients)

- NIL represents how these resources exist in network including campus, branch, data center, MAN, etc.
- Objective of NIL : To provide connectivity anywhere anytime.
- NIL includes network devices and links to connect resources in different places in network.

Interactive Services Layer : Includes both application networking services and infrastructure services.

- Enables efficient allocation of resources to applications and business delivered through Networked Infrastructure.

Services included :-

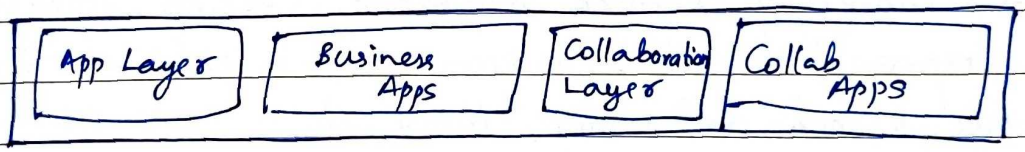
Voice and collaboration	Compute	IP multicast
mobility	App networking	
wireless	Adaptive network Management	
Security and identity	Quality of service	
Storage	High availability	

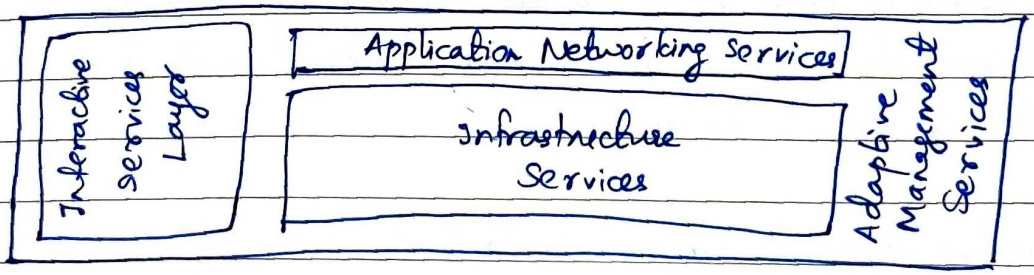
Application Layer : Includes business applications and collaboration applications

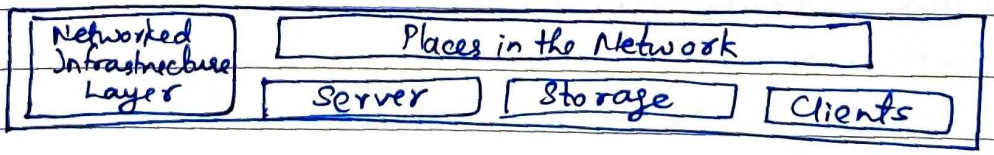
Objective : Meet business requirements and achieve ~~effects~~ efficiencies by leveraging the interactive services layer

Collaborative properties :-

Cisco Unified Contact Center
Cisco Unity (Unified messaging)
Cisco IP Communicator and Cisco Unified IP phones
Cisco Unified Meeting place
Video delivery using Cisco Digital Media System.
IP telephony.







Q3- Benefits of using SONA framework :-

→ • Functionality : Supports organizational requirements

• Scalability : Supports growth and expansion of organizational tasks by separating functions and products into layers ; this separation makes it easier to grow the network.

• Availability : Provides necessary services reliably - anywhere, anytime

• Performance : Provides the desired responsiveness, throughput, and utilization on a per application basis through the network infrastructure and services.

• Manageability : Provides control, performance monitoring, and fault detection.

• Efficiency : Provides required network services and infrastructure with reasonable operational costs and appropriate capital investment on a migration path to a more intelligent network, through step-by-step network services growth.

• Security : Provides for an effective balance between usability and security while protecting info assets and infrastructure from inside and outside threats.

Q4- PPDIOO network lifecycle phases and correct descriptions.

→

a). Prepare phase - Business requirements and strategy related to the network are established.

b). Plan phase - Network requirements are identified

c). Design phase - Network design specification is produced

d). Implement phase - The network is built

e). Operate phase - Includes fault detection and correction and performance monitoring

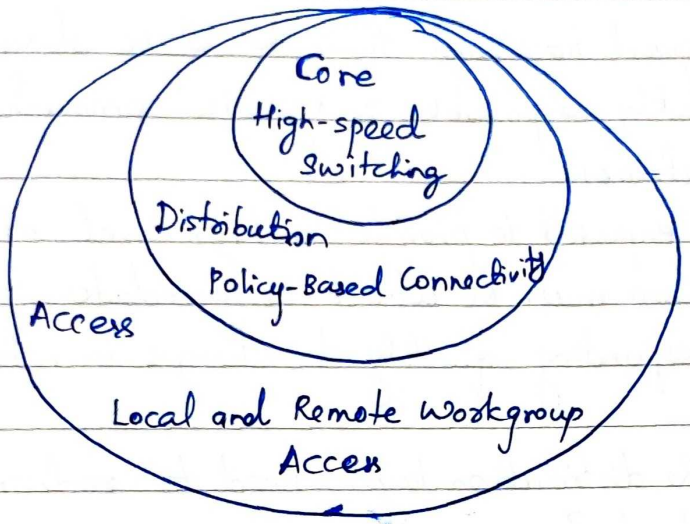
f). Optimize phase - Based on proactive management of the network.

Q5- What are the three basic steps of the design methodology?

→

q6- Role of each layer in Hierarchical network model.

→



Access Layer : Concentration point at which clients access the network
AL devices control traffic by localizing service requests to access media
AL grants user access to network resources.

Characteristics :-

AL typically incorporates switched LAN devices with ports that provide connectivity for workstations and servers.

Distribution Layer : Represents both a separation between the access and core layers and a connection point between the diverse access sites and the core layer.

Determines department or workgroup access and provides policy-based connectivity.

Characteristics :-

DL devices control access to resources that are available at the core layer and must therefore use bandwidth efficiently.

Core Layer : Provides fast and efficient data transport. Network Backbone. Provides interconnectivity between DL devices. (High End Routers & switches).

Characteristics :-

CL is a high-speed backbone that should be designed to switch packets as quickly as possible to optimize communication transport within the network.

CL devices are expected to provide a high level of availability and reliability. Core must be able to accomodate failures by rerouting traffic and responding quickly to changes in network topology.

Q7- Why might the distribution layer need to redistribute between routing protocols?

→ The distribution layer represents both a separation between the access and core layers and a connection point between the diverse access sites and the core layer. It is where routing and packet manipulation are performed.

The distribution layer allows the core layer to connect diverse sites while maintaining high performance.

To maintain good performance in the core, the distribution layer can redistribute between bandwidth-intensive access-layer routing protocols and optimized core routing protocols.

Q9- What is the Role of Service Provider functional area?

→ The service provider functional area is responsible for connectivity into Services Provider networks. This includes a number of diff. connectivity options, from internet access through Public Switched Telephone Network (PSTN) access.

The second level of division within the service provider functional area includes different modes used to connect these different service options :-

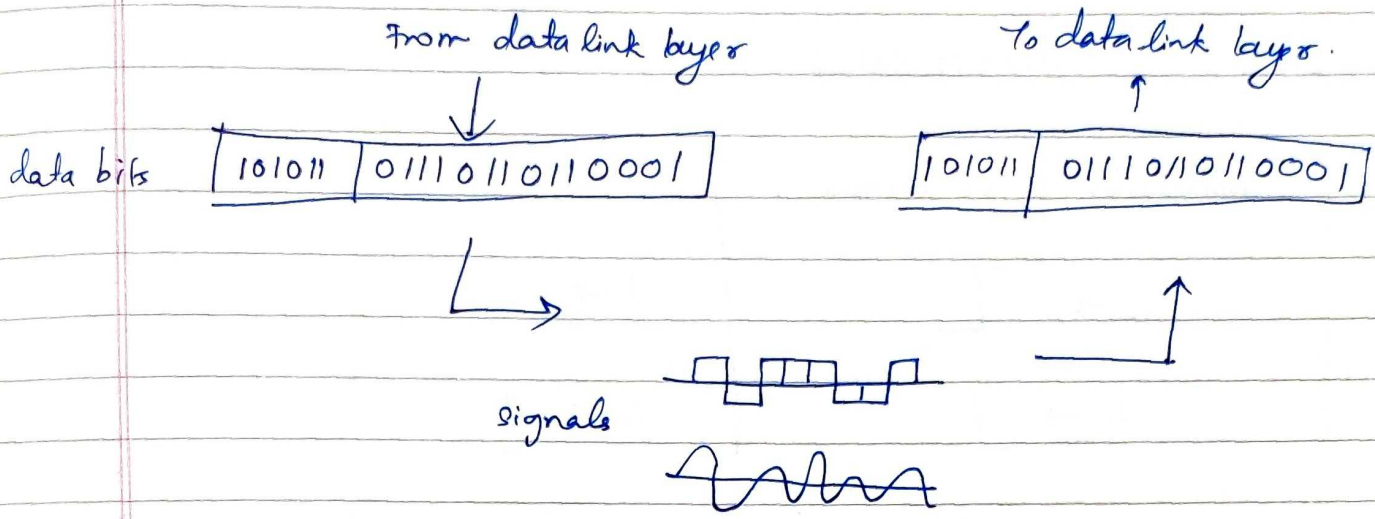
1 lg tandool
½ kg daal.
udad
poke

Sabudana ½ vati

- ISP
- PSTN (Public Switched Telephone Network)
- Frame ~~Relay~~ Relay and ATM Module.

Physical layer

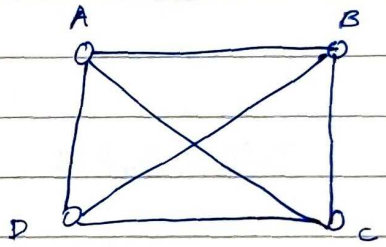
Physical layer



functionalities

- Cables and connectors
- Physical topology
- Hardware (Repeater, Hubs)
- Transmission mode
- Multiplexing
- Encoding

Mesh Topology - Point to point



No. of cables : $\frac{n(n-1)}{2}$

No. of Ports : n-1

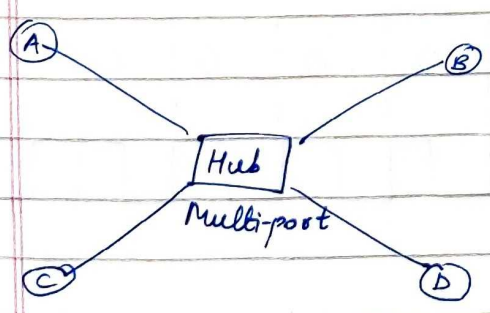
Reliability : High

Cost : High

Security : Provides security.

Disadvantages :- Maintenance is high.

Star (Hub). - point to point



No. of cables : n

No. of ports : Total = n

Reliability : Not reliable (If Hub fails)

Cost : Lower compared to mesh.

Security : Provides security but less.

Similarly.

Bus, Ring

Vaagarjan
S P Gupta

Dr Thomas
IEEE

Q46. Manchester vs differential manchester encoding

101111100001

Manchester : Dr. Thomas

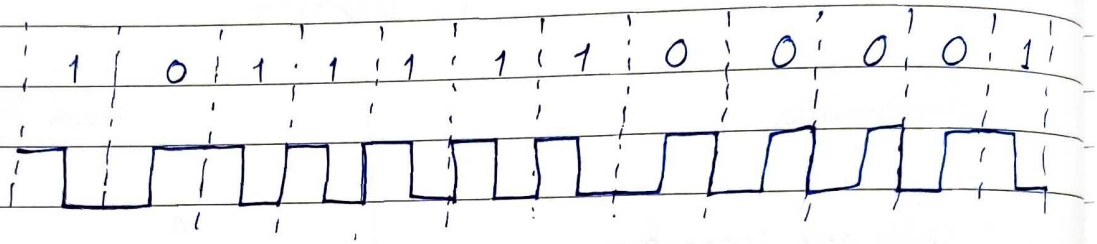
1 →

0 →

IEEE

1 →

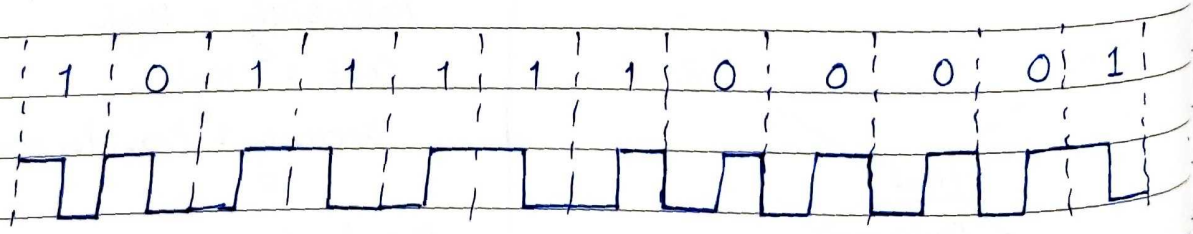
0 →



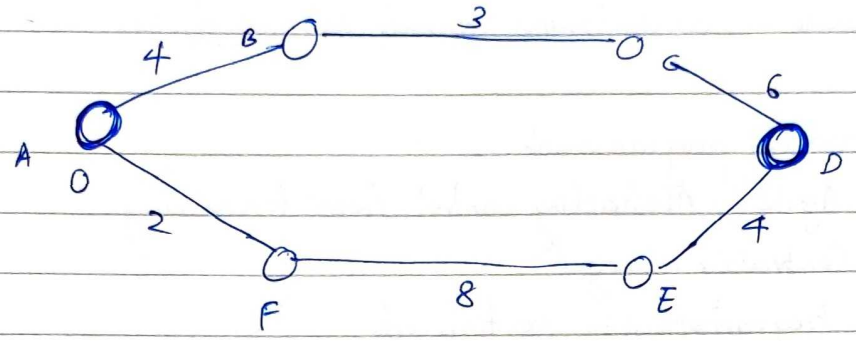
Differential :

0 → edge in the beginning

1 → no edge (continue)



Q47- Dijkstra's $A \rightarrow D$.



A – B – C – D.

Source	Destination				
A	B	C	D	E	F
	∞	∞	∞	∞	∞
A, F	4	∞	∞	∞	(2)
A, F, B	(4)	∞	∞	10	(2)
A, F, B, C	(4)	(7)	∞	10	(2)
A, F, B, C, E	(4)	(7)	13	(10)	(2)
A, F, B, C, E	(4)	(7)	13	(10)	(2)

Software Defined Network

Physical separation of network control plane from forwarding plane, and where a control plane controls several devices.

- Directly programmable
- Agile : Abstracting control from forwarding.
- Centrally managed
- Programatically configured

Operation - Control plane / Data plane

Data plane : processing and delivery of packets based on state in routers and endpoints.
e.g. IP, TCP, Ethernet, etc

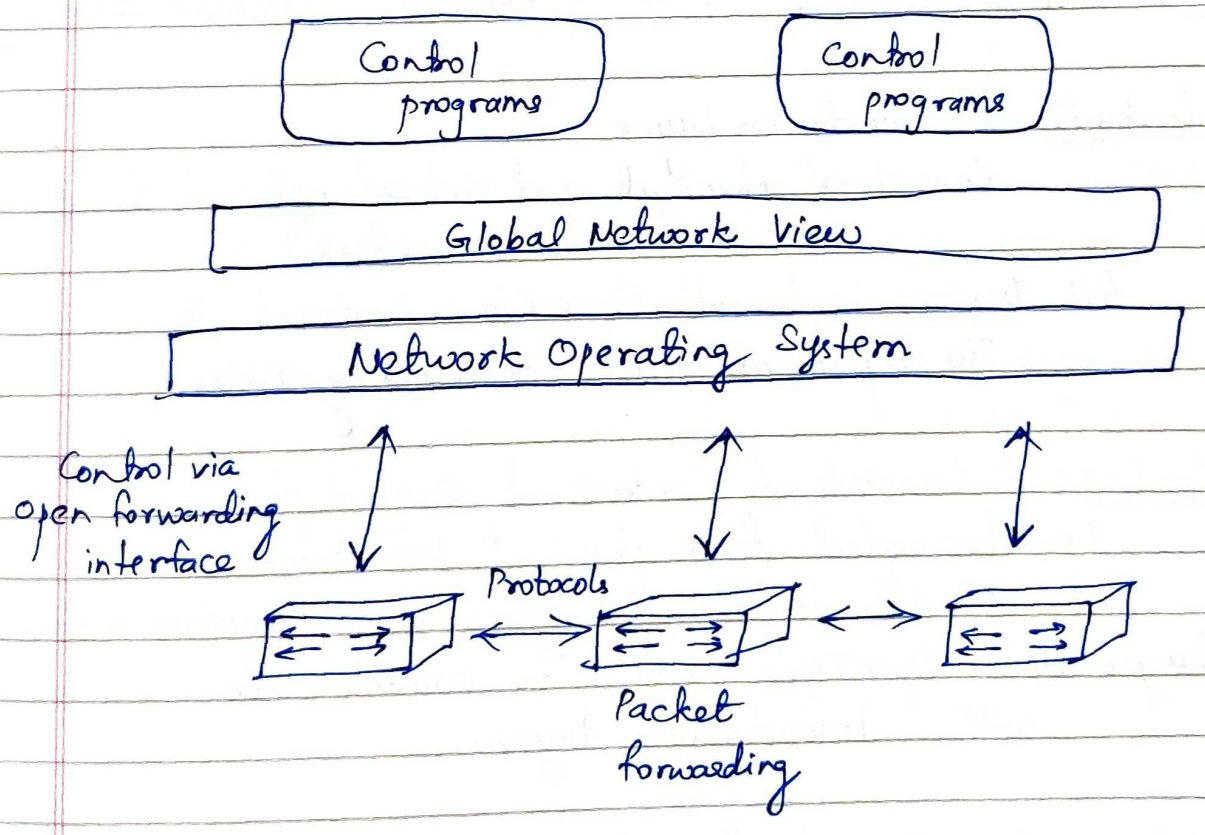
Control plane : establishing the state in routers. Determines how and where packets are forwarded.
Routing, Traffic engg, firewall state.

It is an architecture to control not just a networking device but an entire network.

Purpose :

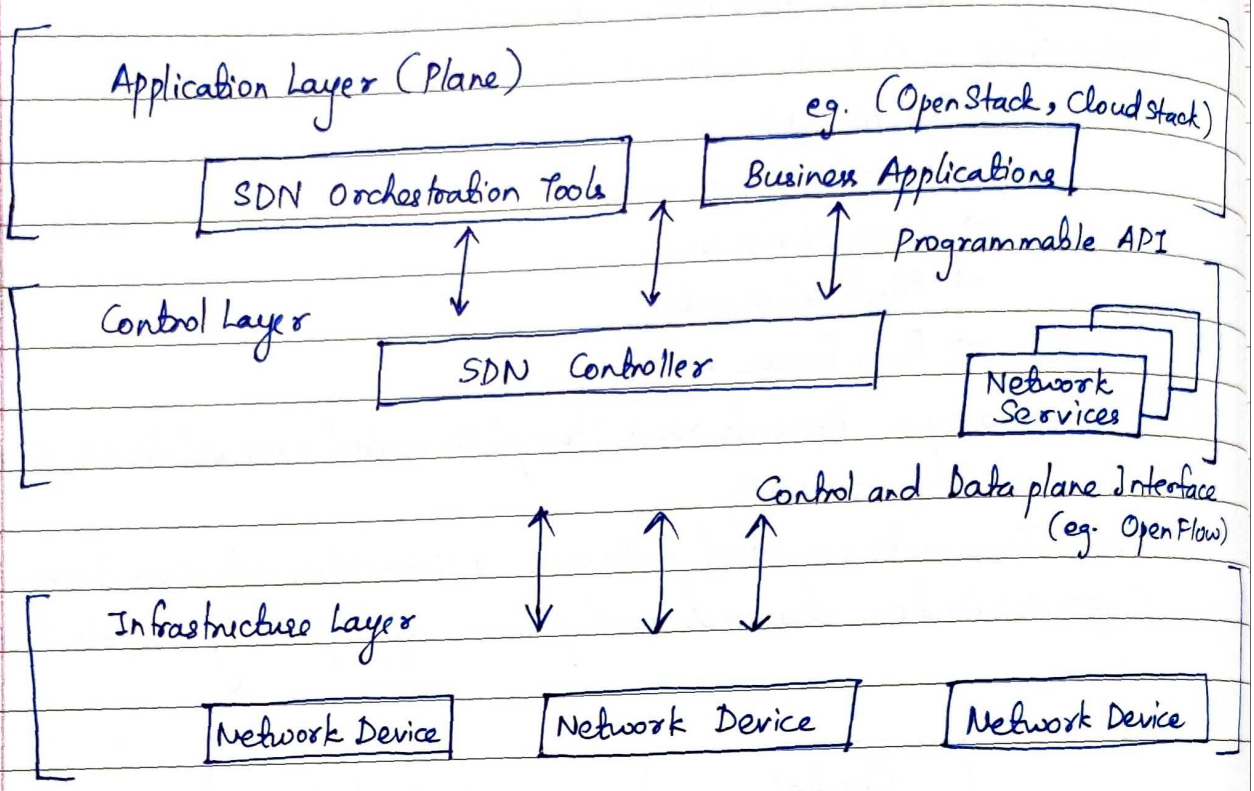
- Virtualization - Using network resources without worrying about phy location
- Orchestration - Control and manage thousands of devices with one command
- Programmable - Changes behaviour on the fly.
- Dynamic Scaling - Changes size, quantity
- Automation - To lower OpEx minimise manual involvement.
  - → Troubleshooting
  - → Reduce downtime
  - → Policy enforcement
  - → Add new workloads, sites, devices and resources.

- Visibility - Monitor resources, connectivity
- Performance - Optimize network device utilization
  - → Traffic engg
  - → Capacity optimization
  - → Load balancing
  - → High utilization.
  - → Fast failure handling
- Multi-tenancy - Tenants need complete control over addresses, topology, routing, security.
- Service Integration - Load balancers, firewalls, Intrusion Detection Systems provisioned on demand and placed appropriately on the traffic path.



Need : To facilitate innovation in the network.
Layered Architecture with standard Open Interfaces
More accessibility since software can be easily developed by more vendors.
More flexibility with programmability.

Architecture of SDN. ⟨ICA⟩

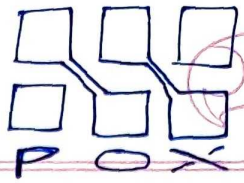


Infrastructure : Foundation Layer
Consists of physical and virtual network devices (switches & routers)
All Devices implement OpenFlow protocol To implement traffic forwarding rules

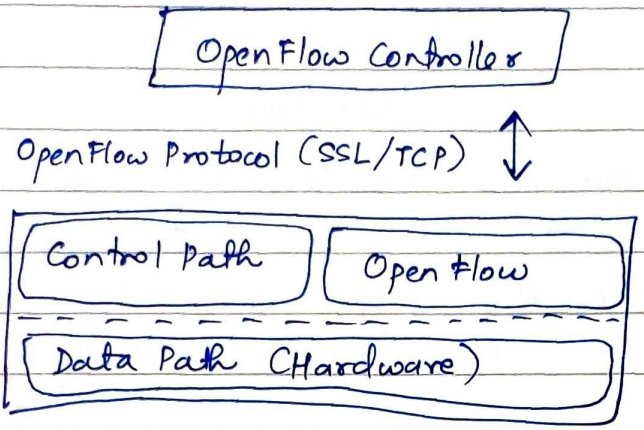
Control : Consists of Centralized control plane i.e. decoupled from physical infrastructure to provide centralized global view to entire network.
Layer Uses OpenFlow protocol to communicate with infrastructure layer.

Application : Consists of network services, application and orchestration tools used to interact with Control layer.
Provides Open Interface to communicate with other layers in architecture.

Controllers : NOX/POX
Ryu
Floodlight
Open Daylight



OpenFlow : Open API that provides standard interface for programming the data plane switches.



OpenFlow protocol :

Protocol for remotely controlling the forwarding table of a switch or router and is one element of SDN.

Implemented on Ethernet switches to allow the data plane to be managed by a controller present on control plane in SDN architecture

OpenFlow based controllers discover and maintain an inventory of all the links in the network.

Then create and store all the possible paths in entire network.

- It can instruct switches and routers to direct the flow of traffic by providing software-based access to flow-tables that can be used to quickly change the network layout and traffic flows as per users requirements

NOX/POX Architecture.

Components

POX			Common		NOX
L3_Learning	L2_Multi	Spanning_tree	Web Services	Topology discovery	Open Roads
MAC_blocker	Packet_dump	Routing	Host tracking	L2_Learning	Authenticator

Component API

Cooperative Threading | Event Harness | OpenFlow API

Asynchronous I/O

Socket I/O | File I/O