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UNIT - III
ROUTING

Internet, N/w layer to deliver a datagram from Source to distination.

datagram is destined only one destination (one-to-one delivery) → Unicast routing.

datagram is destined for several destinations, (one-to-many delivery) → multicast routing.

UNICAST ROUTING:

Unicast Routing in internet, with large no of routers and huge no of hosts done by using hierarchical routing

A packet is routed, hop by hop from its Source to destination by help of forwarding tables.

Source host needs to forwarding table, delivers its packet to default router in local Network.

destination host no needs forwarding table either receives packet from default router in local N/w.

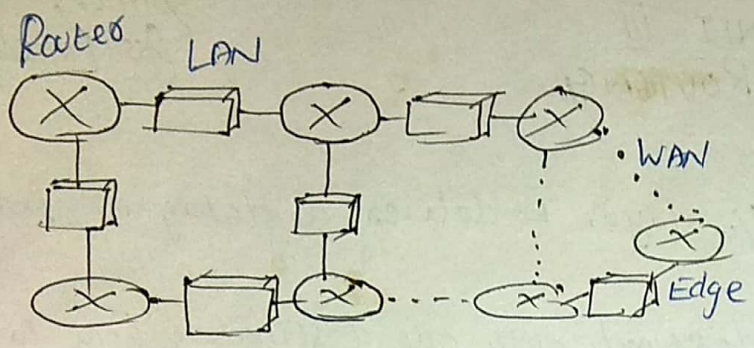
Routing a packet from its Source to destination means routing the packet from a Source Router (The default router of source host) to a destination router (the router connected to the destination N/w).

An Internet as a Graph: To find the best route, an internet can be modeled as a graph.

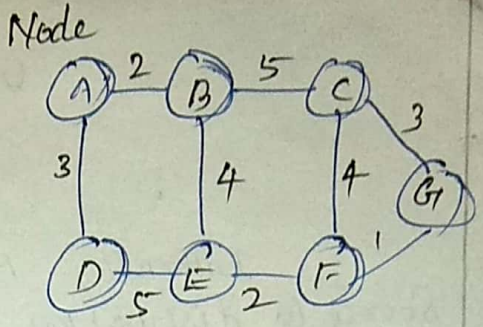
A Graph in Computer Science is a set of nodes and Edges (lines) that connect the nodes.

Each router as node and each N/w b/w a pair of routers as an edge. → 'Weighted graph'

Weighted Graph used to represent a geographical area, the nodes can be cities and edges can be roads connecting cities.



(a) An internet



(b) weighted graph

Least-Cost Routing:

When an internet modeled as weighted graph, To best route from the source router to destination router, to find the least cost b/w two.

ROUTING TABLE:

A host (or) router has a routing table with an entry for each destination (or) combination of distinations to route IP packets.

Routing table either Static (or) Dynamic.

Static Routing Table:

It contains information entered manually. Administrator enters the route for each destination into the table.

when table is created, cannot update automatically when there is a change in internet.

table must be altered manually by administrator

Used in a small internet does not change very often (or) experimental internet for troubleshooting.

Dynamic Routing Table:

Updated periodically by using one of dynamic routing protocols such as RIP, OSPF (or) BGP.
(open shortest path first, Routing Information protocol, Border Gateway Protocol.)

whenever is change in Internet, such as a shutdown of a router (or) breaking of a link, dynamic routing protocols update all the tables in routers automatically.

UNICAST ROUTING PROTOCOLS.

A static table is one with manual entries. A dynamic table, updated automatically when there is a change somewhere in the internet.

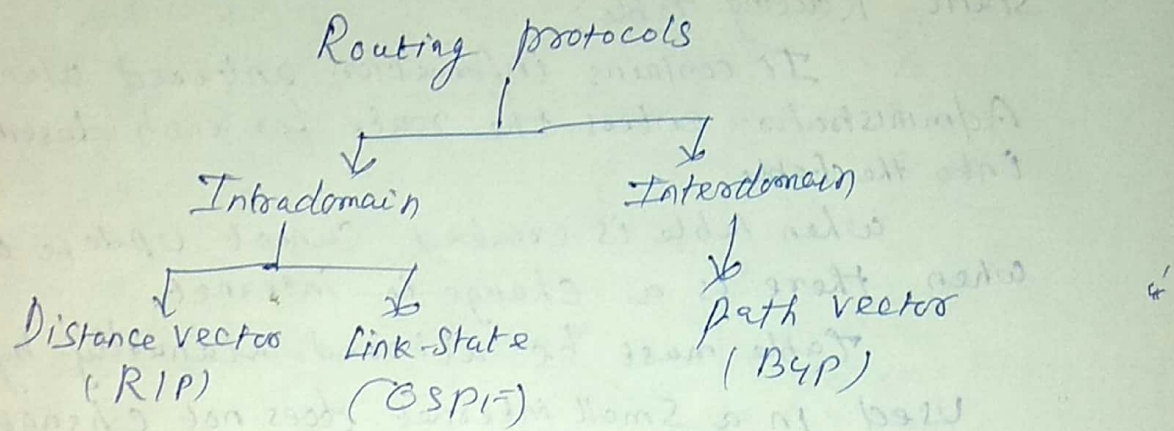
A Routing protocol is a combination of rules and procedures that routers in Internet inform each other of changes.

It allows routers to share whatever know about the internet (or) their neighborhood.

RIP : Routing Information protocol - implementation of the distance vector protocol.

OSPF : open shortest path first - (implementation of the link state protocol.

BGP - Border Gateway protocol - implementation of the path vector protocol.



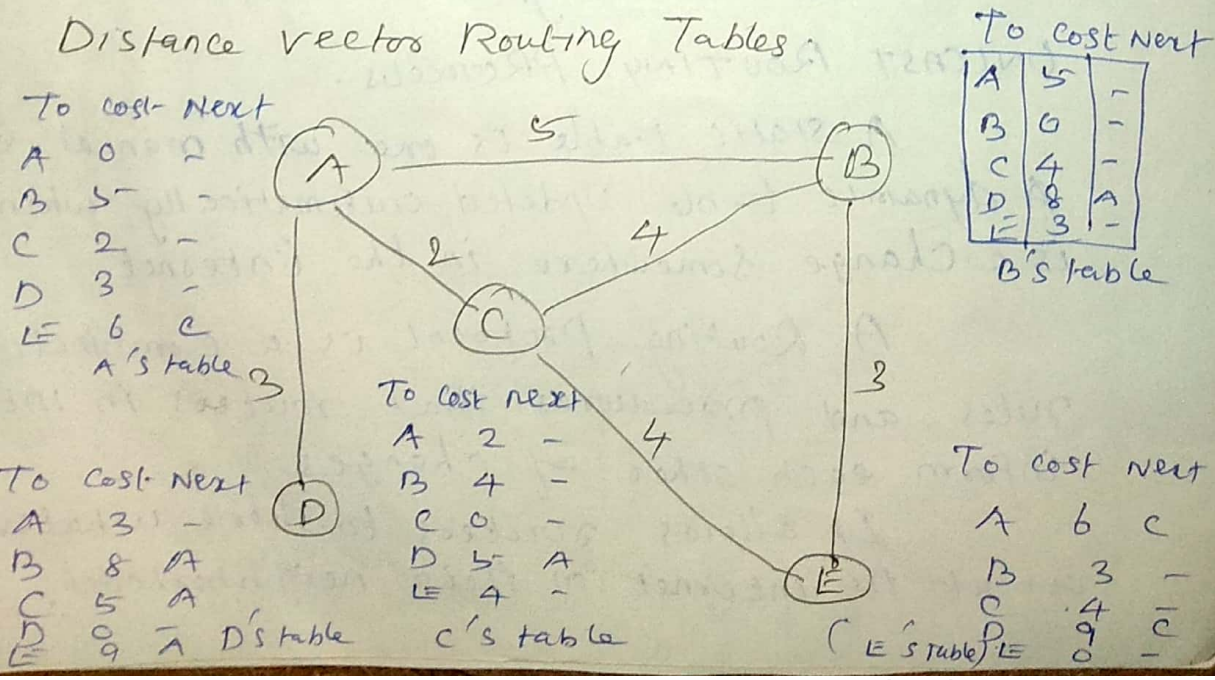
DISTANCE VECTOR ROUTING:

The least-cost route b/w any two nodes is route with minimum distance.

each node maintains a vector(table) of minimum distances to every node.

The table at each node also guides the packets to the desired node by showing the next stop in the route (next-hop routing)

Distance vector Routing Tables:

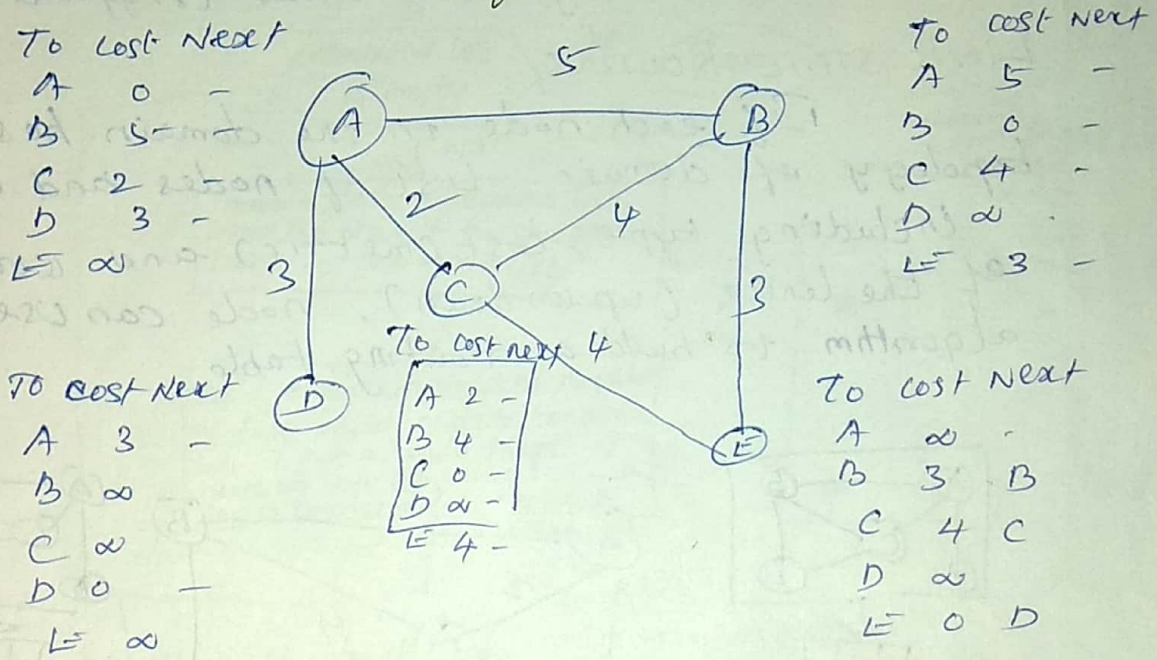


Initialization:

Each node knows how to reach any other node and the cost.

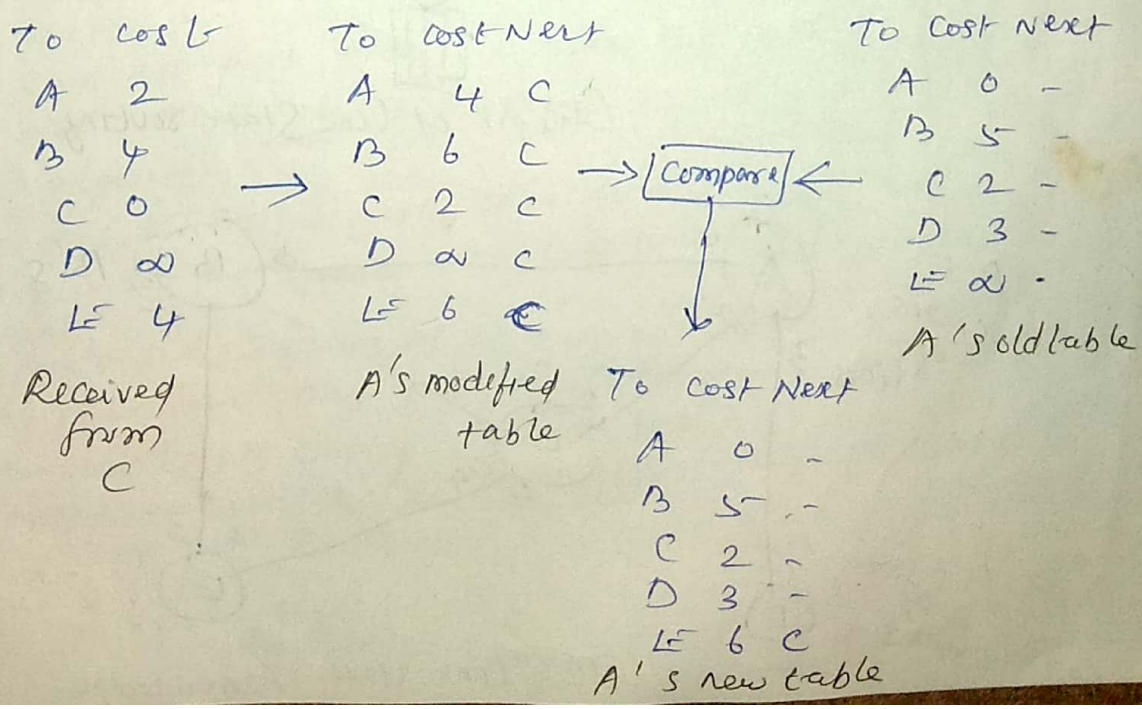
At the beginning, each node can know only the distance b/w itself and its immediate neighbors those directly connected to it.

Initialization of tables in distance vector routing



In distance vector routing, each node share its routing table with its immediate neighbors periodically and when there is a change.

Updating in distance vector routing.

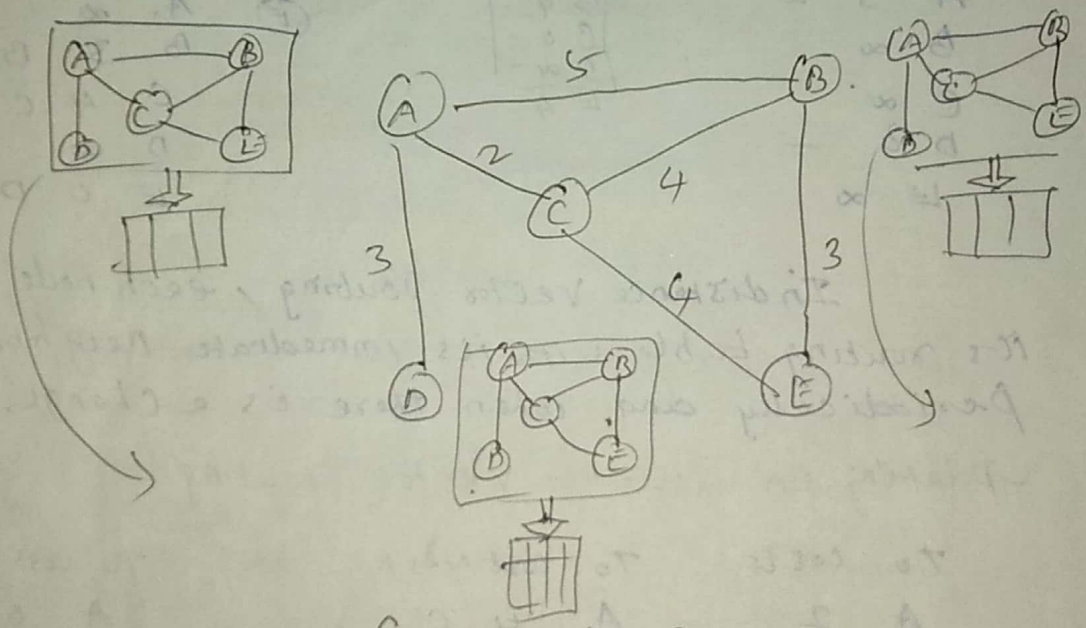


Periodic Update: A node sends its routing table, normally every 30s in a periodic update.
period depends on the protocol using distance vector routing.

Triggered Update: A node sends its two-column routing table to its neighbors any time its a change in its routing table. called triggered Update

LINK STATE ROUTING:

If each node in the domain has entire topology of domain. List of nodes and links, including type, cost (metric) and condition of the links (up or down), node can use Dijkstra's algorithm to build a routing table



Concept of Link State routing

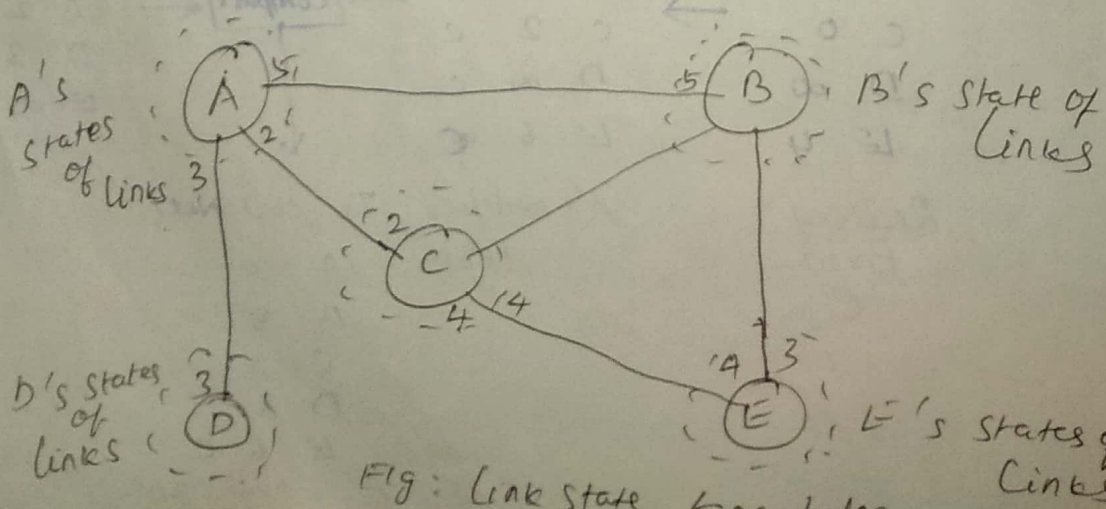
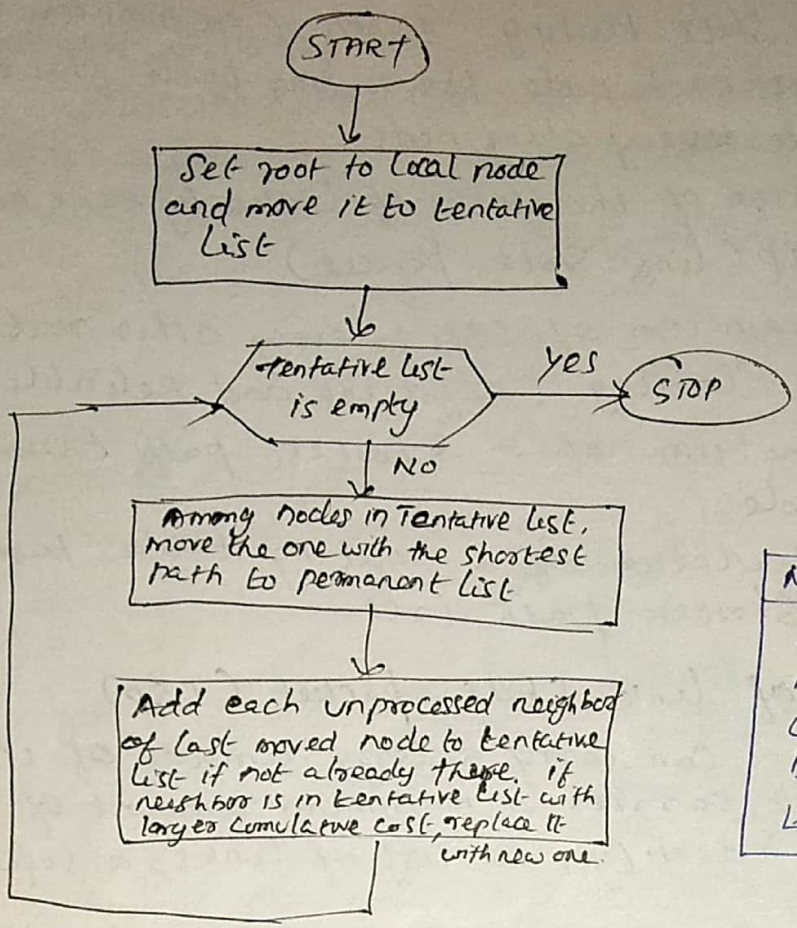


Fig: Link state knowledge

Dijkstra Algorithm:



Calculation of Routing table from Shortest-path tree

Table: Routing table for Node A

Node	Cost	Next Router
A	0	-
B	5	-
C	2	-
D	3	-
E	6	C

Formation of Shortest path Tree: Dijkstra Algorithm

After receiving all LSPs, each node will copy of whole topology. However, the topology is not sufficient to find the shortest-path to every other node. A shortest path tree is needed.

A tree is a graph of nodes and links, one node is called the root.

All other node can reached from root through only one single route.

A shortest path tree is a tree the path b/w the root and every other node is shortest.

Dijkstra algorithm:

Creates a shortest path tree from a graph. The algorithm divides the nodes into two sets. (i) tentative (ii) permanent.

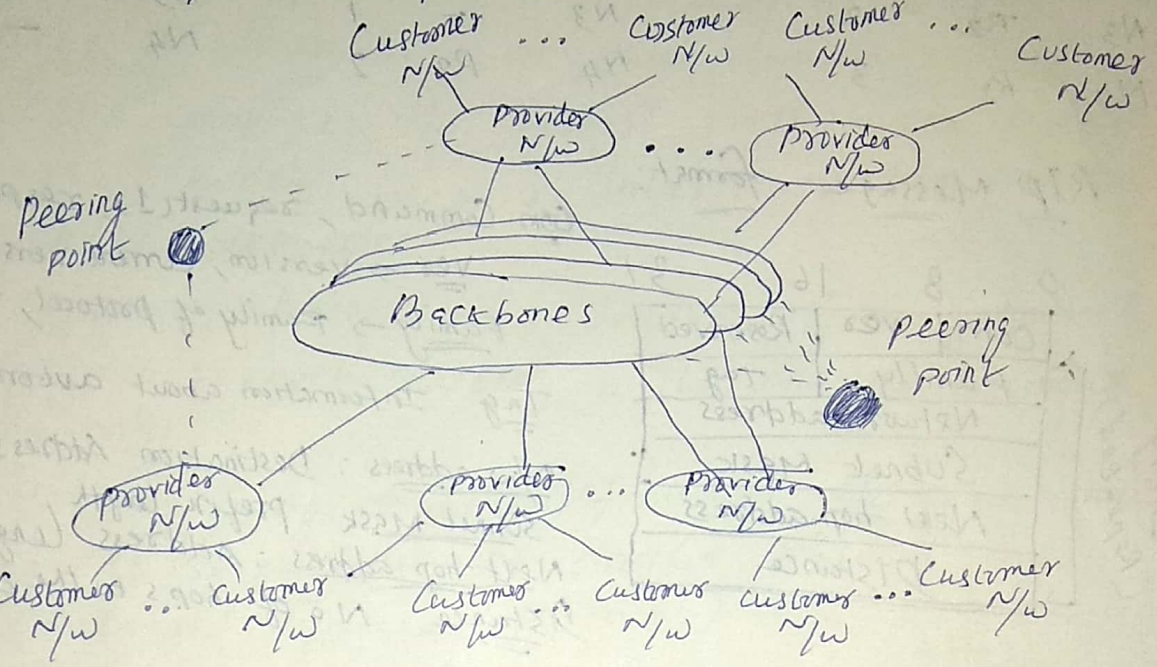
It finds the neighbors of a current node - tentative examines them and they pass the criteria — permanent-

1.	permanent List: Empty	tentative list	A(0)
2.	permanent list: A(0)	Tentative list,	B(5), C(2), D(3)
3.	" " C A(0), C(2)	"	B(5), D(3), E(6)
4.	" " A(0), C(2), D(3)	"	B(5), E(6)
5	A(0), B(5), C(2), D(3)		E(6)
6	A(0), B(5), C(2), D(3), E(6)	tentative list: Empty.	

UNICAST ROUTING PROTOCOLS:

Internet Structure.

The internet has changed from a tree like structure, with a single backbone, to a multi-backbone structure run by different private corporations.



Several backbones run by private communication Companies provide global connectivity

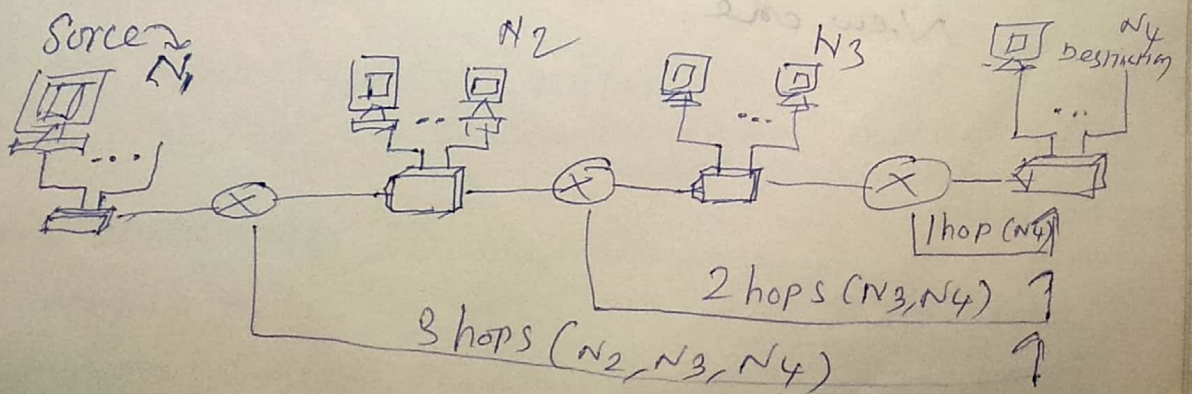
Peering points allow connectivity b/w backbones.

RIP [Routing Information Protocol]

Widely used interdomain routing protocols based on distance-vector routing Algorithm.

RIP was started as part of Xerox Network S/m (XNS) it was Berkeley Software Distribution (BSD) version of UNIX.

RIP routers advertise the cost of reaching different N/w's instead of reaching other nodes in a theoretical graph.



Forwarding Tables:

Forwarding Table for R_1

Destination N/w	Next Router	Cost in Hops
N_1	–	1
N_2	–	1
N_3	R_2	2
N_4	R_2	3

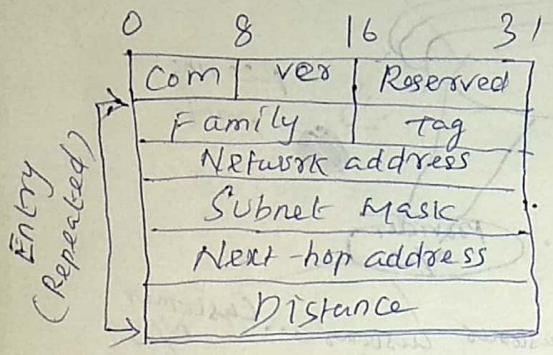
Forwarding Table for R_2

Destination N/w	Next Router	Cost in hops
N_1	R_1	2
N_2	–	1
N_3	–	1
N_4	R_3	2

Forwarding Table for R_3

Destination N/w	Next Router	Cost in Hops
N_1	R_2	3
N_2	R_2	2
N_3	–	1
N_4	–	1

RIP Message format:



Com: Command, request(1), response(2)

ver → version, Current version is 2

Family → Family of protocol, TCP/IP value 2

Tag: Information about autonomous s/m

N/w address: Destination Address

Subnet Mask: prefix length

Next-hop address: Address Length

Distance: No of hops to the destination

RIP Algorithm:

1. If the received route doesn't not exist in old forwarding table, should be added to the route.
2. If the cost of received route is lower than the cost of the old one, the received route should be selected as new one.
3. If the cost of the received route in higher than the cost of old one, but the value of the next router is same in both routes the received route should be selected as New one.

OSPF (Open Shortest path First)

It's a link state routing protocol.

Each node contains a routing directory database. database contains informations about the routers interfaces are operable. Information is periodically broadcast to all routers in same domain.

OSPF computes the shortest path to the other routers. widely used as interior router protocol in TCP/IP Networks.

OSPF is classified as Internal Gateway protocol (IGP), it support routing within one autonomous system only.

Exchange of routing information b/w autonomous systems is responsibility of another protocol an EGP (External Gateway protocol).

OSPF can support one (or many N/w's.

Features of OSPF:

1. It can store multiple routes to a destination.
2. OSPF can converge very quickly to N/w topology change.
3. OSPF support multiple metrics.
4. It is not susceptible to routing loops.

An area is identified by a 32-bit number known as area ID.

The backbone area is identified with area ID 193.0.0.0

OSPF uses four types of routers:

1. Internal Router → Router with all links connected to N/w within same area
2. Area border router → to more than one area
3. A backbone router → links connected to the backbone
4. Autonomous System Boundary Router (ASBR) → Links connected to another autonomous S/m.

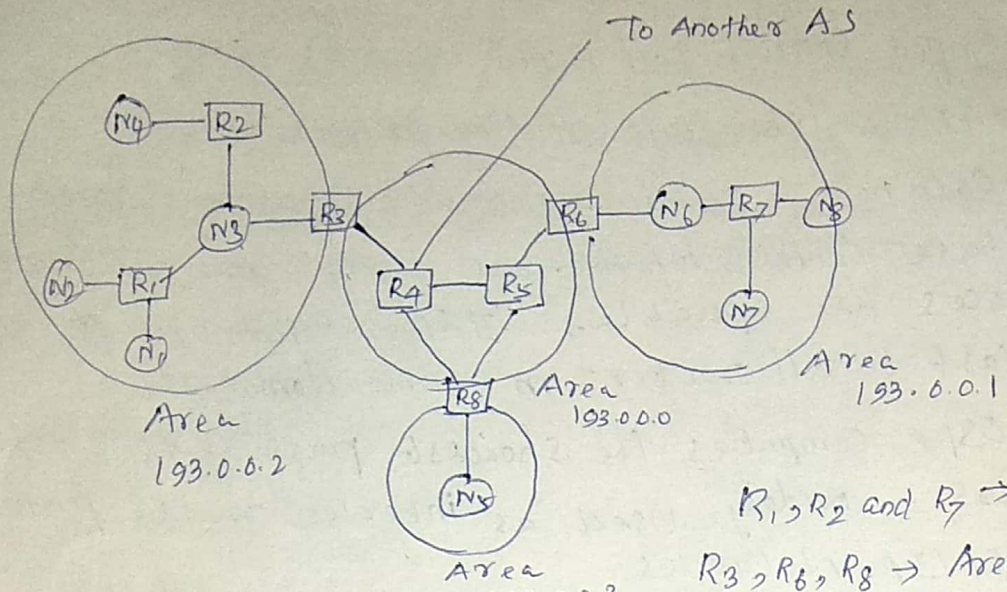


Fig: OSPF Areas.

Internal Routers
R_1, R_2 and R_7 → Routers

R_3, R_6, R_8 → Area Border Routers.

R_3, R_4, R_5, R_6, R_8 → Backbone Router

R_4 is an (ASBR)

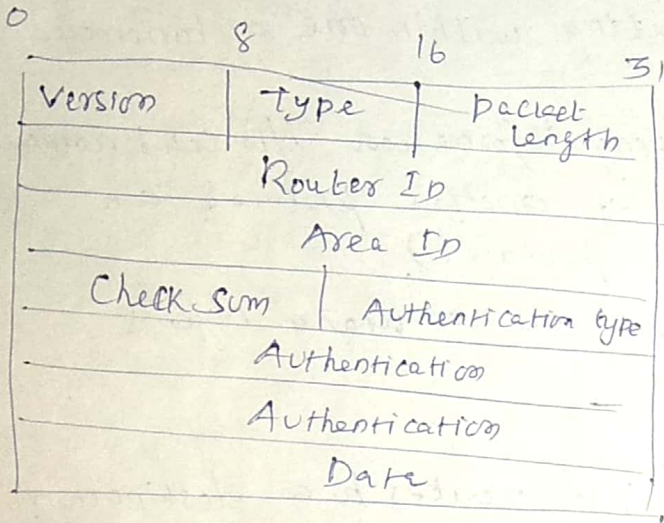


Fig: OSPF Common header

1. Version → Specifies the protocol version.
2. Type → 1. Hello, 2. Database description
3. Link status 4. Link status update
5. Link status Acknowledgement
3. Packet length: packet in bytes.
4. Router ID: Identifies the sending router
5. Area ID: Identifies the area Packet to Txd.
6. Checksum: To detect errors in the packet. It performed on the entire packet.
7. Authentication type: Identifies the authentication type is used.

OSPF Advantages:

1. Low traffic overhead.
2. Fast convergence
3. Larger N/w metrics
4. Area based topology
5. Route Summaries.
6. Support for complex address structures.
7. Authentication. → use of passwords for dynamic discovery traffic, and checks that paths are operational in both directions. To prevent misconfigured routers from "poisoning" the routing tables throughout the internet.

Dis Advantages:

1. memory overhead. → may limit max size of an area.
2. processor Overhead → CPU usage is low
3. Configuration.

BGP (Border Gateway protocol): Interdomain routing Protocol using path vector Routing. 1st appeared in 1989.

TYPES OF AUTONOMOUS SYSTEMS:

The internet is divided into hierarchical domains called Autonomous S/m's.

Ex, Large corporation Manages its own N/w.

A Local Isp provides services to Local Customers is an autonomous S/m.

Three categories: 1. Stub 2. Multihomed 3. Transit

1. Stub AS:

A stub 'AS' only one Connection to another 'AS'. Interdomain data traffic in a Stub 'AS' can either Created (or) Terminated in the 'AS'.

Hosts in AS can send data traffic to other ASs. Hosts in 'AS' Can Receive data Coming from hosts in other ASs

A stub 'AS' either a source(or) a sink. ex, small Corporation (or) a small Local Isp.

2. Multihomed AS:

More than one connection to other ASs, but still only a source (or) sink for data traffic.

It can receive data traffic from more than one AS. Send data traffic to more than one AS, but no transient traffic. Ex: Large Corporation is connected to more than one regional.

3. Transit AS:

It's a multihomed AS that allows transient traffic.

Ex, National & International ISPs (Internet backbones)

PATH ATTRIBUTES:

Each attribute gives some information about Path. Attributes two categories:

1. A well known attribute → one that every BGP router must recognize.
2. An optional attribute → one that needs not be recognized by every router.

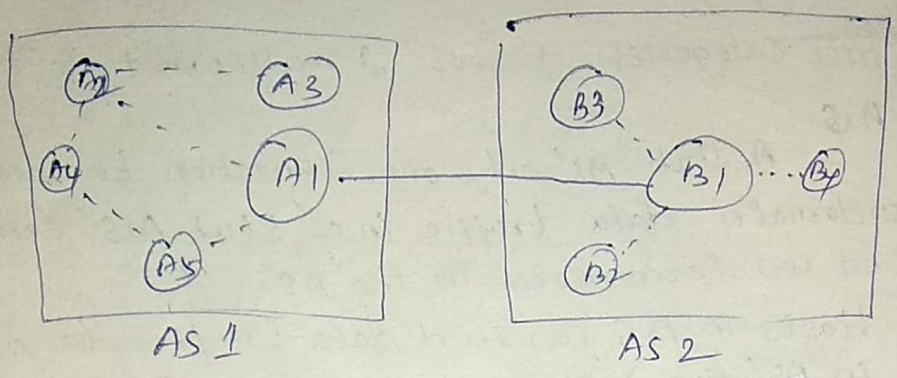
Two types.

BGP : 1. E-BGP 2. I-BGP

E-BGP session is used to exchange information b/w two speaker nodes belonging to two different autonomous S/m (AS).

I-BGP session, used to exchange routing information b/w two routers inside an (AS).

Fig: Internal and External BGP Sessions



— E-BGP Session ..... I-BGP sessions

MULTICAST ROUTING PROTOCOLS:

Unicasting: Unicast Communication is one source and one destination. The relationship b/w source and destination is one-to-one.

Type of communication both source and destination address, IP datagram unicast addresses assigned to the hosts (or host interfaces, to be more exact.

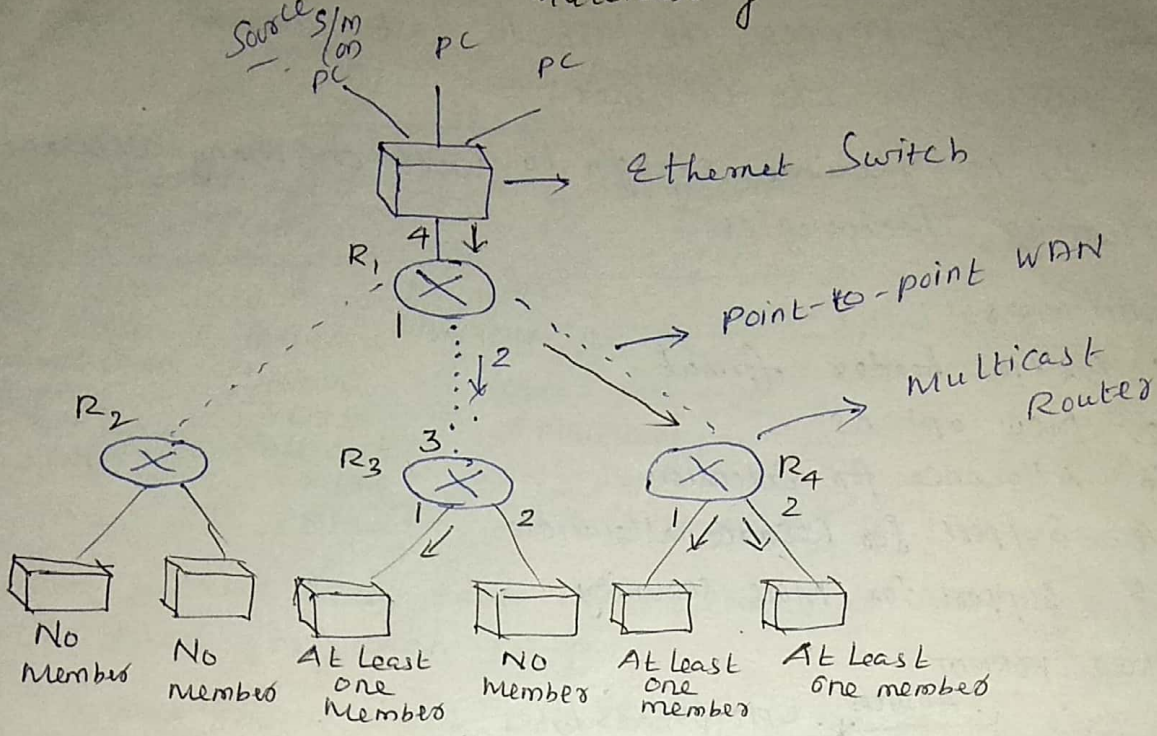
MULTICASTING: one source and a group of destinations, one-to-many.

In this communication, the source address is a unicast address, but destination address is a group address.

A group of one or more destination networks in which at least one member of group is interested in receiving the multicast datagram.

The group address defines the members of the group. A multicast router to send out copies of the same datagram through more than one interface.

Fig: Multicasting



Router R_1 needs to send out the datagram through interfaces 2 and 3. similarly, R_4 needs to send out the datagram through both its interfaces. R_3 there is no member belonging to this group in area reached by interface 2, it only sends out the datagram through interface 1.

Emulation of Multicasting with Unicasting:

1. Multicasting is more efficient than multiple unicasting.
2. Multiple Unicasting, the packets are created by source with a relative delay b/w packets.

MULTICAST APPLICATIONS:

1. Access to Distributed Databases.
2. Information Dissemination.
3. Teleconferencing
4. Distance Learning

BROADCASTING: It means one-to-all communication, a host sends a packet to all hosts in an internet.

Broadcasting is not provided at internet level because, it may create a huge volume of traffic and use a huge amount of Bandwidth.

IPv6:

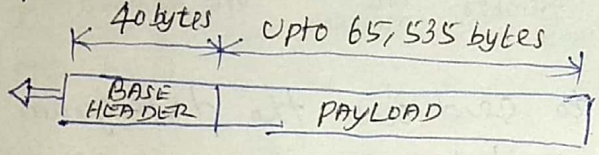
IPv4 provides the host to host Communication b/w systems in the internet.

It is flexible enough to work on many different Networking Technologies.

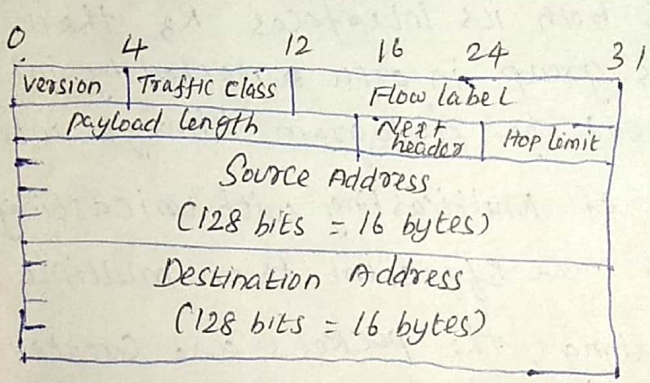
ADVANTAGES:

1. Better header format
2. New options
3. Allowance for Extension
4. Support for Resource allocation
5. Support for More security

PACKET FORMAT:



(a) IPv6 packet



(b) Base Header

Traffic Class: 8 bit field is used to distinguish different payloads with different delivery requirements.

Flow Label: 20 bit field is designed to provide special handling for particular flow of data.

Payload Length: 2 byte payload length field defines the length of the IP datagram excluding the header.

IPv4 defines header length and Total length.

IPv6 " fixed 40 bytes, only length of payload need to defined.

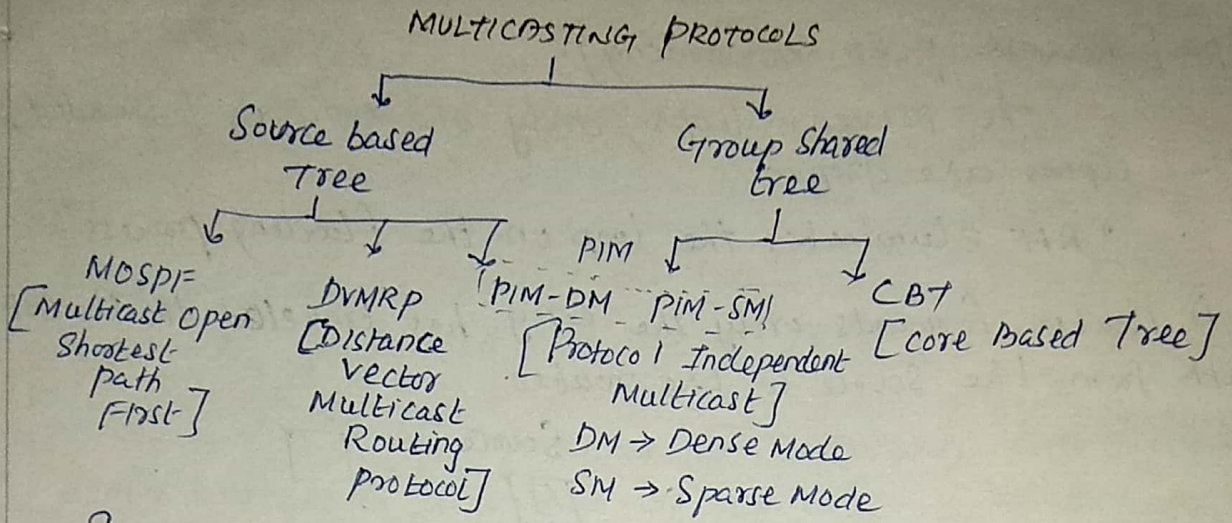
Next header: 8-bit field defining 1st extension header (present) (or) type of data follows the base header in the datagram.

Hop Limit: 8-bit hop limited field same as IPv4.

Source and destination addresses: 16 byte (128 bit) & 16 byte (128 bits)

Payload: Compared to IPv4, payload field in IPv6 a different format

ROUTING PROTOCOLS:



Source Based tree, each router needs to have one shortest path tree for each group.

Group Shared tree, only the core router, which has a shortest path tree for each group, is involved in multicasting.

MOSPF: Extension of OSPF protocol uses multicast link state routing to create source-based trees.

Multicast Distance vector (D.

protocol requires a new link state update packet to associate the unicast address of a host with the group address (or) addresses the host is sponsoring. This packet is called the Group-membership LSA.

MOSPF is a data driven protocol.

MOSPF router a datagram with a given source and group address, the router constructs the Dijkstra shortest path tree.

DVMRP [Multicast-Distance Vector]

Multicast routing does not allow a router to send its routing table to its neighbors.

Router never actually makes a routing table.

Four Decision-Making strategies.

1) Flooding: broadcasts packets, but creates loops in the S/m's.

A router receives a packet and without even at destination group address, sends it out from every interface

except the one from which it was received.

RPF [Reverse path forwarding]:

To prevent loops, only one copy is forwarded, other copies are dropped.

"RPF eliminates the loop in the flooding process"

A Router forwards only the copy has traveled the shortest path from the source to the router.

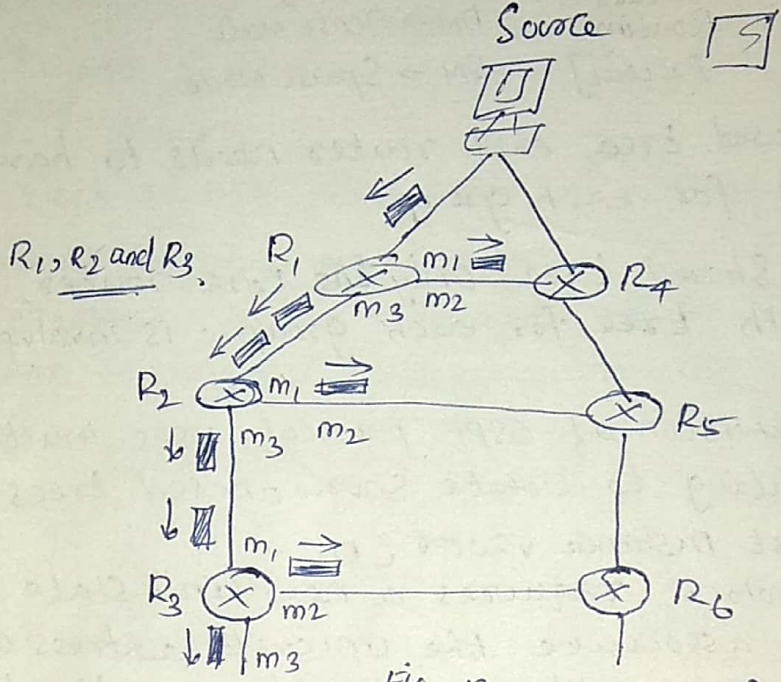


Fig. Reverse path forwarding (RPF)

RPB [Reverse path Broadcasting]: RPF guarantees that each N/w receives a copy of the multicast packet without formation of loops.

"RPB creates a shortest path broadcast tree from the source to each destination."

It guarantees that each destination receives one and only one copy of the packet.

RPM [Reverse path Multicasting]:

RPB doesnot multicast the packet, it broadcasts it. not efficient. To increase efficiency

Multicast packet must reach only those networks that active members for particular group is called RPM

To convert broadcasting to multicasting,

DVMRP: [Distance vector Multicast Routing protocol]

Implementation of multicast distance vector routing. Source-based routing protocol, based on RIP

CBT [Core-Based Tree] protocol is a group-shared protocol uses a Core as root of the tree.

'AS' is divided into regions. 1. Core [Center router (or) rendezvous router]

Formation of the Tree:

After the rendezvous point is selected, every router is informed of unicast address of the selected router.

Each router then sends a unicast join message to wants to join the group.

Message passes through all routers are located b/w the sender and rendezvous router.

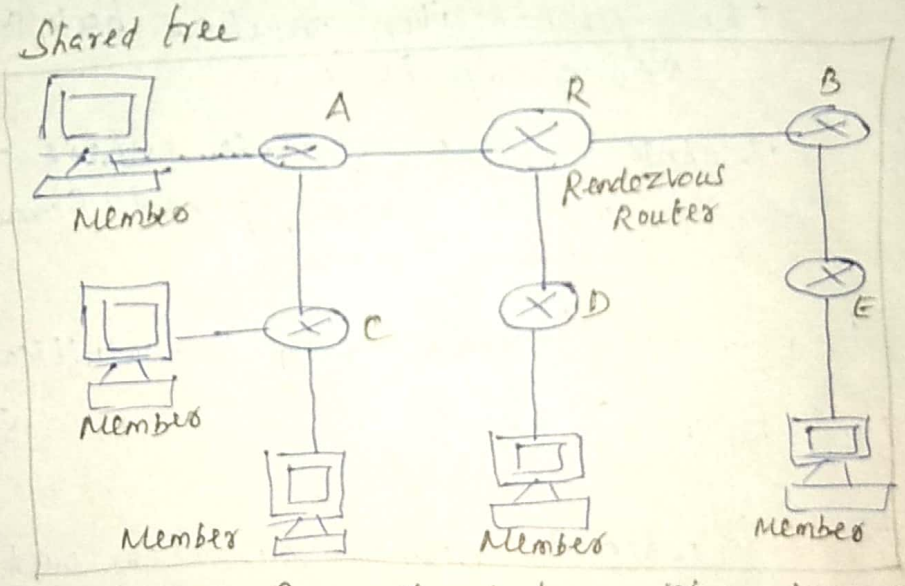


Fig: Group-shared tree with rendezvous routers

PIM. [Protocol Independent Multicast]

Common protocol needs a unicast routing protocol for its operation; Unicast protocol either a distance-vector protocol (or) a link-state protocol.

PIM needs to forwarding table of a unicast routing protocol to find the next router in a path to destination.

Two different modes are (1) Dense (2) Sparse

Dense → Number of active members of a group in the internet is large.
The probability router has a member in a group is high.

Sparse → only a few routers in the internet active members in the group.
The probability router has a member of group is low.

Ex: Technical Teleconference where a number of members are Spread Somewhere in the internet.

(i) PIM-DM [Protocol Independent Multicast - Dense Mode]
(ii) PIM-SM [" " " - Sparse Mode]

(1) PIM-DM: when the number of routers with attached members is large relative to number of routers in the internet is called PIM-DM

The protocol uses a source-based tree approach & similar to DVMRP but simpler.

TWO STEPS:

1. A router has received a multicast packet from Source 'S' destined for Group 'G' first uses the RPF Strategy to avoid receiving a duplicate of packet.
2. If the packet is arrived from next router in reverse direction, the RPF router forwards the packet from all its interfaces except one from which the packet has arrived.