

UNIT-3

Network Layer: Design Issues

1. Addressing

IP addressing - Each device on network must have unique address

Hierarchical - manage address efficiently & Reduce size of Routing table.

2. Routing -

Path Determination - best path through the network

Scalability - protocols must be able to scale as network grows

3. Packet Forwarding -

Forwarding technique - how packets are forwarded

4. Error handling & Diagnostics -

Error Detection & correction - Detect & correct errors in transmitted packet

5. Congestion Control -

Avoid Congestion - techniques to prevent network congestion

Handling - packet dropping.

6. QoS (Quality of Service) -

Traffic prioritization - high priority traffic

Resource Reservation - along with network path

7. Security -

Secure Routing - protection from being tampered with

Network layer

- Third layer of OSI
- handles services from transport layer & further forwards the service requests to Data link layer.
- translates logical address to physical address
- determines the route (source to destination) manage traffic problems - switching, Routing & Controls the congestion.
- **Role** - Network layer is to move packets from sending host to receiving host.

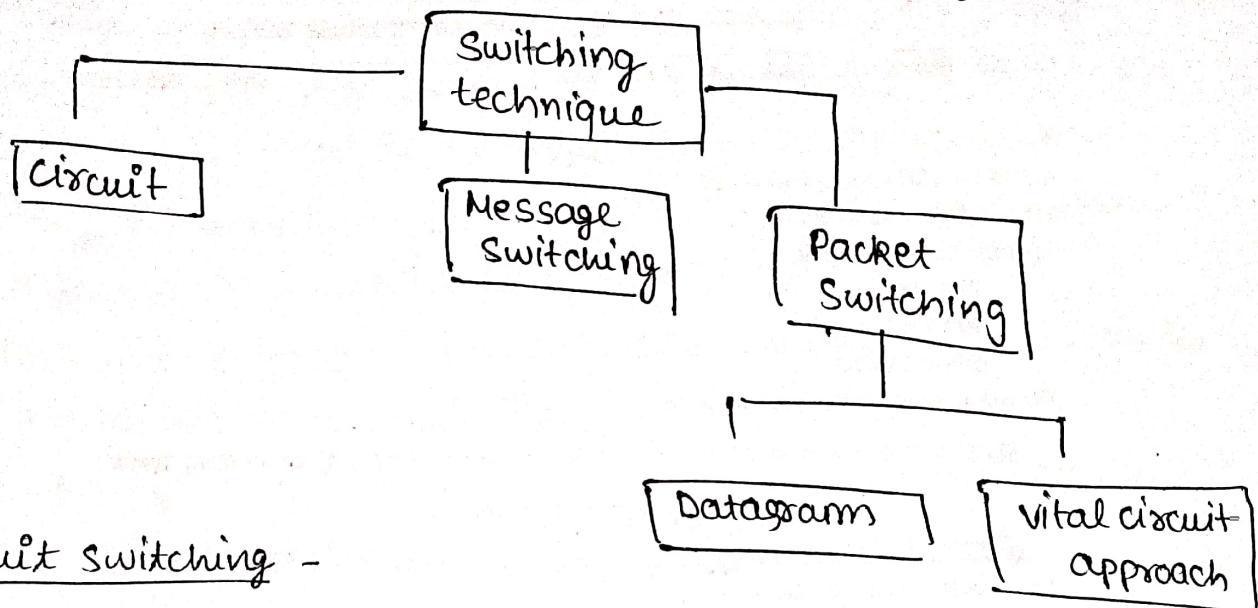
Main functions -

1. Routing - jab packet router input link pe data hai to Router usko output link pe bhej data hai.
2. Logical Addressing - implements physical addressing & network layer implements the logical addressing. used to distinguish b/w source & destination system.
It adds header to packet include logical address of sender & receiver
3. Fragmentation - breaking of packets into smallest individual data units

PACKET SWITCHING

Switching → used to connect the system for making one to one communication.

Decide best Route for data transmission.



Circuit switching -

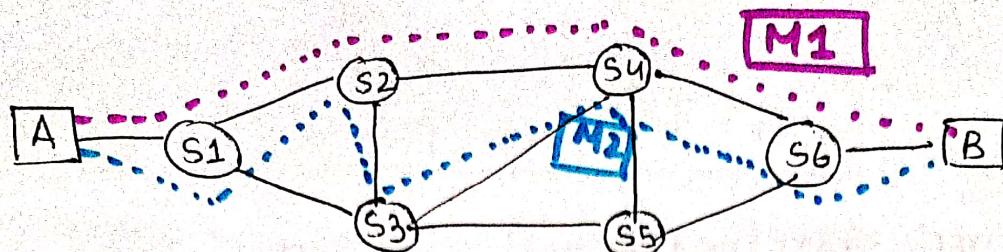
- ↳ established a dedicated path between Sender & Receiver
- ↳ Ek baar jab connection establish ho jata hai, jo dedicate Path hota hai it will remain Exist until connection is terminated.
- ↳ Before Data transfer, connection will be established first.

Phases

- 1. Connection Establishment.
 2. Data transfer.
 3. Connection Disconnection.

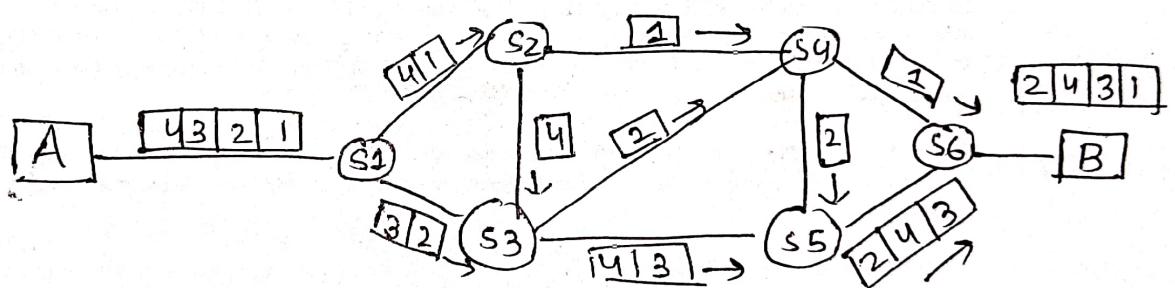
Message switching -

- ↳ store & forward mechanism.
- ↳ Message is transferred as a complete unit & routed through immediate nodes at which it is stored & forward
- ↳ no establishment of Dedicated path.
- ↳ Programmed in such a way so that they can provide the most efficient routes.



Packet switching

- Message is sent in one go, but divided into small pieces
- Message splits into smaller pieces as packets & given a unique number to identify order at receiving end.
- Every packet contains some info in header as source address, destination add & Seq. no.
- Packet travel across network, take shortest path as possible.
- all packet reassemble at receiver end.
- If any packet is corrupted or missing then message will be sent to Resend the message.
- If correct then ack.

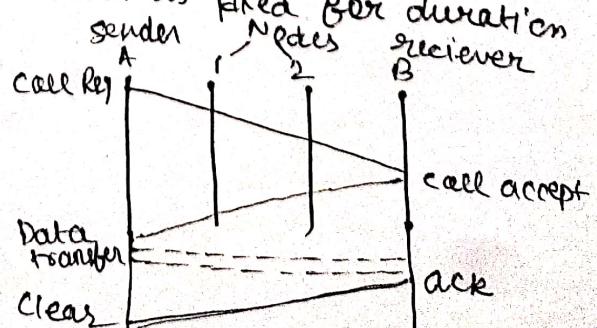


Datagram

- Packet switching technology
 - ↳ known as Datagram
 - considered as an independent entity
- Packet contains info about destination & switch uses this info to forward the packet to correct destination.
- Packets are reassembled at Receiving end.
- the path is not fixed.
- Connection less switching.

vital

- connection oriented.
- preplanned route is established before the message are sent
- call Request & accept - packets are used to establish the connection b/w sender & receiver
- Path is fixed for duration



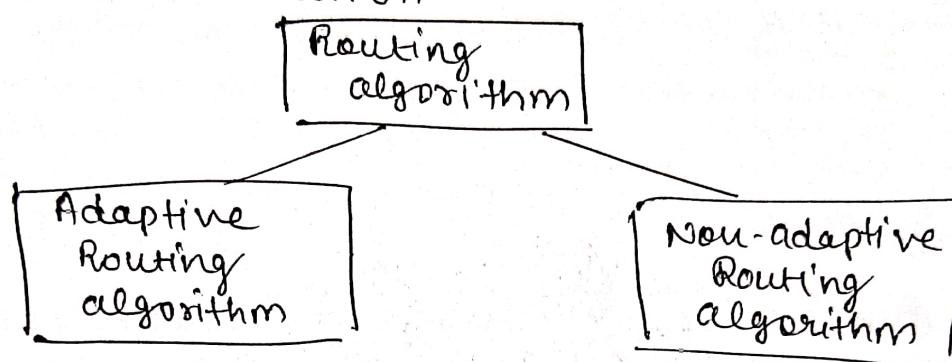
ROUTING ALGORITHM

- determines best route from Source to Destination through which packets can be transmitted.

- Routing protocol at network layer provide this job.

Provides the Best Path → "least cost path"

- Routing - process of forwarding the packets from source to Destination



↳ Dynamic Routing algorithm

↳ makes the Routing ~~algo~~ decision based on topology & network traffic.

↳ Parameters - hop count, distance estimated transit time.

Centralized

↳ computes the least-cost path
↳ takes connectivity between the nodes & link cost as input & info obtained

Ex → link state

Isolation

↳ obtains Routing info by using local info rather than gathering info from other nodes

Distributed

↳ decentralized
never know complete path from source to destination

Flooding

Every incoming packet sent to all outgoing links.

Random walks

↳ sent by the nodes to one neighbors randomly

(dynamic algo) Distance vector Routing Algorithm -

Iterative
its process continues until no more info is available to be exchanged between neighbours

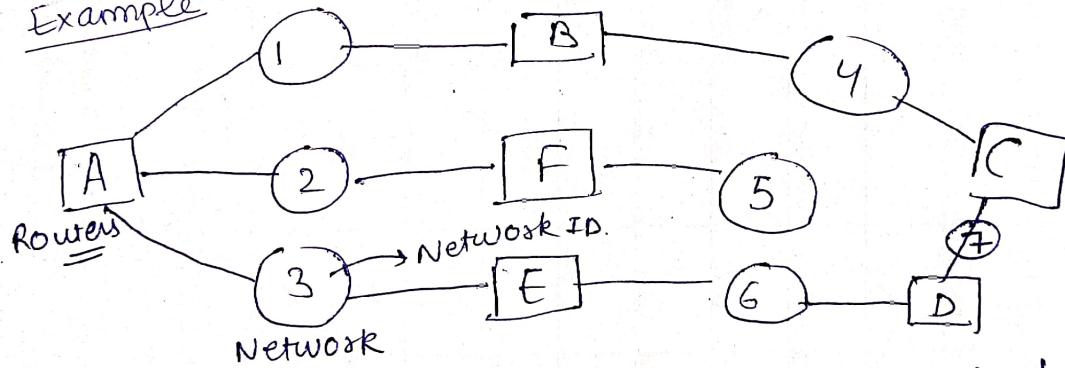
Asynchronous
doesn't require all of its nodes operate in lock step with each other.

Distributed
(each node receive Kargi info from one or more directly attached neighbours . calculation perform Kargi or result back to Neighbours)

- Each router maintains a distance table → "vector" algorithm -

- (1) A router transmits its distance vector to each neighbors in packet .
- (2) Router receiver & saves the most recently received distance vector from each of its neighbour .
- (3) Router recalculate distance vector when
 - (1) it receives a distance vector from neighbour contain diff. info .
 - (2) discover that link to a neighbour has gone down .

Example -



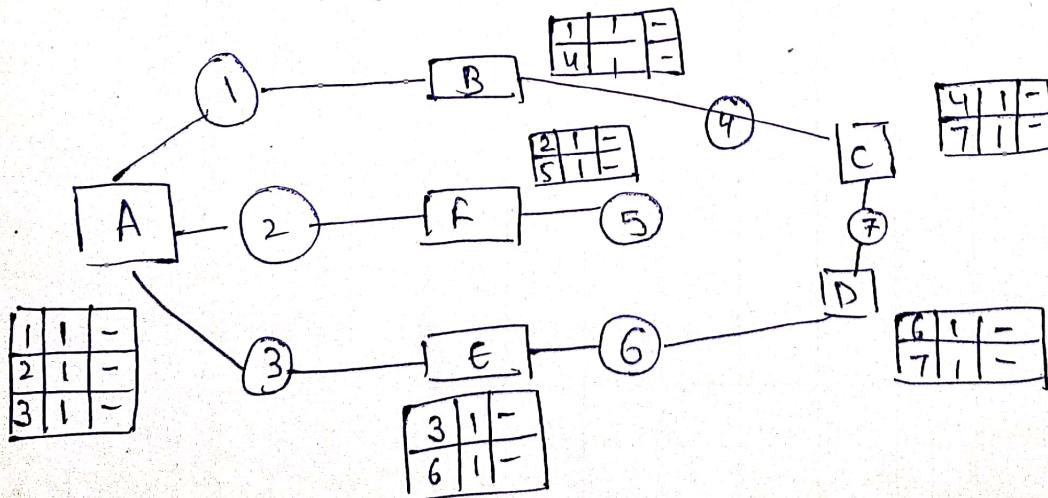
A → BFE
B → AC

C → BD
F → A
E → AD

D → EC

Routing table

ID	Cost	Next Hop



Updating table

$$\begin{array}{|c|c|} \hline 1 & 1 \\ \hline 4 & 1 \\ \hline \end{array} + \text{One loop} =$$

$$\begin{array}{|c|c|c|} \hline 1 & 2 & B \\ \hline 4 & 2 & B \\ \hline \end{array}$$

1	1	-
2	1	-
3	1	-

1	2	B
4	2	B



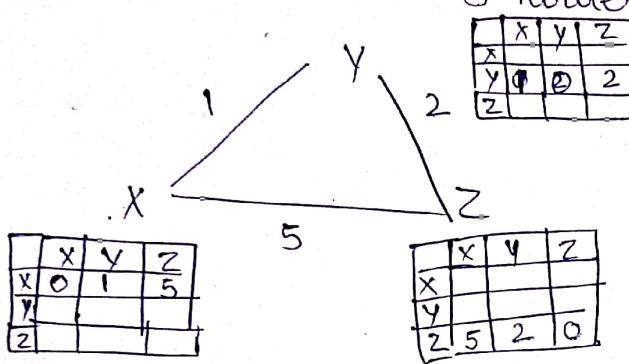
1	1	-
1	2	B
2	1	-
3	1	-
4	2	B

duplicate data
sirf whi Rakhega jiski cost kam hogi

1	1	-
2	1	-
3	1	-
4	2	B

For EXP

consider 3 Routers



Exchange Routing Table

X will get Z & Y Routing table

So, new Routing table will be like this -

x	x	y	z
x	0	1	5/3
y	1	0	2
z	3/0	2	0

now as we can see when

Y is intermediate node b/w

x & z it have low cost ($3 < 5$)

	x	y	z
x	0	1	3
y	1	0	2
z	3	2	0

Same steps for y & z.

y =	x	y	z
x	0	1	3
y	1	0	2
z	3	2	0

z =	x	y	z
x	0	1	3
y	1	0	2
z	3	2	0

circuit

Q0

Cong.

Ad

Cef

R

!

F

J

Link state

Technique in which each router shares the knowledge of neighbourhood with every other router in internetwork.

Phases

Reliable flooding

Initial State

(Each node knows cost of its neighbours)

Final state

(Knows entire graph)

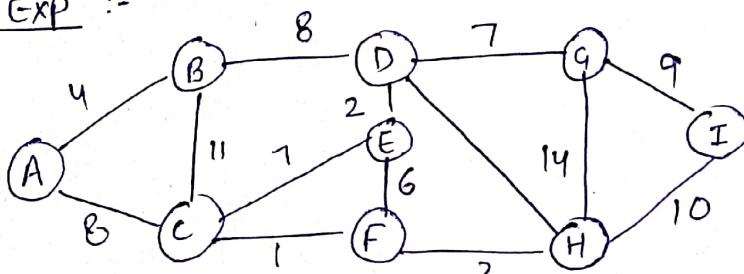
Route cal.

↳ Dijkstra's algo
(used to find shortest path from one to every other node)

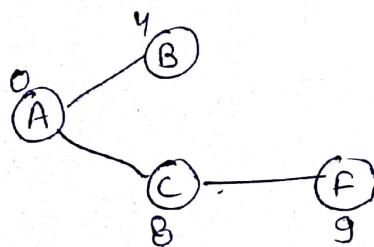
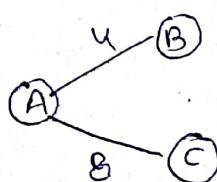
↳ iterative, property hoti hai after kth

iteration of algorithm the least cost path are well known for K destination nodes.

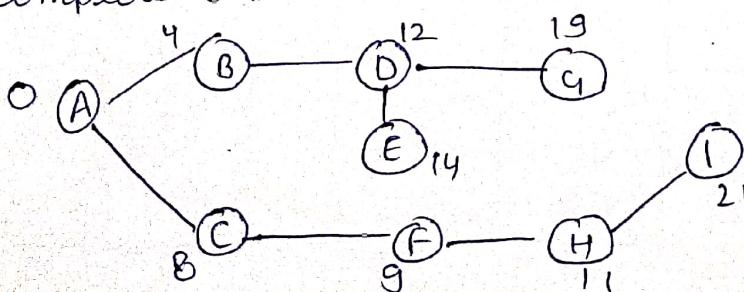
For Exp :-



Let's start with A vertex,



Complete will be



Circuit Flooding -

Communication method where data packets are sent to all connected devices. Even if they are not intended recipient of data.

Why flooding

1. Address Resolution - translate IP to actual MAC.
2. Routing protocol - Link state Routing
3. Multicast tree Establishment - Create Multicast Distribution tree
4. Emergency Broadcast - regardless of location make sure that message reach all network device.

Features

1. Broadcasting - send to every device connected to network
2. No prior knowledge - precise address of device optional
3. Simple & Robust - straightforward, simple doesn't rely on intricate routing algorithms
4. Loop prevention - use Time to live counters to stop data packets
5. Security considerations - expose private info to recipient who weren't intended.

Broadcasting -

→ allow message to be received by all nodes of network
→ transmission of signals from Radio or television.

Broadcasting

unicast

ek source info send
karta hai ek hi destination
ko.
Ex → Phone call

multicast

multiple destination ko
hi ek hi time

Ex → Radio

Flooding

- Packets ko har node tak Bhejna, Bina Kisi specific Routing ke.
- redundancy avoid ke lie
- limited to network infrastru.
- minimal control, Packets har node tak pauchte hai
- network congestion & collision

Broadcasting

ER source se multiple recipients tk info Bhejna

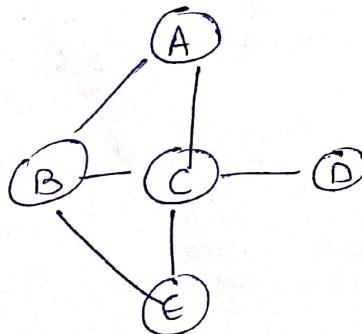
info Delivery ke lie
coide Range

controlled, specific to chosen medium/audience

Efficiently reach large audience

Flow Based Routing -

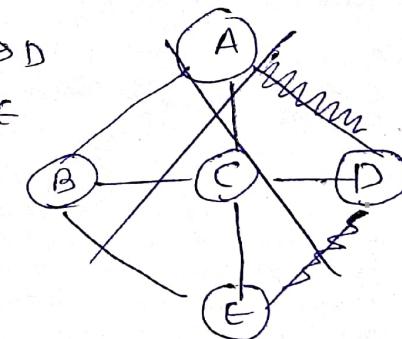
- ER gaetwork routing technique hai jisme network traffic ko different flows mei catagorize Karke route Karte hai.
- har individual packet ko alog se route kia jata hai.



$$(A \rightarrow D) = A \rightarrow C \rightarrow D$$

$$(B \rightarrow E) = B \rightarrow C \rightarrow E$$

$$(A \rightarrow E) = A \rightarrow B \rightarrow F$$

# Multicast Routing -

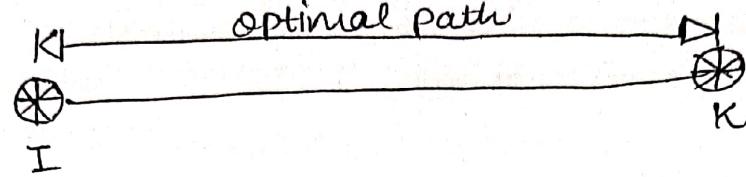
↳ ER single source se multiple destinations tk Data packets Efficiently Bheje jate hai.

↳ sirf unko bhjti hai jo actively participate kar sake hai.

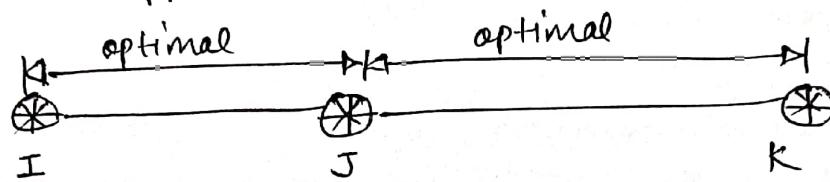
↳ Bandwidth converse Karti hai.

optimality principle

Statement - if the router J is on the optimal path from I to Router K, then optimal path from J to K also falls along same route.



Now suppose J lies between I & K



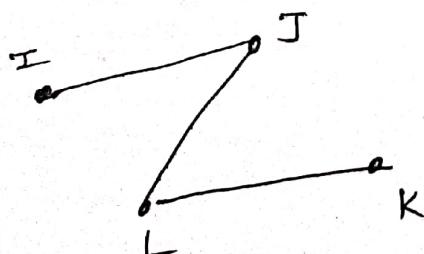
Importance -

- * Efficiency → avoid wasting resources by exploring unnecessary paths.
- * Loop prevention - Routing algorithm can prevent creating loops in network.

Limitations -

- * Dynamic networks - assumes all routers have complete & up-to-date info. about network.
- * cost metrics - optimal path kisi ke lie kuch bhi ho skta hai
least cost, fastest, shortest or combination of factors.

For EXP . Let IJK, L are the routers & connection between them.



Let suppose $I \rightarrow J \rightarrow L \rightarrow K$ is optimal path from I to K then $J \rightarrow L \rightarrow K$ is the optimal path from J to K.

Flow control -

- ↳ technique used to regulate the flow of Data b/w Different nodes in a network
- ↳ Ensure Karta hai Sender ER dm se overwhelm na Kare, (Matlab bolt Sara Data ER sath Send na Kare)
- ↳ goal : to prevent buffer overflow , lead to dropped packets & poor network performance.

Congestion control -

(GTS - GTTS)

- ↳ technique to prevent congestion in a network
- ↳ yeh occur hota hai jab bolt Sara Data ER sath bheja jata hai. network pe.
- ↳ lead to ~~pro~~ dropped packets & poor network performance.

Similarities

- (1) Regulate the flow of Data.
- (2) prevent packet loss.
- (3) improve network Efficiency.

Flow

- (1) Traffic from Sender to Receiver is controlled
- (2) used in DDL , transport
- (3) Keeps the data from overwhelming
- (4) Sender sends data slowly to Receiver

congestion

- Sender has to control/modulate own rate
- used in network & transport
- keep networks from being congested
- Slowly transmitted into network by transport layer .

	Datagram	virtual circuit network
circuit step	Not needed	Required
QoS	Difficult	Easy if enough resources
congestion control	Difficult	Easy if enough resources
Address	Each pack contain the full source & Destination address	contains a short vc number
Effect of Router failures	None except for Packets lost during crash	VC's passed through failed network are terminated
Routing	independent	choose vc, all packets follow it

Internetworking = inter + networking = connections b/w two completely distinct segments.
 →isme switches, gateways jaise devices use hote hai.
 →jo data ko ek network se dusre network ke pauchate hai.

① Internet - network ko ek satth jodta hai jaise private, edu. organization etc.

② Intranet - private network ek organization ke internal use ke lie hota hai. Ex - employees, Department

③ Extranet - extension of intranet (external parties se connect karta hai) limited access.

④ VPN → privacy & security

⑤ P2P → file avx resource sharing