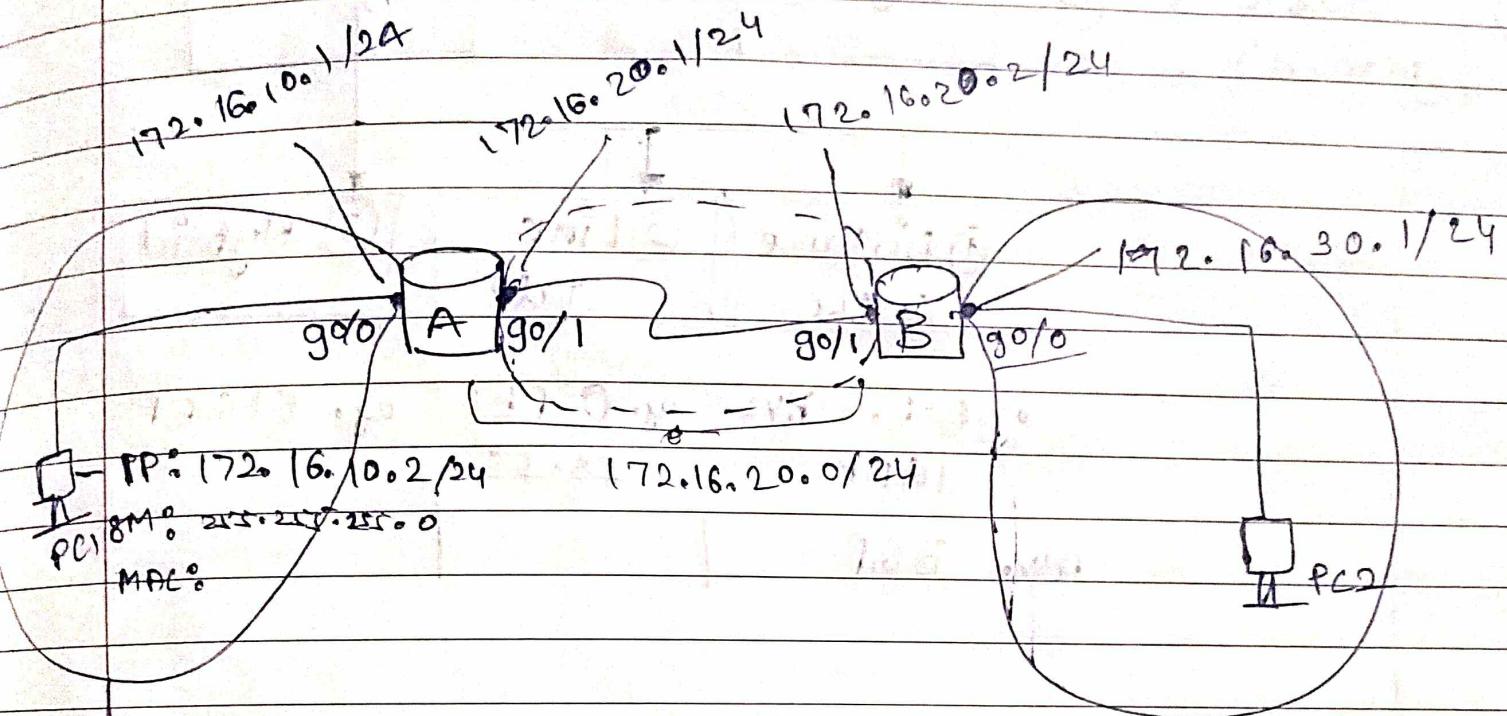


# ROUTING

- Configuring path for packets.
- Programming / adding required network (subnetwork) IP address.



LAN1: 172.16.10.0/24      LAN2: 172.16.30.0/24

'A' Routing Table

C 172.16.10.0/24 → g0/0  
 C 172.16.20.0/24 → g0/1

'B' Routing Table

172.16.30.0/24 → g0/0  
 172.16.20.0/24 → g0/1

connected.  
 S ↓ add  
 static

172.16.30.0/24 → 172.16.20.2/24

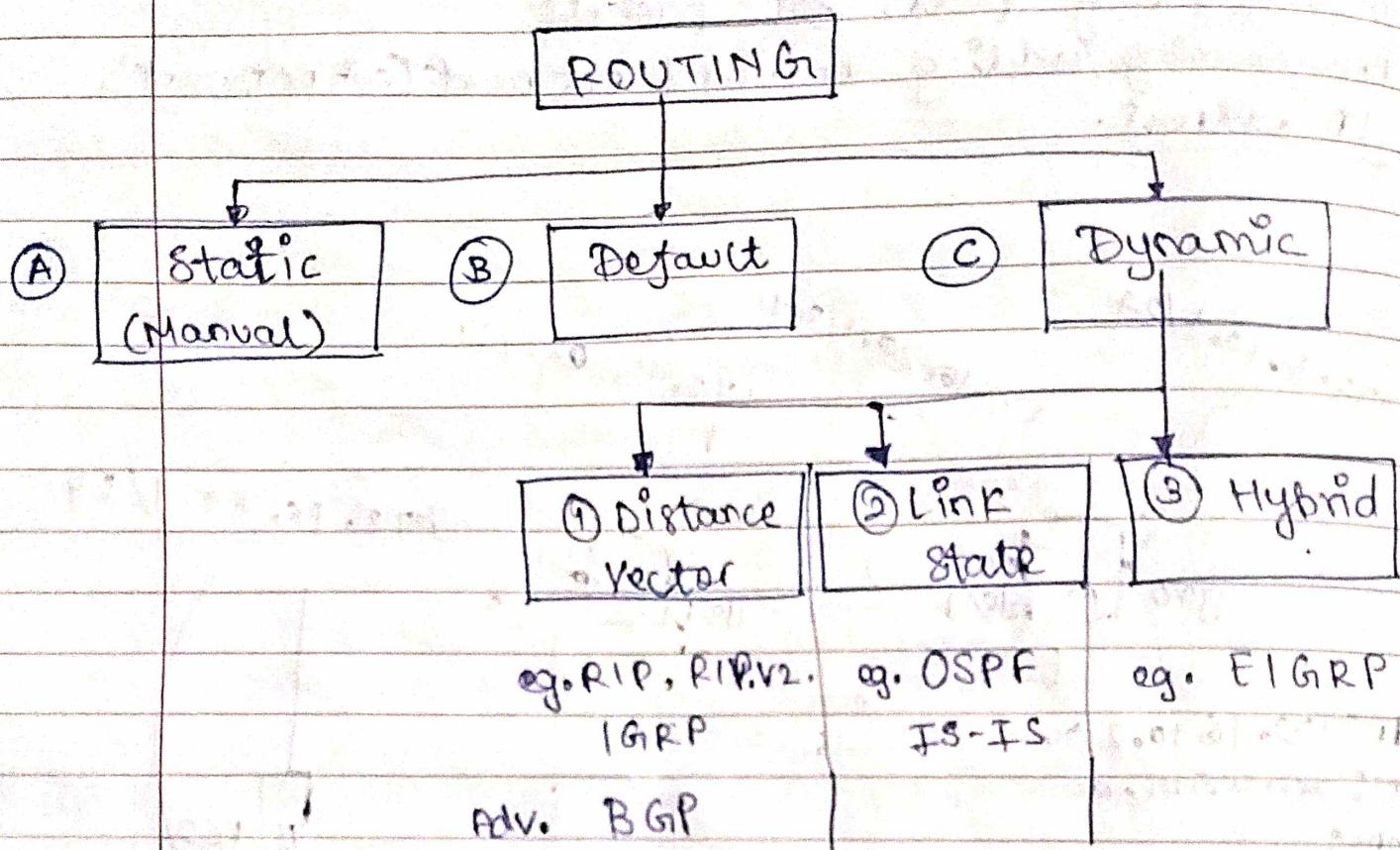
S 172.16.10.0/24 → 172.16.20.1

Next hop address

hop ↔ Router add.

Next hop add

## • Routing Types



- RIP : Routing Information protocol
- (outdated) • IGRP : Interior Gateway Routing Protocol
- EIGRP : External Interior Gateway Routing protocol
- IS-IS : Intermediate System To Intermediate System
- OSPF : Open shortest path first
- \* • BGP : Border Gateway Protocol

# ① STATIC Routing

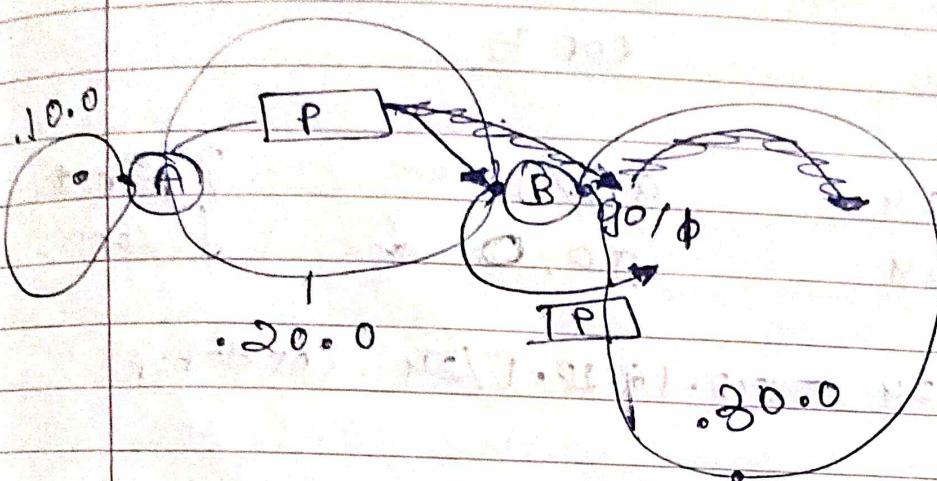
(configuring)

A(config) # ip route [destinationip] [S.M] [Next-hop]

e.g. A(config) # ip route 172.16.30.0 255.255.255.0 172.16.20.2

for B:

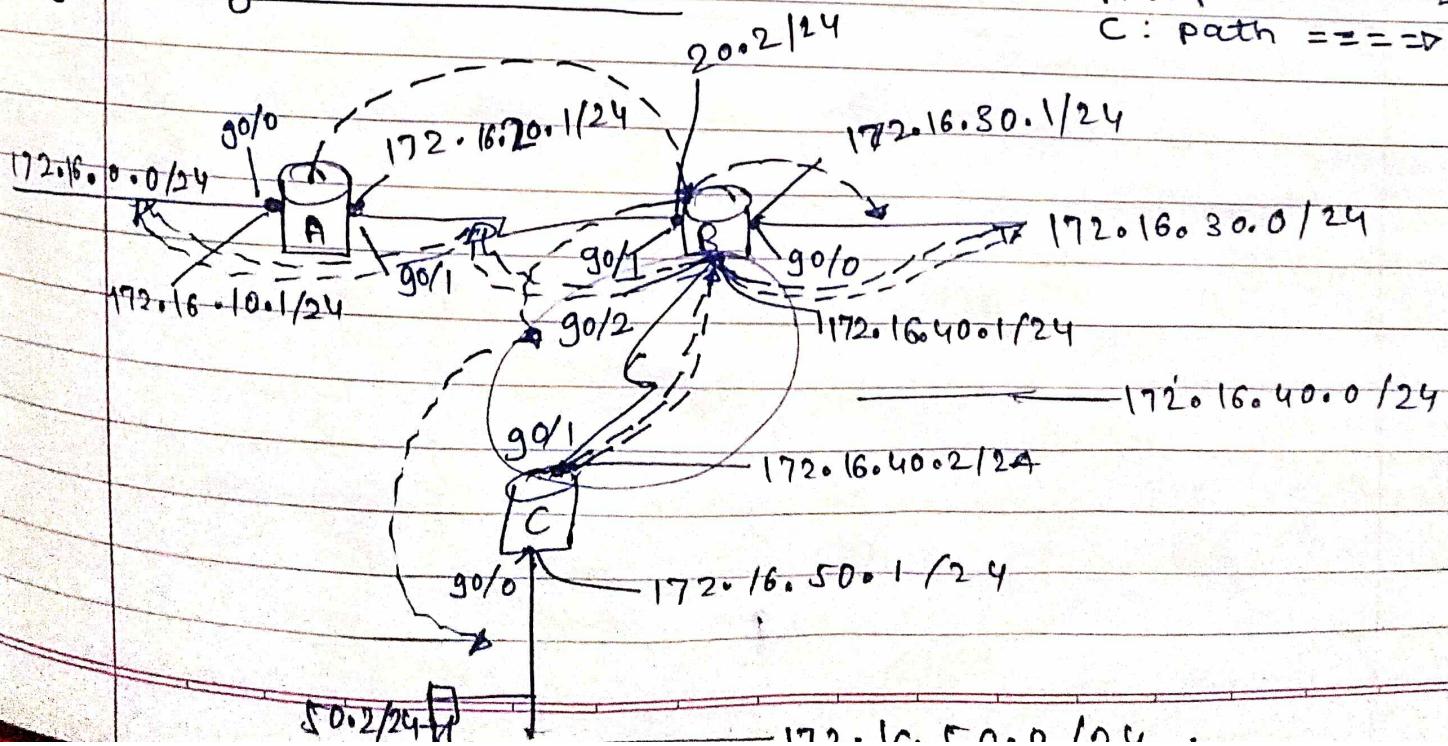
B(config) # ip route 172.16.10.0 255.255.255.0 172.16.20.1  
 dest. ip address S.M  
 Next-hop address



<sup>1st</sup>  
 // Request timeout  $\Rightarrow$  ARP : IP to MAC add resolution

e.g: config static routes.

A  $\Rightarrow$  Path --->  
 C: path ==>



Next hop → immediate add (not next hop)

### • Routing 'A' Table

C 172.16.10.1/24 → g0/0

C 172.16.20.1/24 → g0/1

30 (B) S 172.16.30.0/24 → 172.16.20.2/24.

Next hop!

A0 (C) S 172.16.40.0/24 → 172.16.20.2/24.

150 (S) S 172.16.50.0/24 → 172.16.20.2/24.

### • Routing 'B' Table

FOR B

172.16.20.0/24 → g0/1 ← ? direct conn.

172.16.30.0/24 → g0/0 ↓

(A) S 172.16.10.0/24 → 172.16.20.1/24. (next-hop)

Alternative.

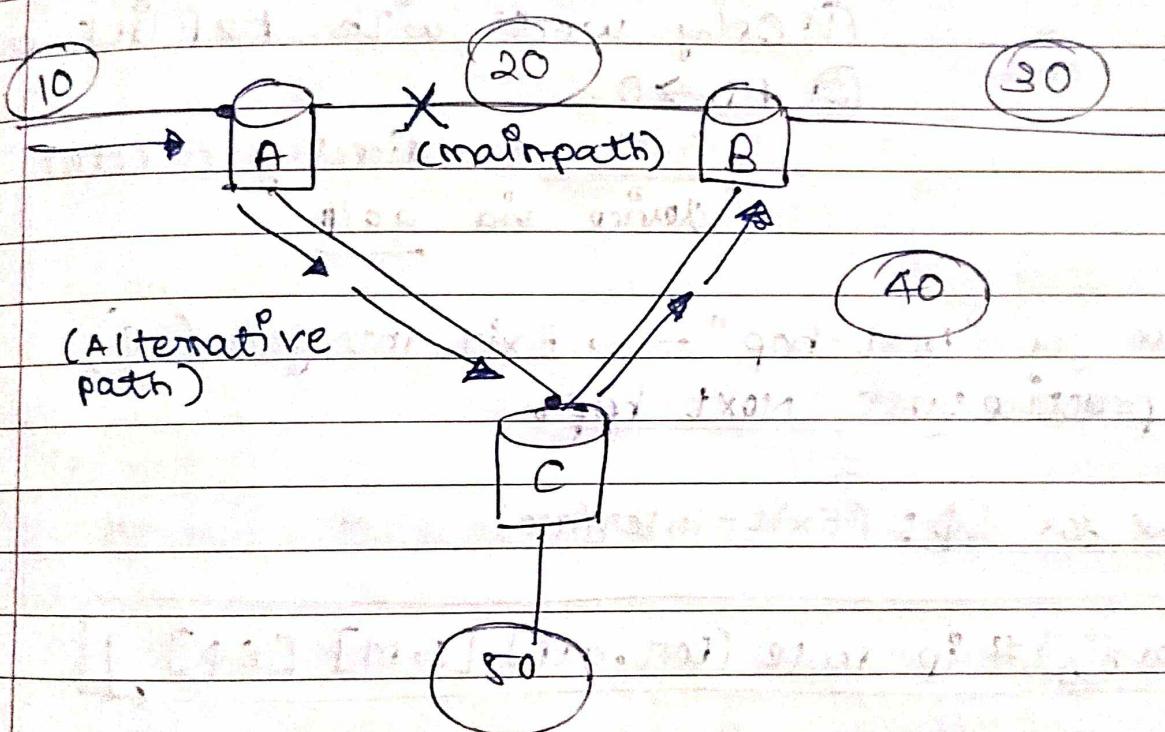
## \* Adding REDUNDANCY, Extra path (link)

ip route (dest-Network) (S.M) (Next-hop) [AD] [Permanent]

- AD - Administrative Distance 1 - 255

↳ Default is 1 at min.

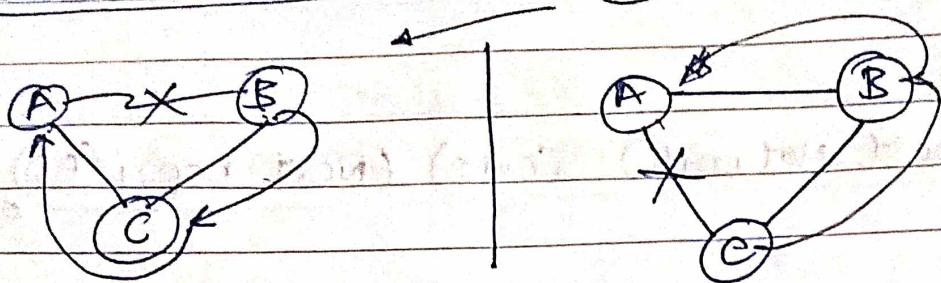
- Permanent: permanent-main route (theory).



- When link from  $A \rightarrow B$  fails, router  $A$  will take link  $A \rightarrow C$ .  
Then  $A$  will access networks 40, 30, 50 via  $C$ .

- When route  $A \rightarrow B$  is up again, the router  $A$  will take route  $A \rightarrow B$  with  $AD = 1$ !

1/ Same scenario for (B), (C).



• P2P Link : Point to Point Link.

• Exit-Interface :  $S\phi$  (serial)  
↳ //Drawbacks

- ① Only works with P2P Link only
- ② AD  $\Rightarrow$  0.

↳ Similar to directly connected device via go/p

• Option for "Next-hop"  $\rightarrow$  Exit Interface ( $S\phi$ )  
✓ Best practice: use Next-hop.

Syntax for  $S\phi$  : (Exit-Interface)

```
A(config)# ip route [dest.add] [s.M] [Sφ]
```

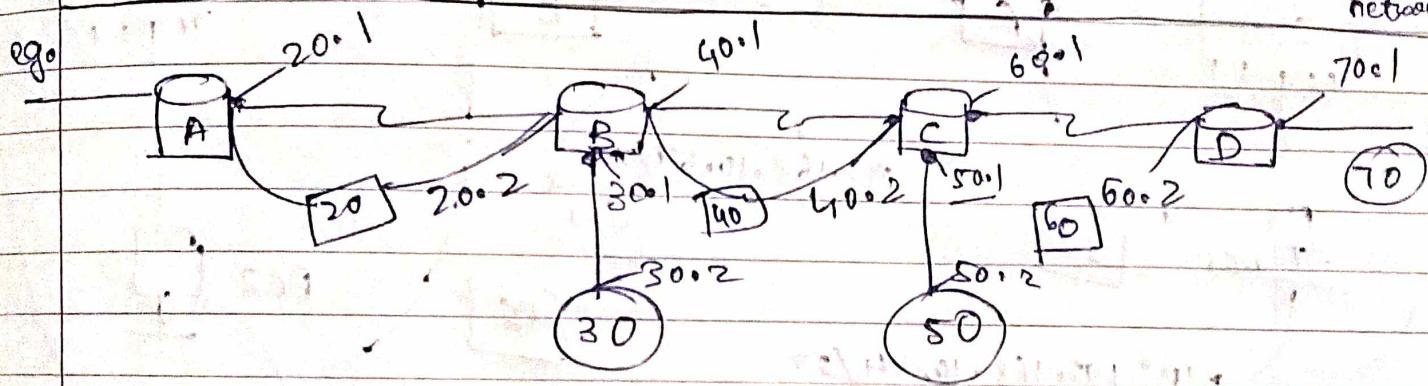
// for all directly connected networks  
AD (administrative distance) is considered 0.

## (B) Default (Routing)

(next-hop)

```
A(config)# ip route 0.0.0.0 0.0.0.0 172.16.20.2
```

- config default route for router
- Used with end-point (stub) router
- network besides "Stub" router is known as "stub" network.
- Default route is accessed ~~at~~ last;  
(i.e., if specific routes are not available).
- \*- Drawback: If network (not available) the packet will be transferred to [next-hop] next router/ network



## Def for A:

```
A(config)# ip route 0.0.0.0 0.0.0.0 172.16.20.2
```

# S 0.0.0.0 → 172.16.20.2

C 172.16.20.0 → 90/1

C 172.16.10.0 → 90/0.

## Def D:

# S 0.0.0.0 → 172.16.60.1

C 172.16.60.0 → 90/1

C → 70.0 → 90/0

## Def B:

# S 0.0.0.0 → 172.16.40.2

C 172.16.20.1 → 90/1

C 172.16.40.1 → 90/0

Default for C :

\* S 0.0.0.0 → 172.16.40.1

C 172.16.40.1 → 90/1

C 172.16.60.2 → 90/0

C 172.16.50.2 → 90/2

Also -

\* Example 2 :

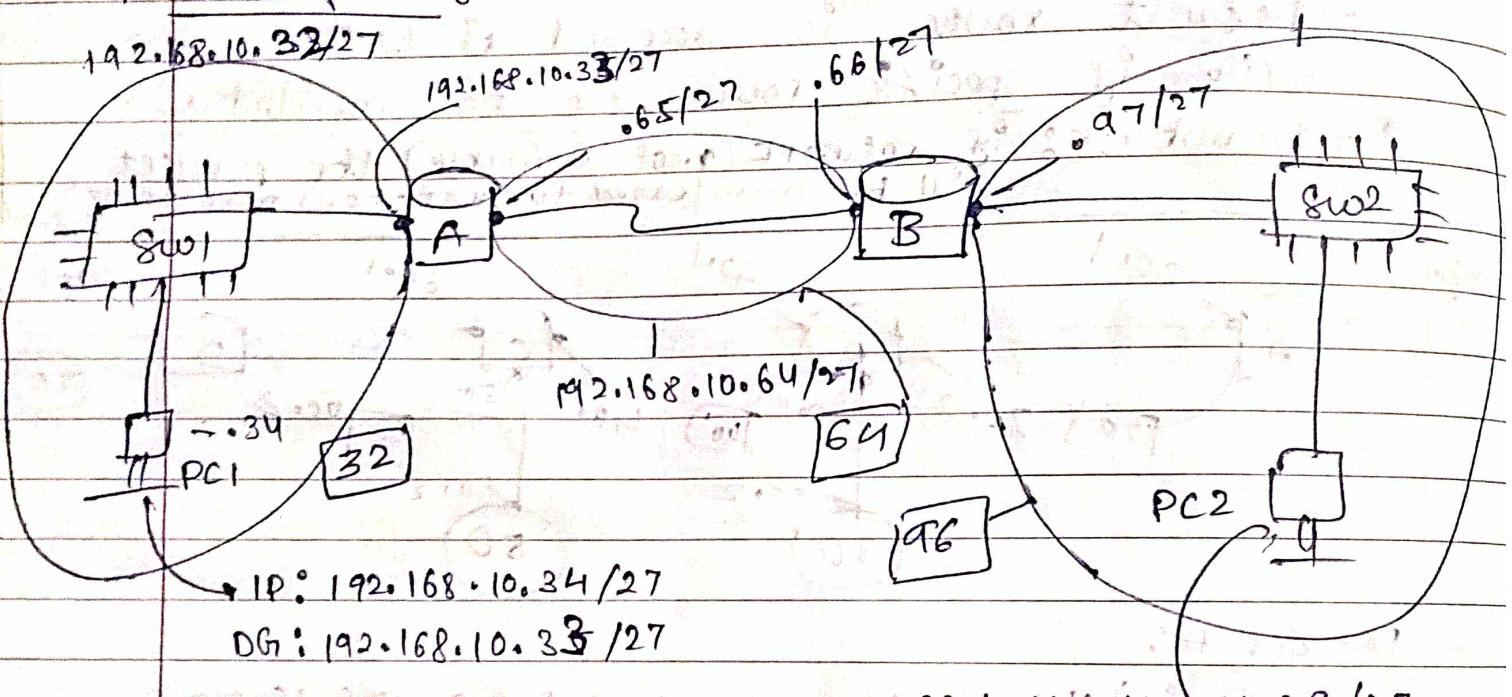
192.168.10.32/27

192.168.10.33/27

65/27

66/27

67/27



IP : 192.168.10.34/27

DG : 192.168.10.33/27

IP : 192.168.10.98/27

DG : 192.168.10.97/27

SM: w. 01.0.11100000  
224

→ Sub Networks ①

1  
64

3  
96

4  
128

5  
160

6  
192

7  
224

Max. g.

RIR — Transfers routing tables bet' routers.

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## DYNAMIC Routing

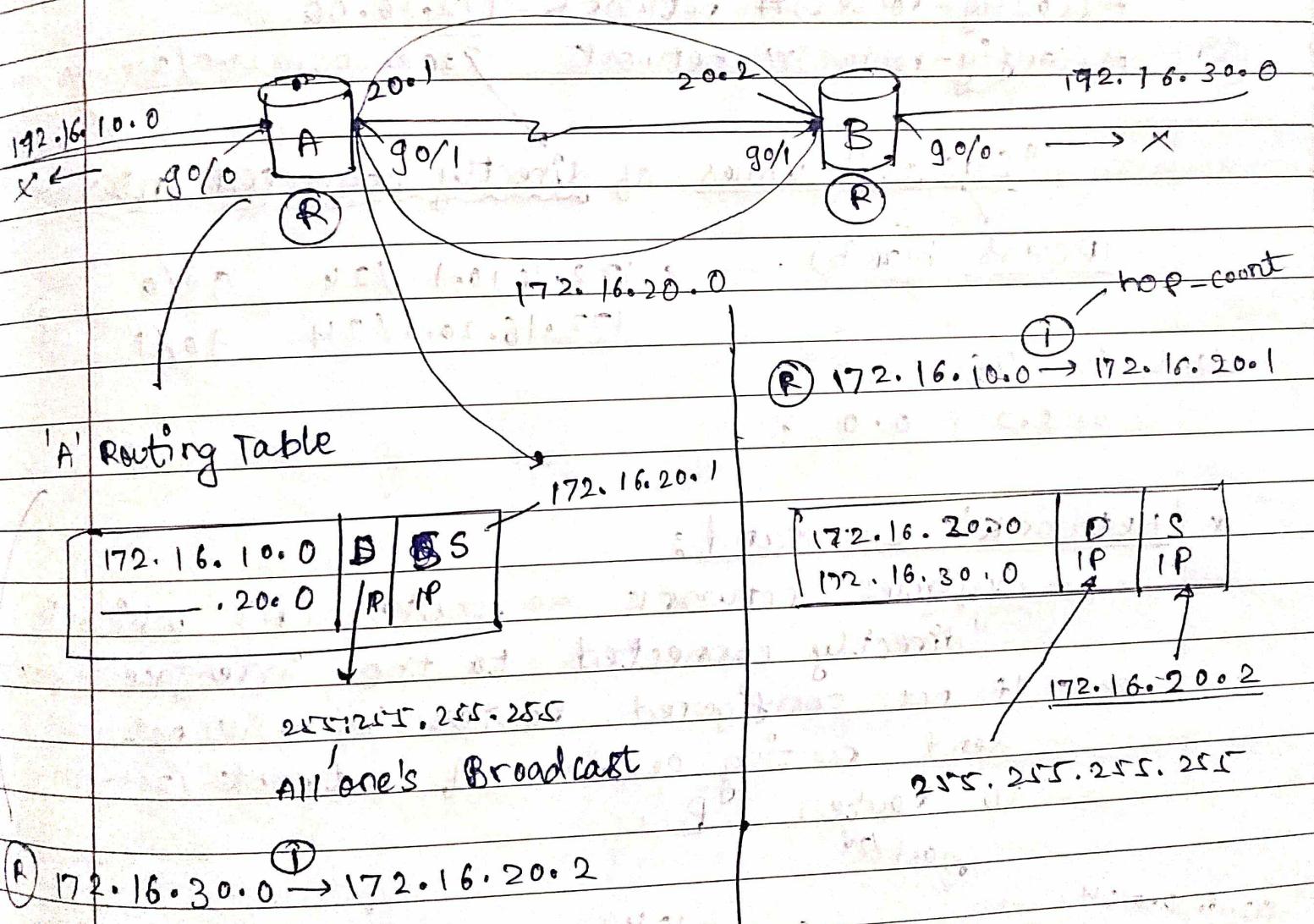
### ① Distance Vector

- RIP, RIP v.2, IGRP, BGP.

#### RIP (Routing Information Protocol)

- Update Timer 30 secs
- Doesn't send 'S.M' information.
- \* Works only with 'FLSM'

SM X



'A' Routing Table

172.16.10.0	B	S
172.16.20.0	R	R
255.255.255.255		

172.16.20.0	D	S
172.16.30.0	I	P
255.255.255.255		

All one's Broadcast

① 172.16.30.0 → 172.16.20.2

② RIP calculates distance based on "number of hops"  
Every router (A, B) has its own hop count  
for the accessible networks.

S.M. should be 200g!

- at every 30 secs, ~~RIP~~ sends updates at every interface

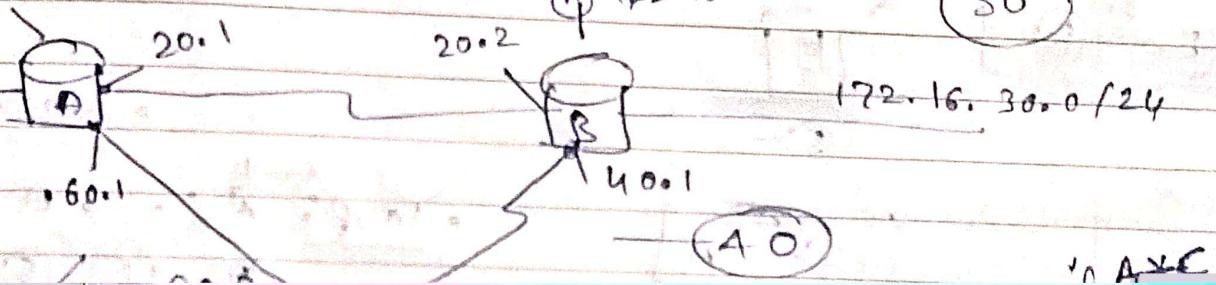
\* To avoid 30 sec update at a interface : by RIP.

A(config-router) # passive-interface go/0 .

- This command won't SEND the updates but can receive updates at the interface.

Q3) 3 router A, B, C .

(R) 172.16.30.0 ① → 20  
 (R) 172.16.10.0 ① → 172.16.20.1  
 (R) 172.16.50.0 ① → 172.16.40.2



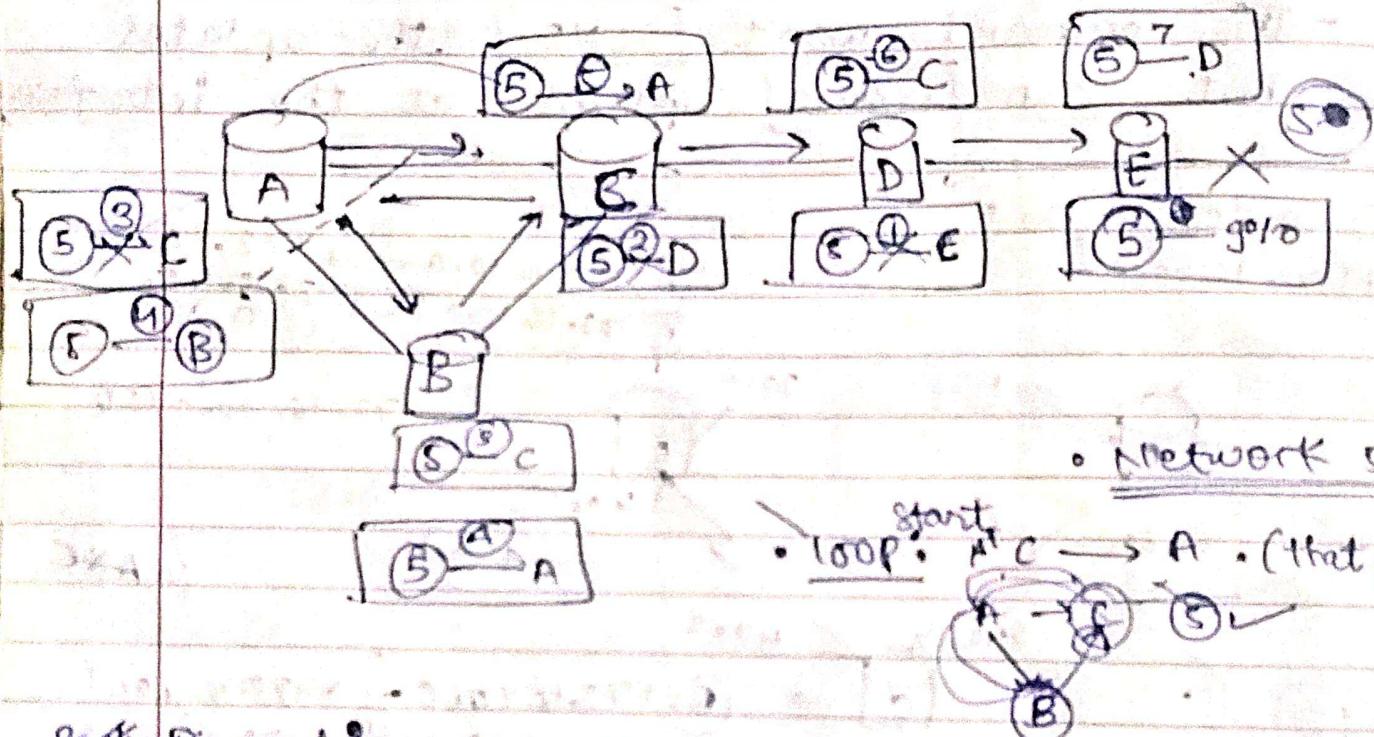
## Drawbacks of RIP

- ① RIP just chooses "hop count" & not bandwidth  
 ② Routing Loops.

pin-hole congestion  
 not handled by RIP

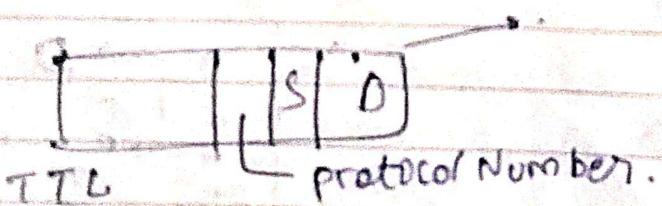
## Routing Loops

30 sec.



## Remedies

### (I) TTL value. Hop count (15)



(Time to leave)

- (II) Split Horizon (Hold down timer = 180)  
 - don't send the updates back from the interface on which updates had received.
- (III) \* - will be applicable only for 180 secs.  
 (Hold off timer)

(send)

Converged updates immediately to all routers regarding network status (down).

## Triggered Update

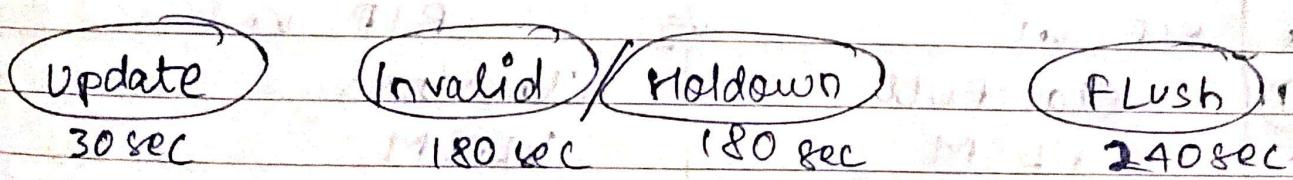
### \* Solutions / Remedies for "Routing Loops"

- ① Hop Count (15)
- ② Split horizon
- ③ Hold down timer
- ④ Triggered Update.

### \* Root Poisoning :

- Routers way of telling that the "network is down"  
 (i.e., the network is can be accessed with '16 Hops' but ~~is~~ with RIP - only 15 hops are allowed).

### \* Timers in RIP :

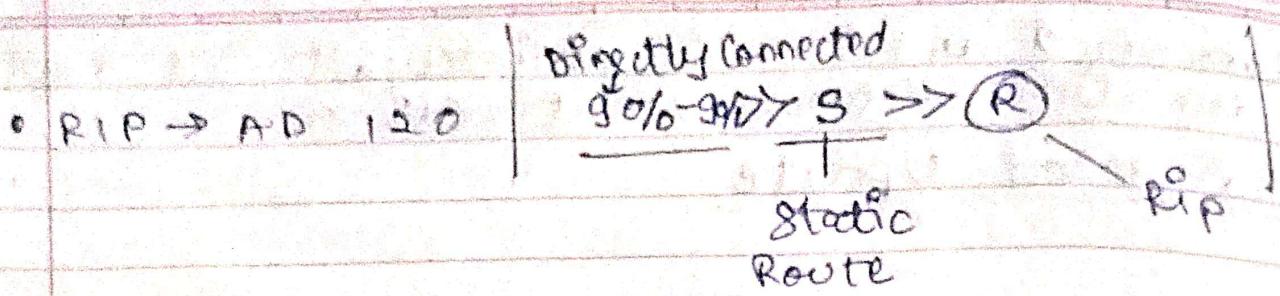


Invalid → Link ~~X~~ is down.

Holdown → Link is on, but

notified that (E) network is down.

entries are deleted fully.



### \* Priority

Routing Process	A.D
Connected (C)	0
static (S)	1
eBGP	20
EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
Ex-EIGRP	170
iBGP	200
Unknown	255

- "Routing process with lowest AD will be chosen".

Time

RIP v1

VS

RIP v2

(backward comp)

①

Classfull

②

FLSM

③

Doesn't send S.M

④

Dest. IP add is

255.255.255.255

⑤

All 3's broadcast

No Authentication

Classless

VLSM

Sends Subnet Mask (S.M)

Dest. IP add is

224.0.0.9

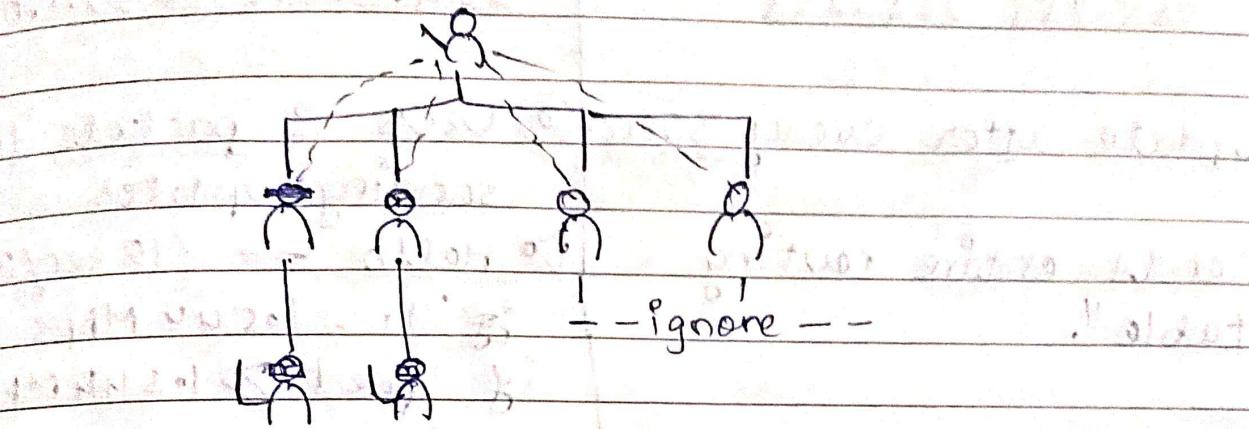
• Multi-cast

Authentication ✓

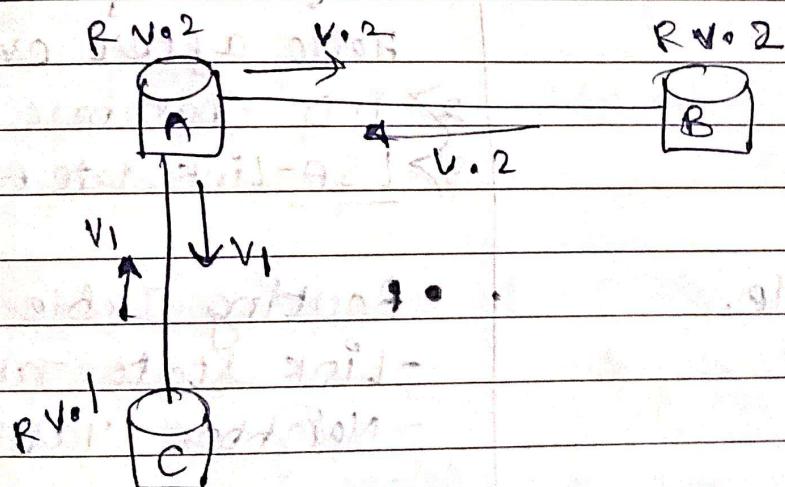
Intermediate devices won't process the packet by multicast add - 224.0.0.9 reserved for ripv2

Devices which understand 'multicast', only those process packets sent by router else devices will discard the 'packets'.

(eg.-Analogy) All people wearing 'ipers' listen to me. Raise your hand



RIP v.2 Routers are backward compatible.



\* Configuring RIP v.2 on routers. (3).

① A(config)# ~~rip~~ router rip ↴

② A(config-router)# network 172.16.0.0 ↴

③ A(config-router)# version 2 ↴

## \* Difference b/w Distance Vector & Link State

### Distance Vector (RIP) v.1

- ① All 1's Brd add  
255.255.255.255
- ② Update after every 30sec.
- ③ "Sends entire routing table".

### Link State (OSPF)

- ④ 2 Multicast add.  
224.0.0.5 + 224.0.0.6
- ⑤ Uses 3 packets for sending updates (30 min)
  - 1) Hello — (10 sec / 30 sec)
  - if  $T_1 = 1.544 \text{ Mbps}$   
if speed  $\geq 1.544 \text{ Mbps} (T_1)$
  - Hello after 30 secs
  - else
  - if Speed  $< T_1$   
Hello after every 10 secs
- 2) DD - Database Description
- 3) LSA - Link State Advt packet

### ⑥ Routing Table.

- Routing Table
- Link State Table (A-B-C-D)
- Neighbor Table

### ⑦ Routing Loops

No Loops.

### ⑧ Supports only FLSM

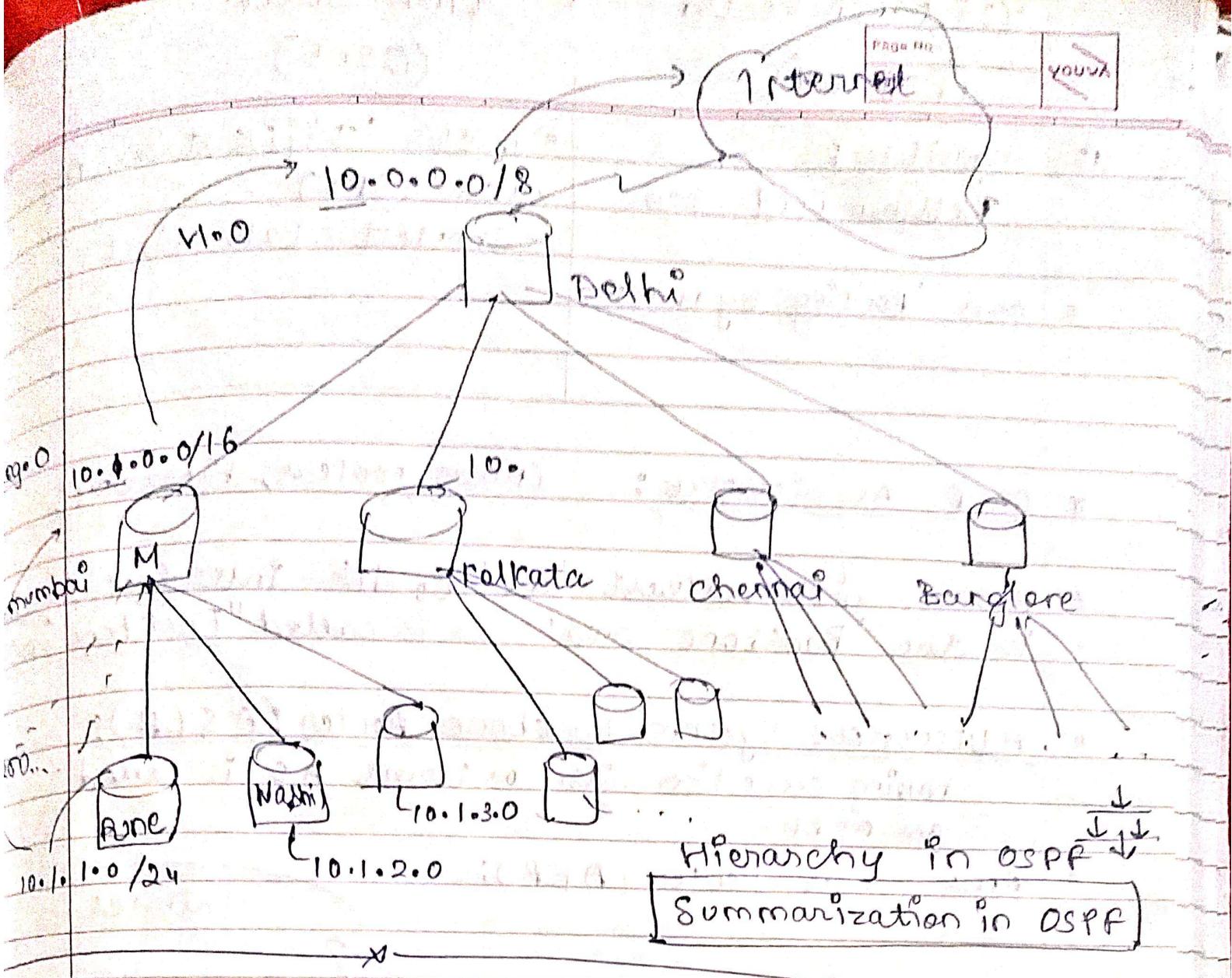
- VLSM
- Summarization
- Hierarchical Addressing

### ⑨ Bandwidth Consuming Protocol.

- Consumes more Memory & Processing power.

eg. Entry WL - Routers

eg. Medium Level - Routers



### RIP v0

- ⑧ Calculates decision based on "Hops".
- Cost  $\rightarrow$  less accurate
- ⑨ Simple configuration
- ⑩ Max. hops = 15
- ⑪ Deployed in "small" networks.

### OSPF

Calculates decision based on "bandwidth".

$\text{Cost} = 10^8 / \text{Bandwidth}$ .

- More accurate cost calc.

Complex configuration

- $2.55 \text{ Hops per area} \times 2^{32} \text{ Area} \approx \text{Unlimited Hops}$
- Deployed in "Medium-Large" networks.

## (Distance Vector) (RIP v.1)

⑫ Algorithm:  
Bellman-Ford Algo.

- AKA 'Routing by rumors'

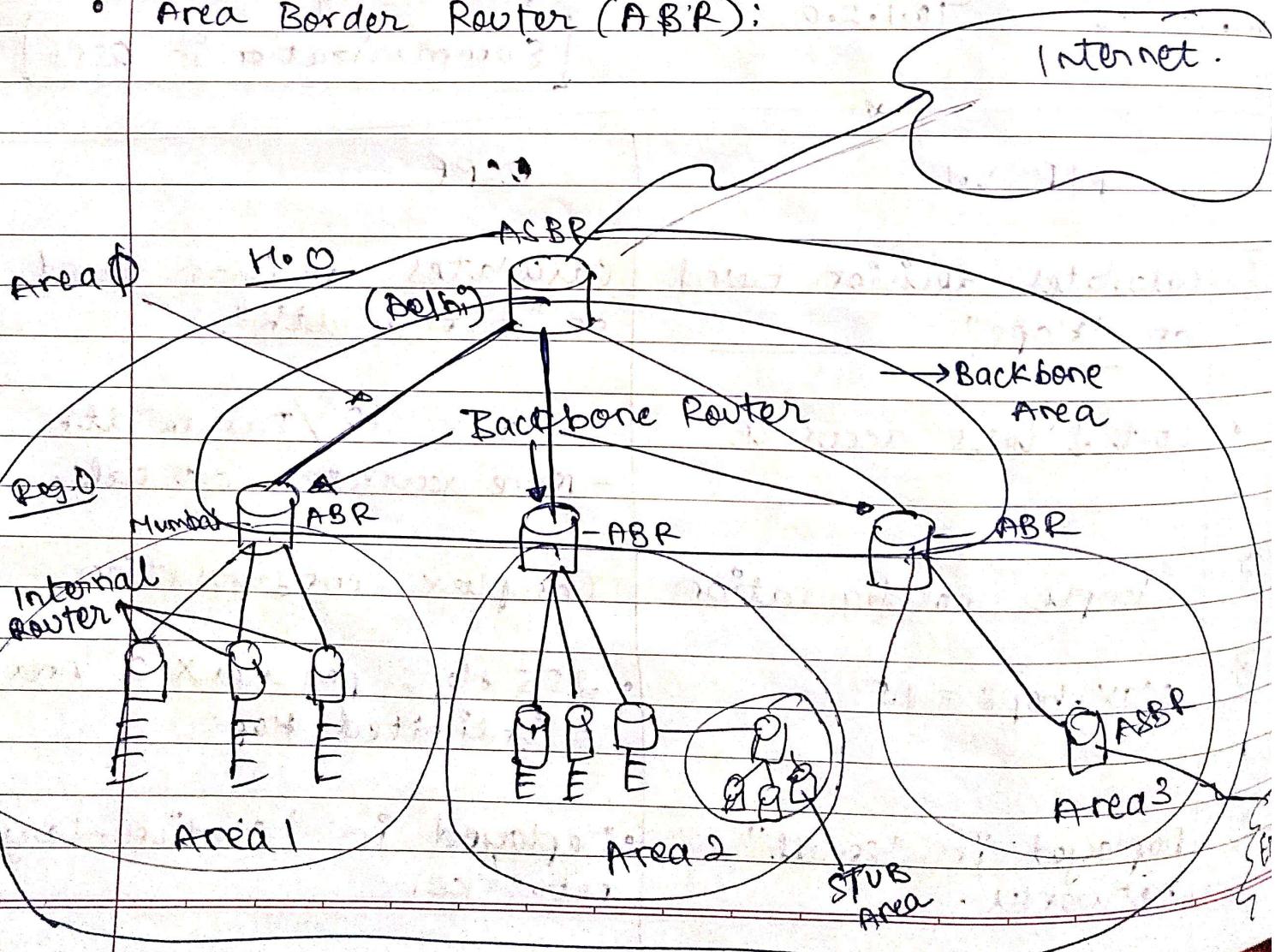
## Link State

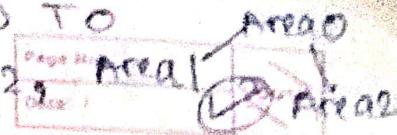
### (OSPF)

- Uses 'Dijkstra's algo'
- AKA (SPF)
- shortest path first.

## \* OSPF Architecture: (Areas, routers, hierarchy)

- Routers with 'at least one' of its interface (to)
- In the 'Backbone Area' → is called "Backbone Router"
- Autonomous System Backbone Router (ASBR):
  - having connection with external AS's is called as ASBR.
- Area Border Router (ABR):



\*\* EVERY AREA MUST BE CONNECTED TO BACKBONE AREA. (Area1  $\rightarrow$  Area2) 

Core of network  $\rightarrow$  Area 0 (Backbone area) (Area zero).

Area 0 links  $\rightarrow$  ↑ High speed link : ↑ Load.

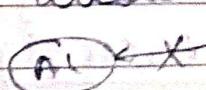
Jio / Airtel : Autonomous Systems. (AS)

Internet : made up of inter-connected autonomous systems.

### \* Types of Areas : (5)

① Backbone Area : Area connected with A.S, Ex.

② Normal Area : Area connected to backbone area.

③ Stub Area : Area which doesn't allow "External routes" 

④ Totally Stub Area : Ex<sup>X</sup>, Inter Area Routes<sup>X</sup> : doesn't share inter-area (A<sub>1</sub>, A<sub>2</sub>) routes.

⑤ NSSA (Not so stubby Area) : Area having link with external autonomous systems.

← e.g. Area 3 → {Ex}

## Config OSPF

- Process Id = significant locally  
-  $1 \rightarrow 65535$
- Wildcard Mask:  $\text{SM} : 255.255.255.255.0$   
 $(1 \rightarrow 0, 0 \rightarrow 1)$   $\text{W.M} : 0.0.0.0.255$ 
  - \*  $\text{S.M} \rightarrow 172.16.10.0/30 \rightarrow 0.0.0.3$   
 $\text{S.M} \rightarrow 172.16.10.1111100$   
 $\text{W.M} \rightarrow 0.0.0.0.0000011$   
 $\therefore \text{W.M} \rightarrow 0.0.0.0.3$

## \* Config of OSPF Routing on router (3)

- ① A(config)# route ospf 10 process id
- ② A(config)# ~~A(config)~~ network 172.16.10.0 0.0.0.255 area 1 network Wildcard area
- ③ A(config-router)# network 172.16.20.0 0.0.0.3 area 1 X X X X

Packets transferred betw neighbor routers in OSPF

Currently.

Router ID : highest of interface. (1P)

Two-way-state : 'Hello' (packet) received with  
Neighbor Id (N.ID) = R.ID .(same)

DD : (Master/slave model)

Slave,



D.D



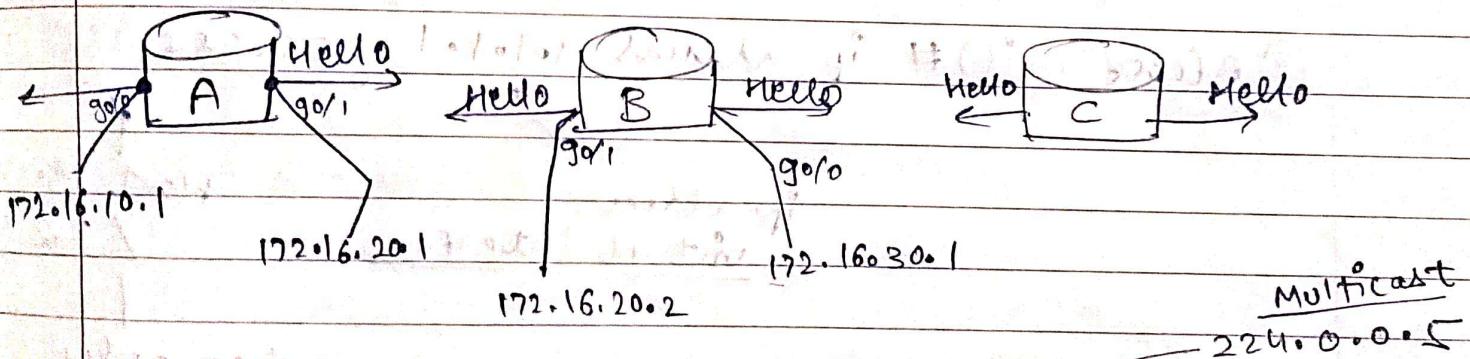
Master,



routing table

LSA packet:

- Change routing table info - if "required"
- after 30 min.
- Entries are changed at each router  
in routing table.



Hello Packet:

R.ID	N.ID	D	SIP
20.1	-----	IP	SIP

A → B

R.ID	N.ID	D	SIP
30.1	20.1	IP	IP

B → A

again

when A receive 'Hello' from B

A:	R.ID	N.ID	D	SIP	20.1	30.1	state
	30.1	20.1	IP	IP			A.R-ID=N.ID

// Hello packets is bet<sup>n</sup> neighbors!

eg. Hello of 'A' won't travel to 'C'.

// Slave → DD → Master )

Master → DD → Slave .

DD - Database  
description  
routing eng

// DD - happens only after 30 mins.  
across routers.

\* Config loop-back interfaces: (3) (Virtual Interface)

① A(config)# int lo  $\emptyset$

② A(config)# no shutdown

③ A(config-if)# ip address 10.10.1.1 255.255.255.255

ip address  
of virtual interface

Host Mask  
1 32

when only

'1' ip is needed

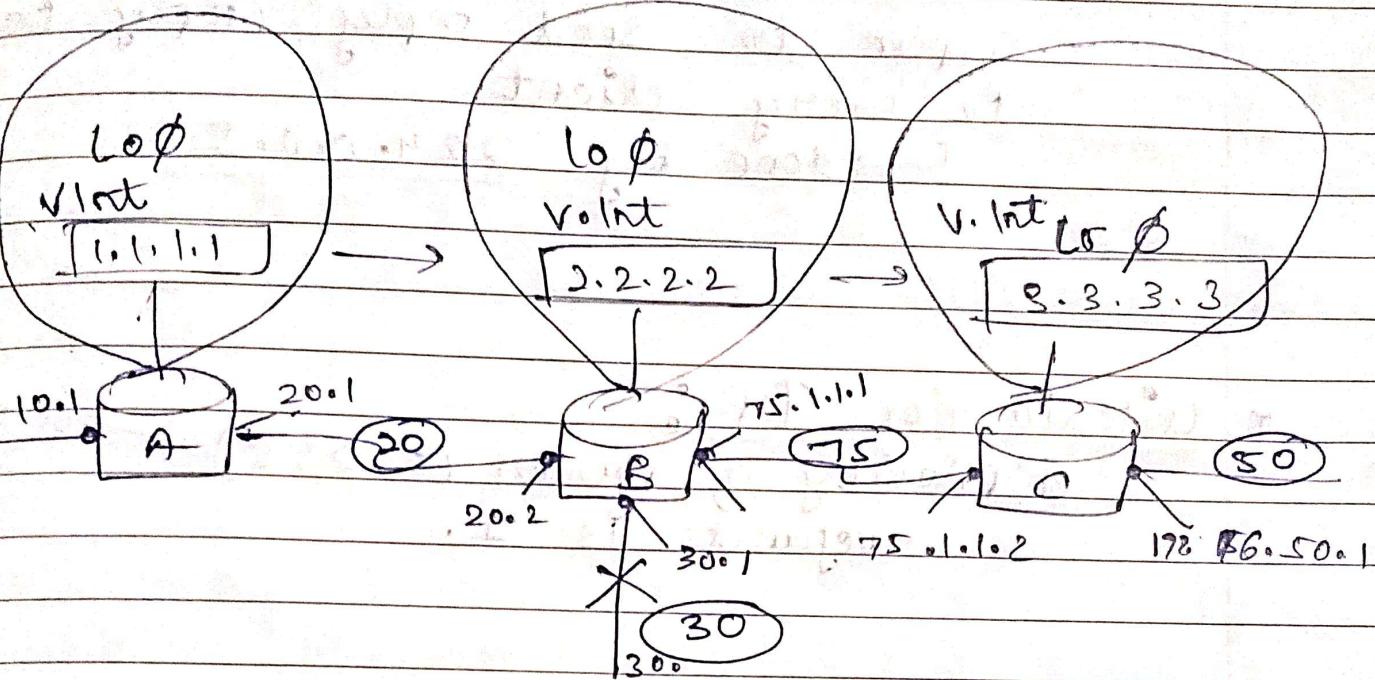
• Why loop-back? - Virtual Interfaces - any IP.

- When int router is down, we can set-up

virtual ip address to the router, to  
router int! avoid connection loss, to ~~the~~ network.

- For "self - testing"

\* Router-ID = Highest of Virtual Interfaces  
 - if not then the highest of physical addresses.



if B's 30.1 X, 30. is down  
 then Router.ID  $\rightarrow$  B = 2.2.2.2.

## // OSPF Summary :

# LSA flow control in OSPF

(Link State Advertisement)

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Date \_\_\_\_\_  
Name \_\_\_\_\_

Controller

- \* DR - Designated Router : (Leader)
- (E) - Any router (Client) receiving LSA
- sends to DR only via 224.
  - Listen to 224.0.0.6 - DR only.
  - Suppose to send reply (reply to LSA) to every client.  
↳ done by 224.0.0.5

## \* Criteria for DR:-

- ① Priority of router (0-255) - set by Admin
- Default is 1.

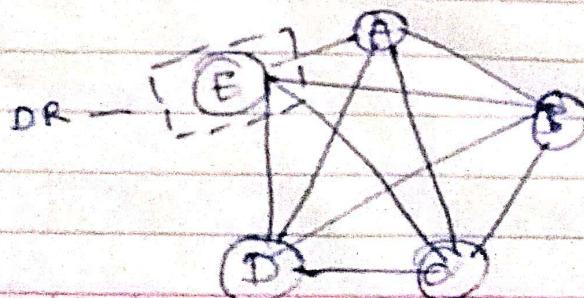
\* DR = Highest of priority  
- If same highest of router.ID

\* BDR = Second highest router with priority  
- If same, highest router.ID

- Back-up DR
- Takes control if DR goes down.  
To ~~add~~ maintain network-integrity.

## \* Why DR?

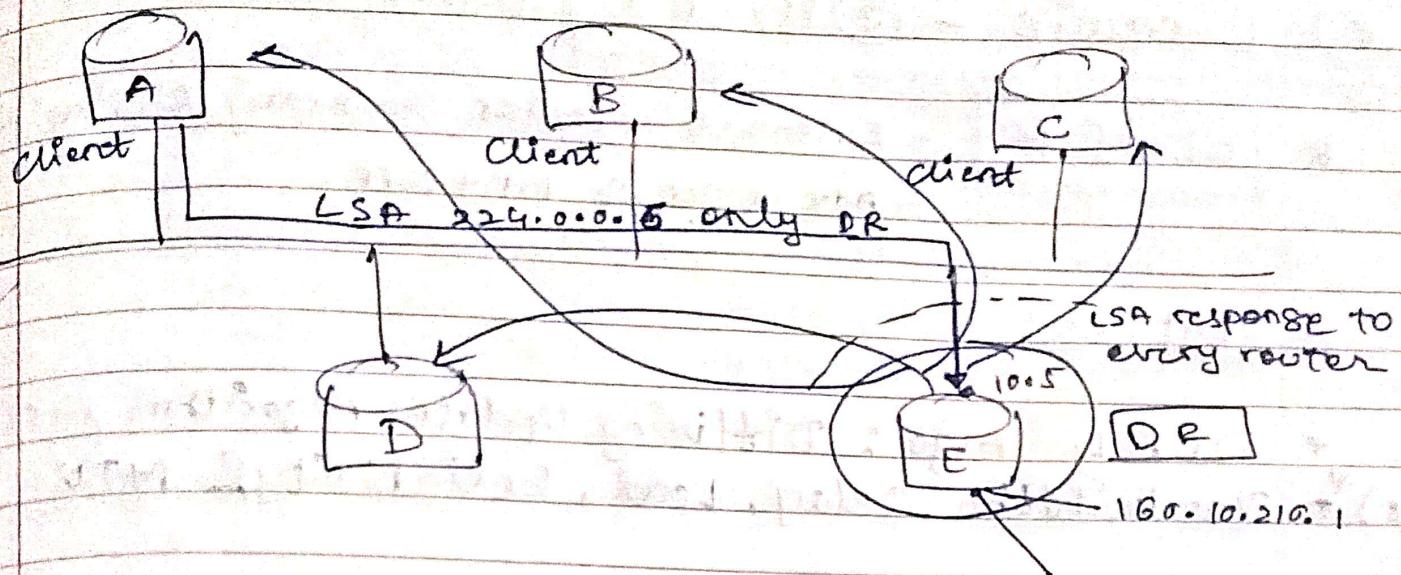
- To avoid flooding of LSA's from every router to each other.



Full Mesh connection.

- LSA - only notifies changes in routing table
- DD - only shares routing tables.
- 30 min → (To maintain reliability)

Page No.:  
Date: *youva*



- Ethernet : BMA (Broadcast Multi-Access) network
- DR only happens with BMA.
- Elections are done for BDR constantly, on every router — locally, net or network.
- (new-DR): → can't enforce elections, until DR & BDR goes down!

#### # Commands for ospf info — ospf monitoring .

- ① show ip ospf database
- ② show ip ospf neighbor
- ③ show ip route

DR, BDR - (new DR) scenario .

BDR	1.1.1.1
BDR	2.2.2.2
DR	210.55.10.1
BDR	200.100.50.1
BDR	3.3.3.3

DR = high R.ID  
BDR = ongoing elec.

at. case

DR → 2.2.2.2  
BDR → 1.1.1.1

until 2.2.2.2 goes down cannot be DR. & new DR → 210.55.10.1

## C) Dynamic - ③ HYBRID (Cisco based)

### \* EIGRP

- External Interior Gateway Routing Protocol
- Adv version of RIP + OSPF.

#### A) Features :

\* DUAL Algo : Diffusing Update Algorithm  
(S) \* Bandwidth, Delay, Load, Reliability & MTU

#### \* Tables (Routing)

Topology  
Neighbor

#### \* Packets : (2)

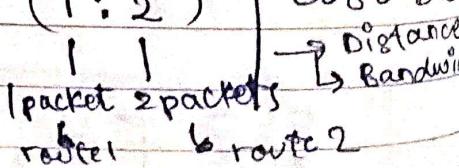
Update, Hello (5/60 secs) based of TTL  
- using RTP

\* RTP : (Reliable Transport Protocol)  
- Reliability factor 100%

\* Supports multi-protocols for routing.  
↙ out ↓  
• PDM - Protocol Dependent Module

#### \* Unequal cost load balancing.

- Takes ratios of paths (1:2)
- Performs Load

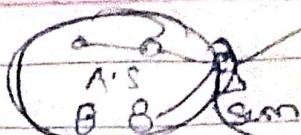


\* - Precalculates alternative paths

#### \* Immediate Backup (path)

## \* Auto Summarization -

- Summarizes network  
into classful IP →



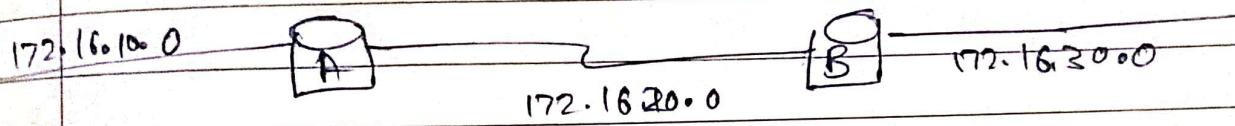
172.16.0.0

## \* Bandwidth Management (50% def).

- Value 50% → 1%
- reduces its own bandwidth if connection overloaded

\* \* \*

## \* Deploying EIGRP (2) configuration.



(autonomous system no.)

AS (1-65535)

① A(config) # router eigrp 100

must be same  
for all  
routers in a  
organization!

② A(config-router) # network 172.16.0.0

classfull value(B)

\* \*

## II Monitoring EIGRP protocol Commands.

- ① show ip eigrp topology
- ② show ip eigrp neighbor
- ③ show ip route