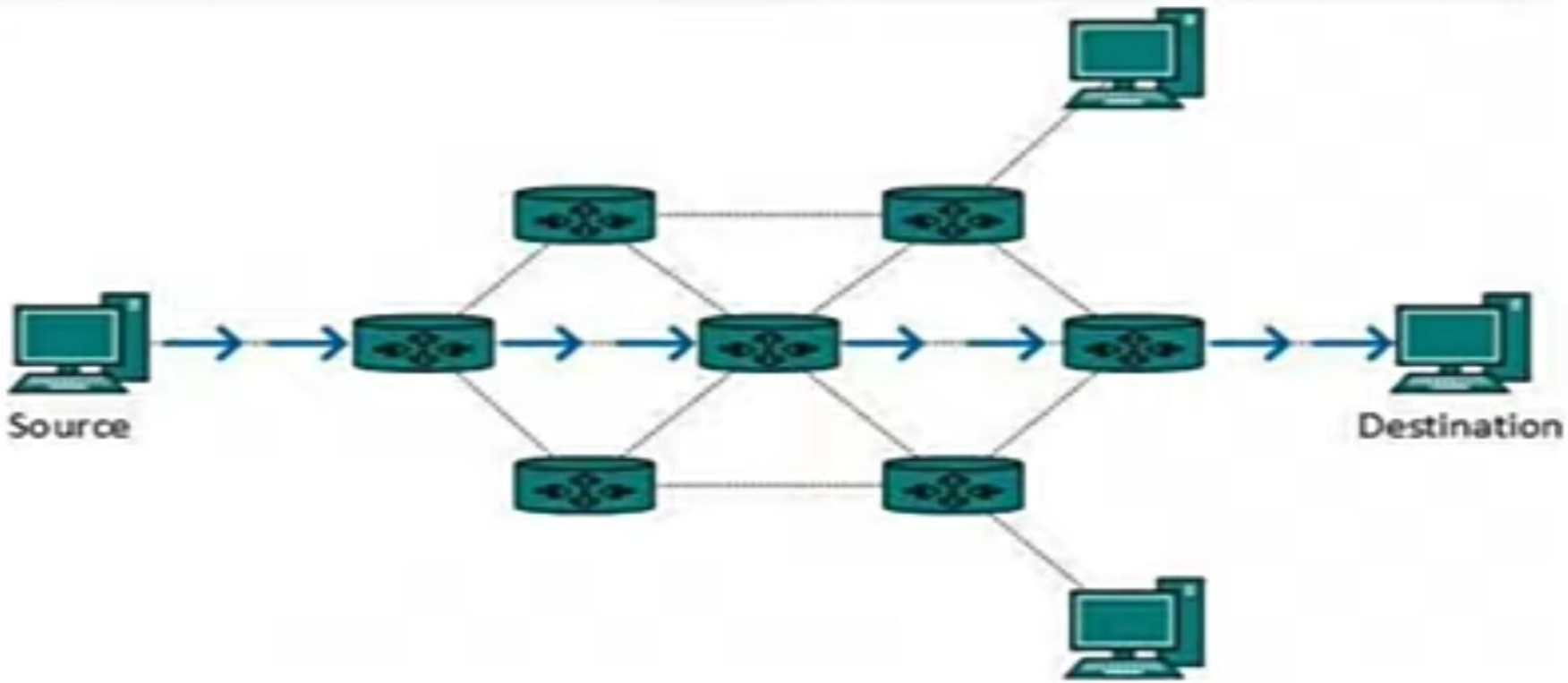
Unit 5

Network Layer : Routing protocols

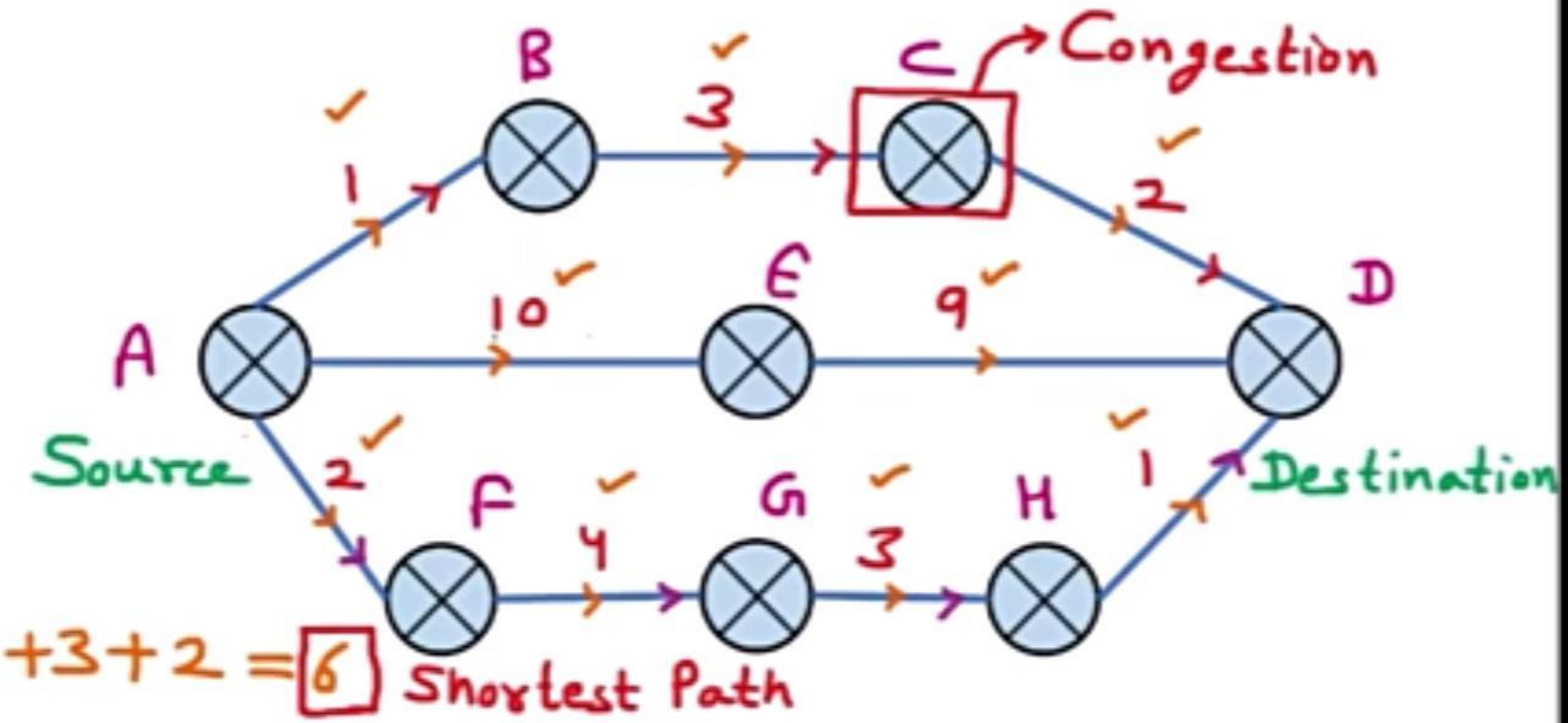
Routing

Routing is a process of selecting path along which the data can be transferred from source to the destination.



Routing

- Finds shortest path from Source to Destination



Paths from A to D

A → B → C → D 1+3+2 = 6

A → E → D 10 + 9 = 19

A → F → G → H → D 2+4+3+1 = 10 Second Best Path

- If shortest path is not optimal then it finds second best path

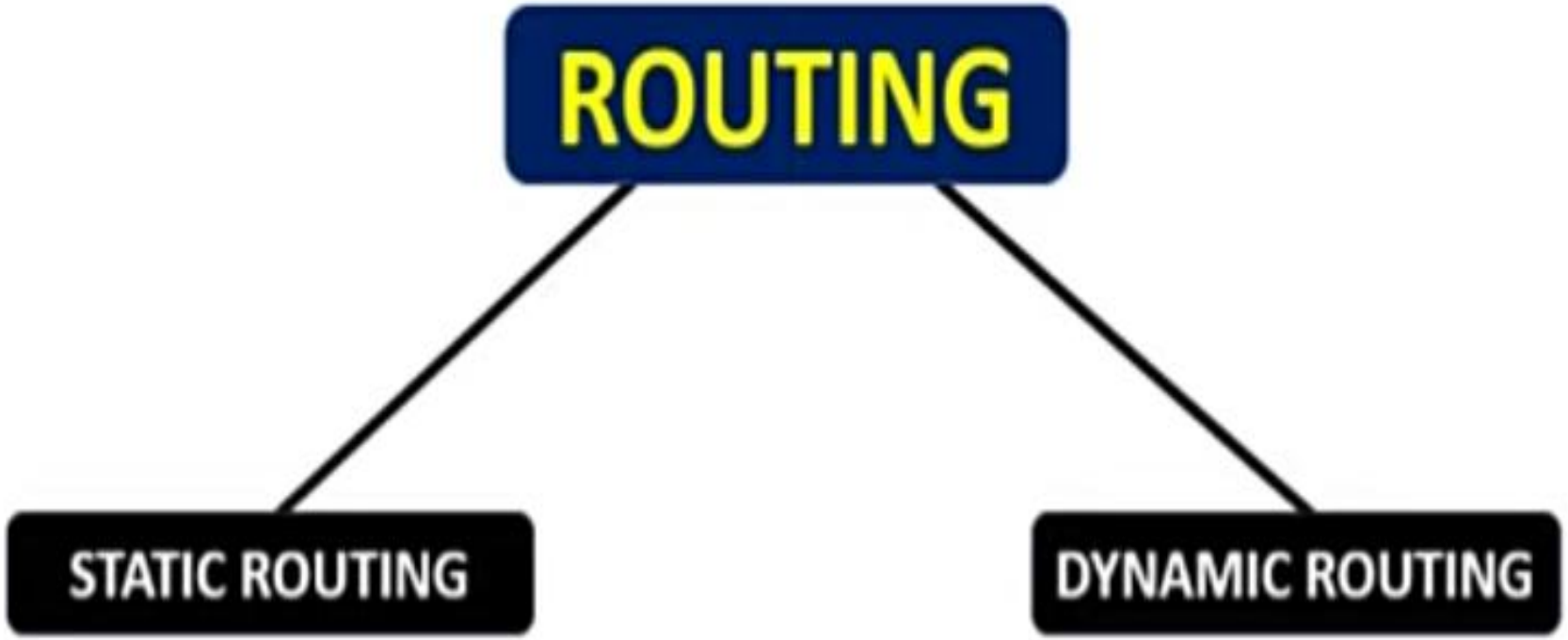
Routing Algorithms

- Optimality Principle
- Shortest Path Routing
- Flooding
- Distance Vector Routing
- Link State Routing
- Hierarchical Routing

Routing

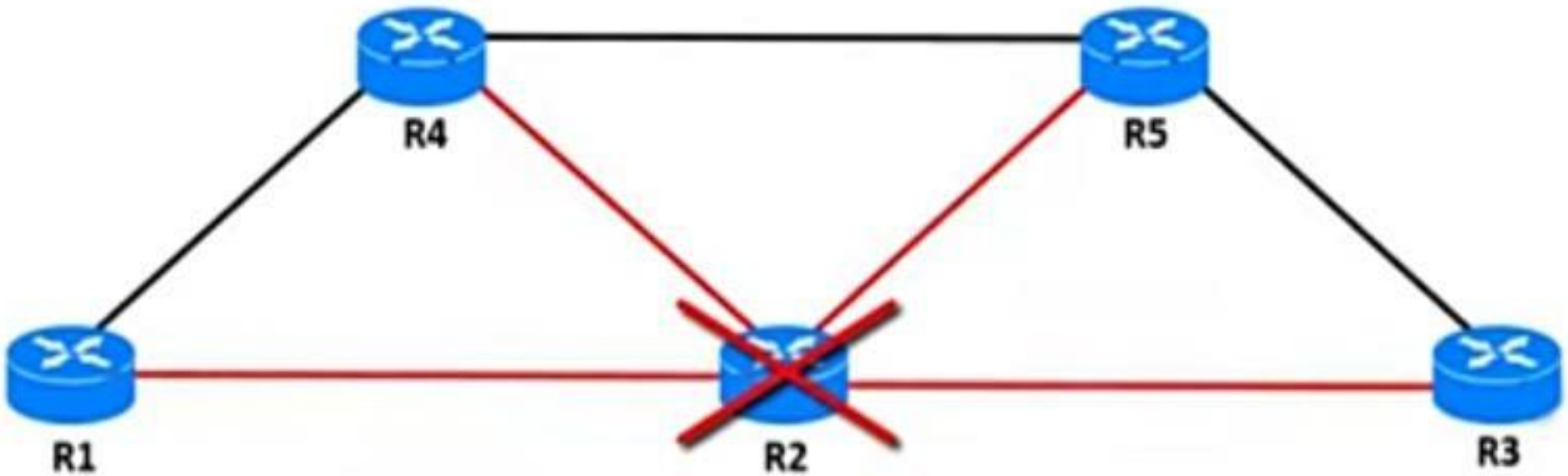
Routing is a process of selecting path along which the data can be transferred from source to the destination.

- Routing is performed by a special device known as a router.
- A Router works at the network layer in the OSI model and internet layer in TCP/IP model
- A router is a networking device that forwards the packet based on the information available in the packet header and forwarding table.
- The routing algorithms are used for routing the packets. The routing algorithm is nothing but a software responsible for deciding the optimal path through which packet can be transmitted.
- The routing protocols use the metric to determine the best path for the packet delivery.
- The routing algorithm initializes and maintains the routing table for the process of path determination.

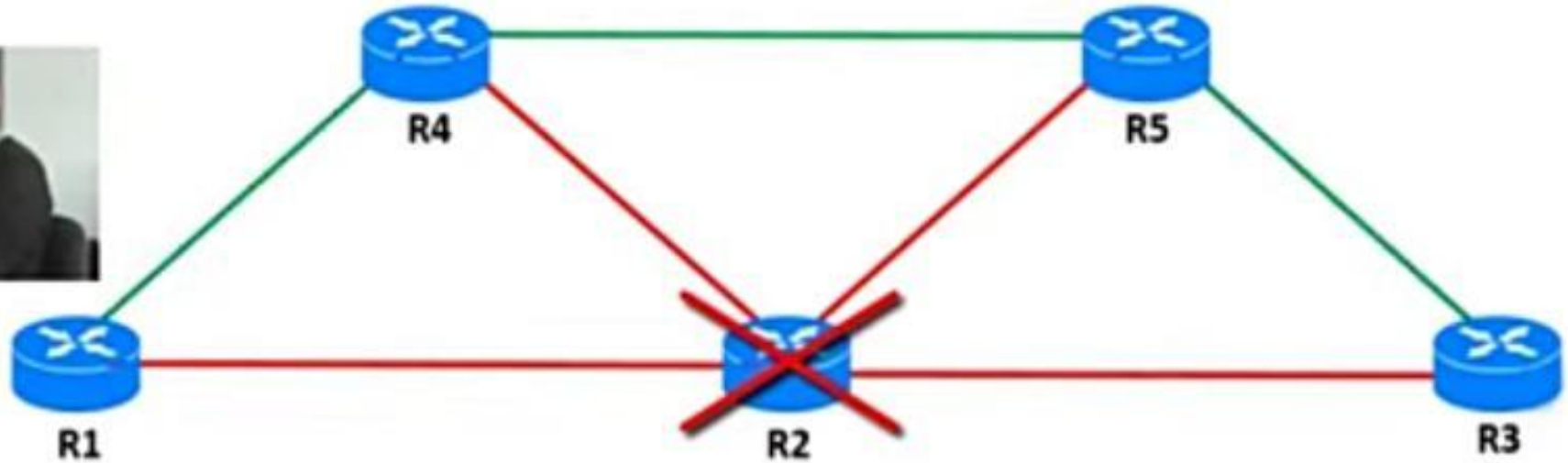

ROUTING
STATIC ROUTING
DYNAMIC ROUTING

WHAT IS STATIC ROUTING?

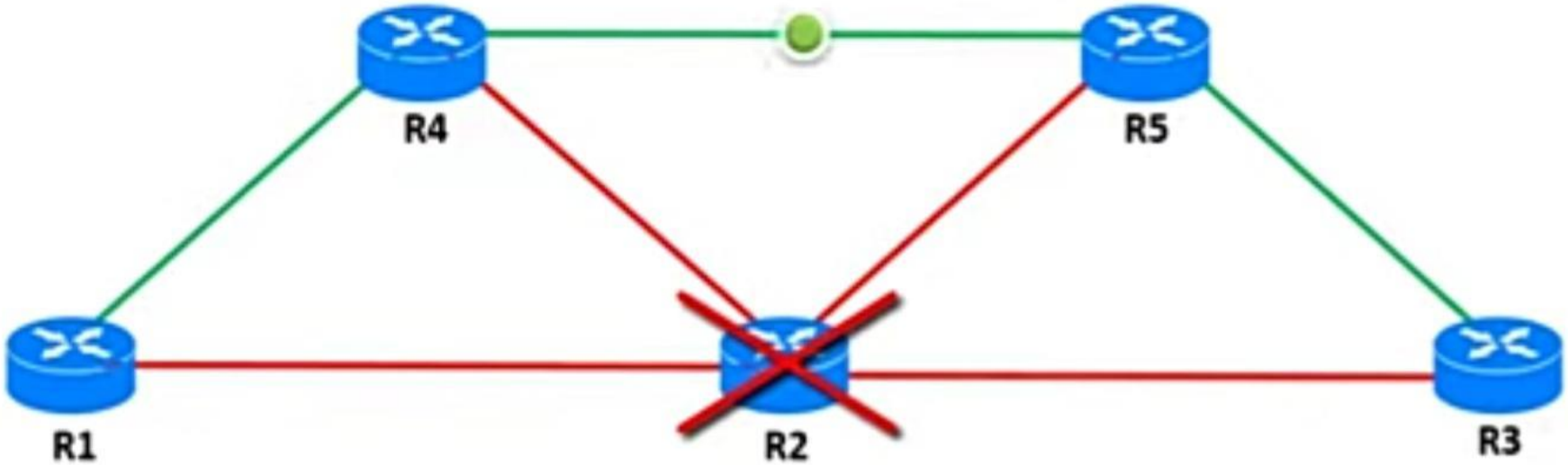
Static Route is the route that the network administrator manually enters into the routing table. It is a one way communication and here we do not use any routing protocol.



The router 1 cannot decide the alternate route for the data packets.



In this scenario, The network administrator have to manually configure the alternate route.



The biggest drawback of static routing is that, it requires 24/7 support. Because, if the default route fail the router cannot decide the alternate route for the data packets.

It is a time consuming process. The user have to wait until the administrator configure the alternate route for the data packets.

Static Routing

Advantages Of Static Routing

Following are the advantages of Static Routing:

- **No Overhead:** It has ho overhead on the CPU usage of the router. Therefore, the cheaper router can be used to obtain static routing.
- **Bandwidth:** It has not bandwidth usage between the routers.
- **Security:** It provides security as the system administrator is allowed only to have control over the routing to a particular network.

Disadvantages of Static Routing:

Following are the disadvantages of Static Routing:

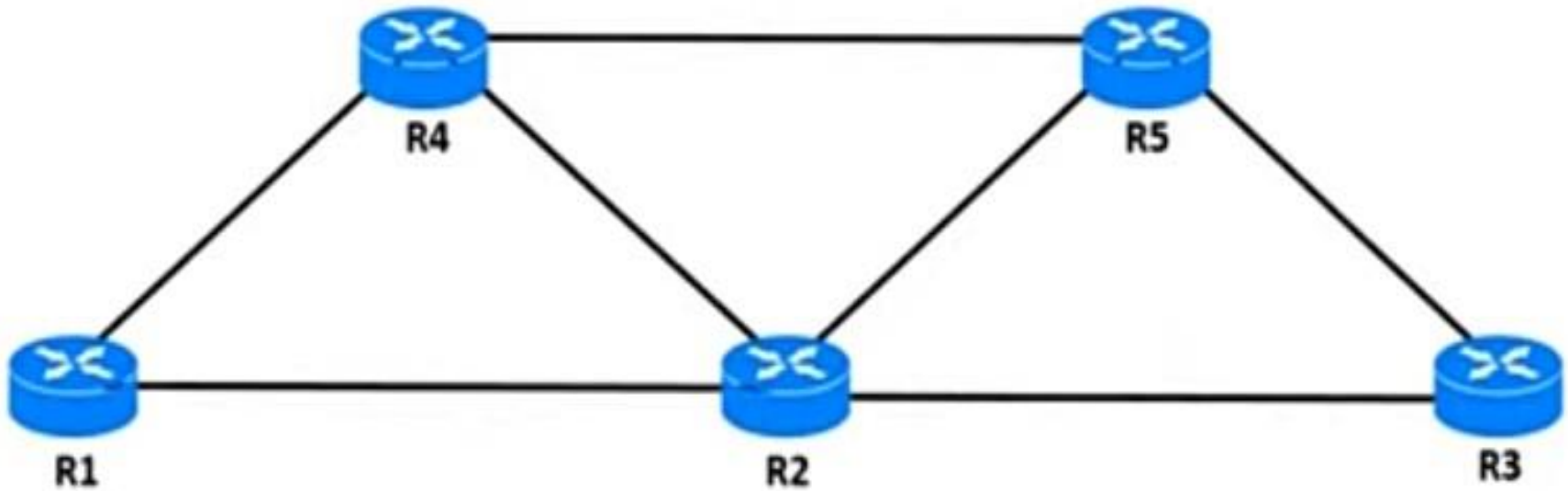
- For a large network, it becomes a very difficult task to add each route manually to the routing table.
- The system administrator should have a good knowledge of a topology as he has to add each route manually.

WHAT IS DYNAMIC ROUTING?

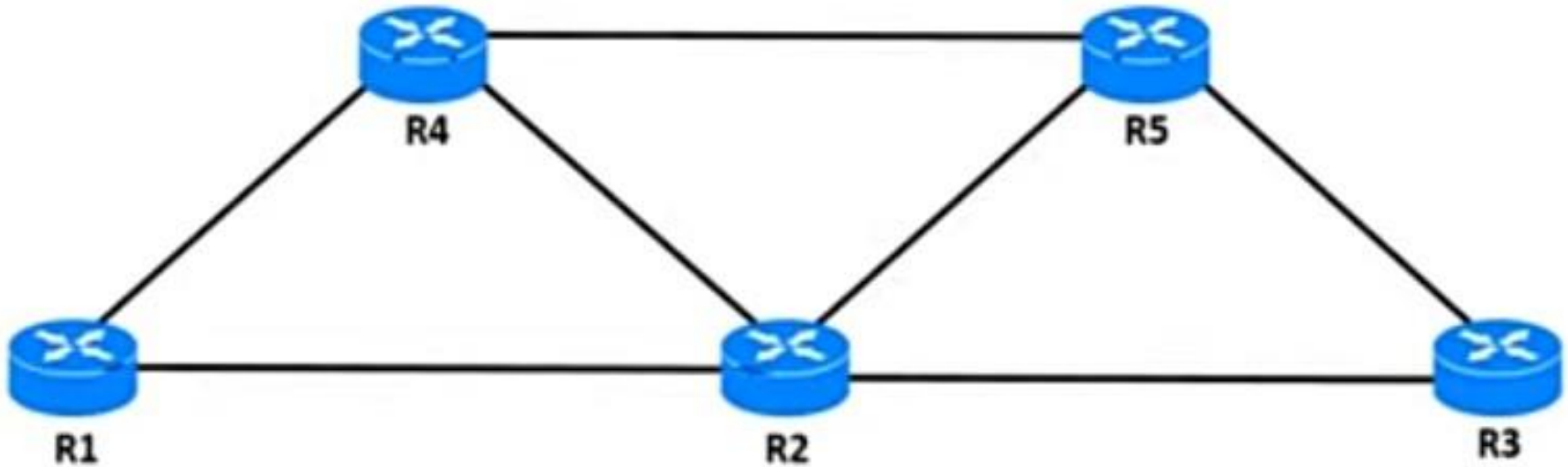
Dynamic routing uses routing protocol for creating a route for the data packets. Here, the router automatically collect and store dynamic route in the routing table.

Dynamic Routing

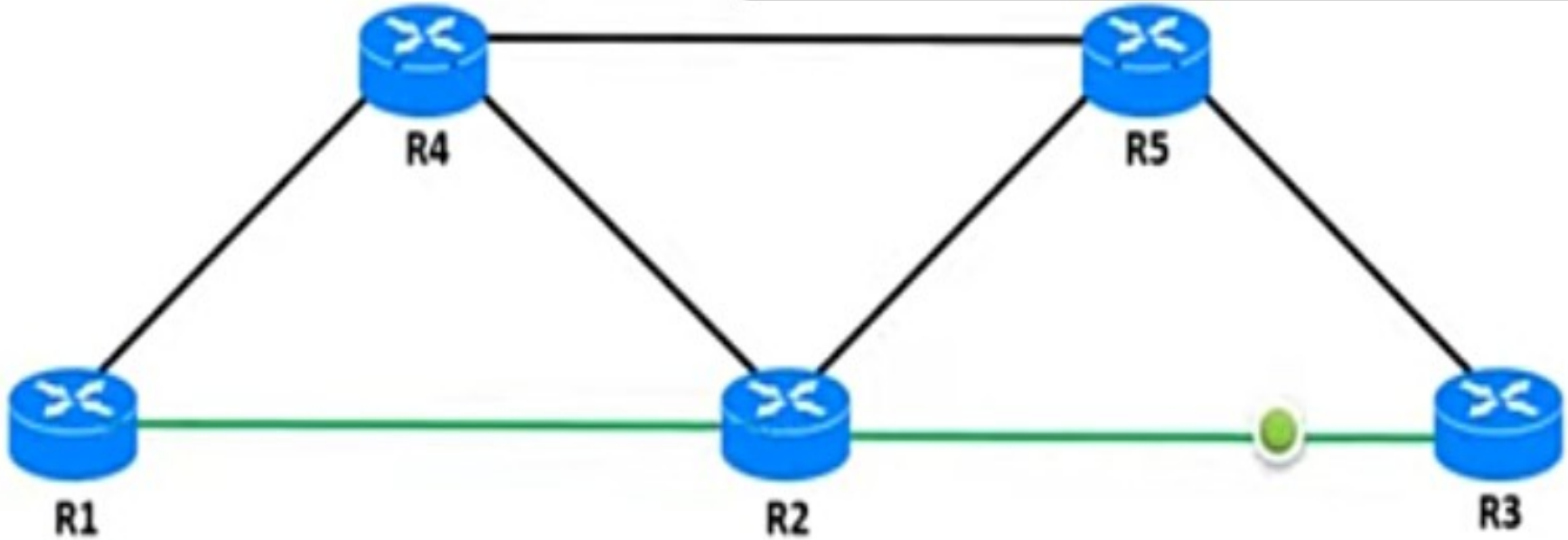
- It is also known as Adaptive Routing.
- It is a technique in which a router adds a new route in the routing table for each packet in response to the changes in the condition or topology of the network.
- Dynamic protocols are used to discover the new routes to reach the destination.
- In Dynamic Routing, RIP and OSPF are the protocols used to discover the new routes.
- If any route goes down, then the automatic adjustment will be made to reach the destination.



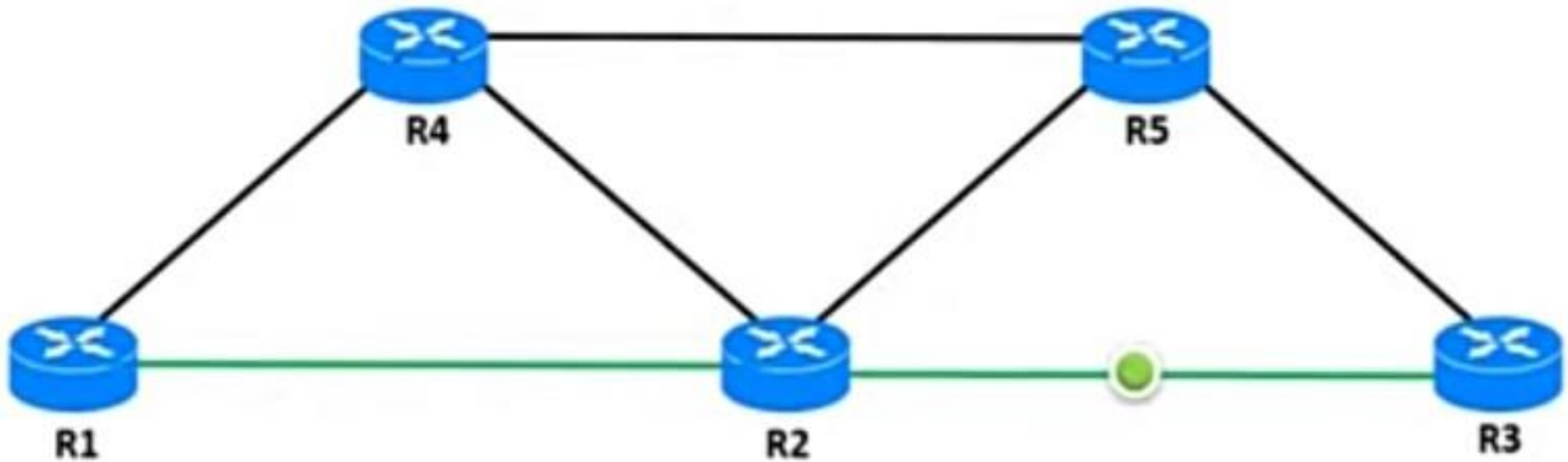
Here, the administrator is not going to create the route for the data packets.



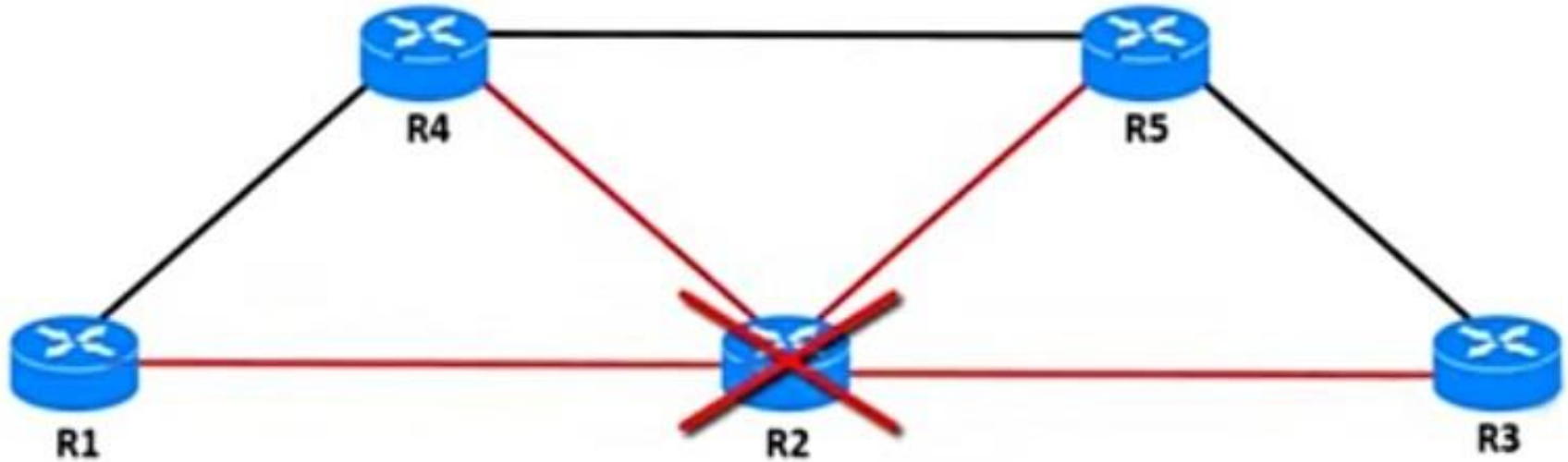
Instead of this, the administrator will assign a routing protocol to this router



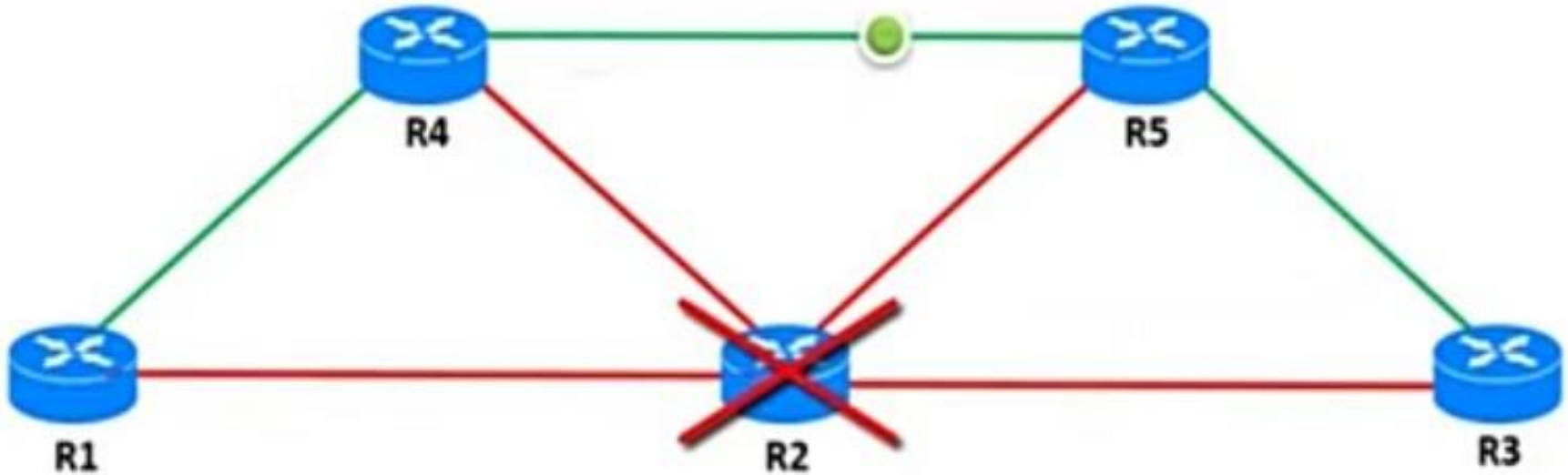
This routing protocol will automatically decide the best route for the data packets.



In this scenario, if any of this router or link get fails,



the routing protocol is so smart that it can automatically choose the alternate route for the data packets immediately



It minimize the work pressure of the network administrator

The users need not to wait for the long time for the link to go up.

DIFFERENCE BETWEEN STATIC AND DYNAMIC ROUTING

STATIC ROUTING	DYNAMIC ROUTING
Does not use routing protocol.	Use routing protocol.
Administrator manually configure the route and makes an entry to the routing table.	Routing protocol decide the route for the data packets and makes an entry to the routing table.
Suitable for small network.	Suitable for large network.
Link failure effects the network.	Link failure does not effects the network.
Security is high.	Security is less.
Route does not change automatically.	Route changes automatically according to the changes in the network.

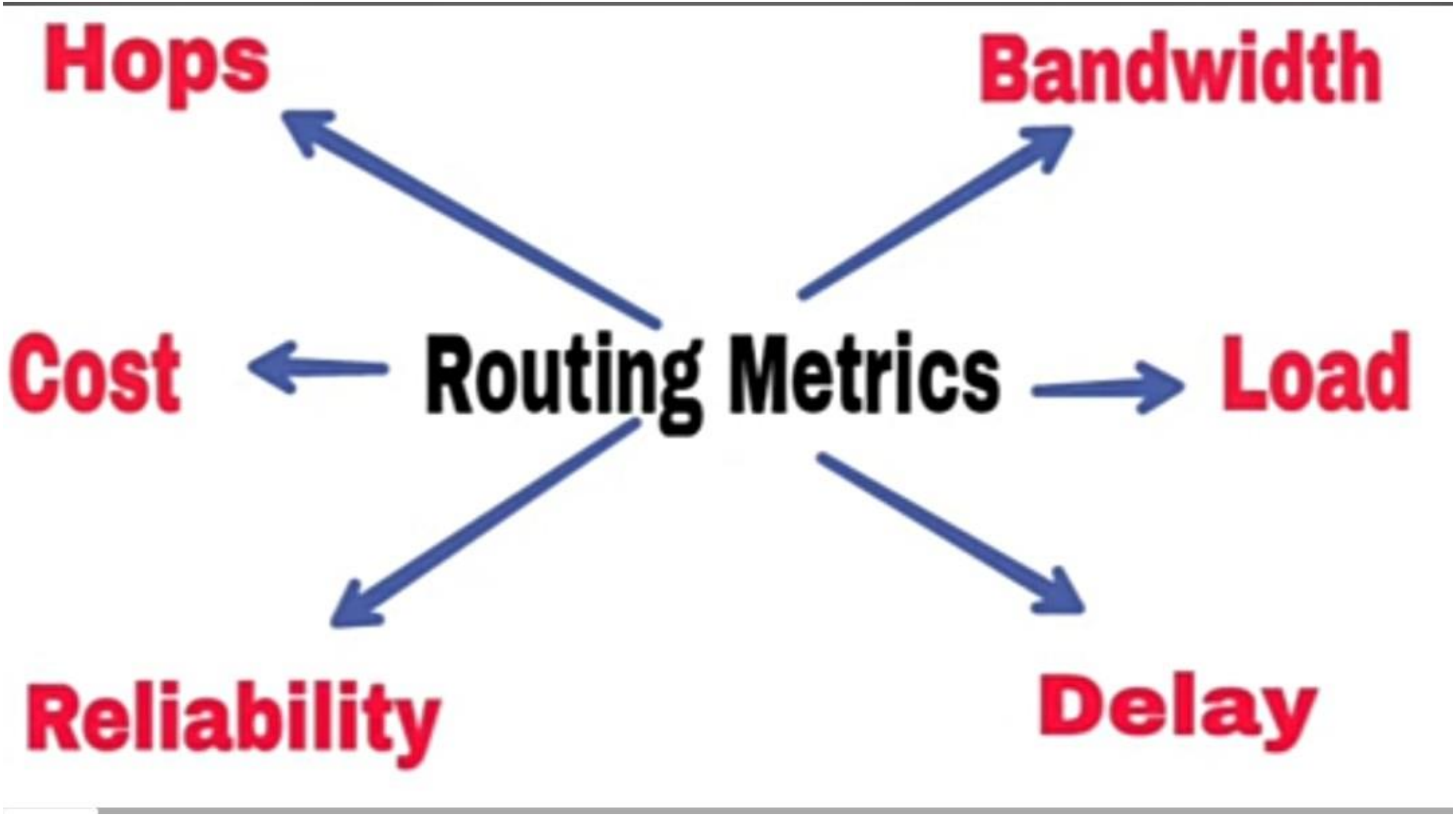
Dynamic Routing

Advantages of Dynamic Routing:

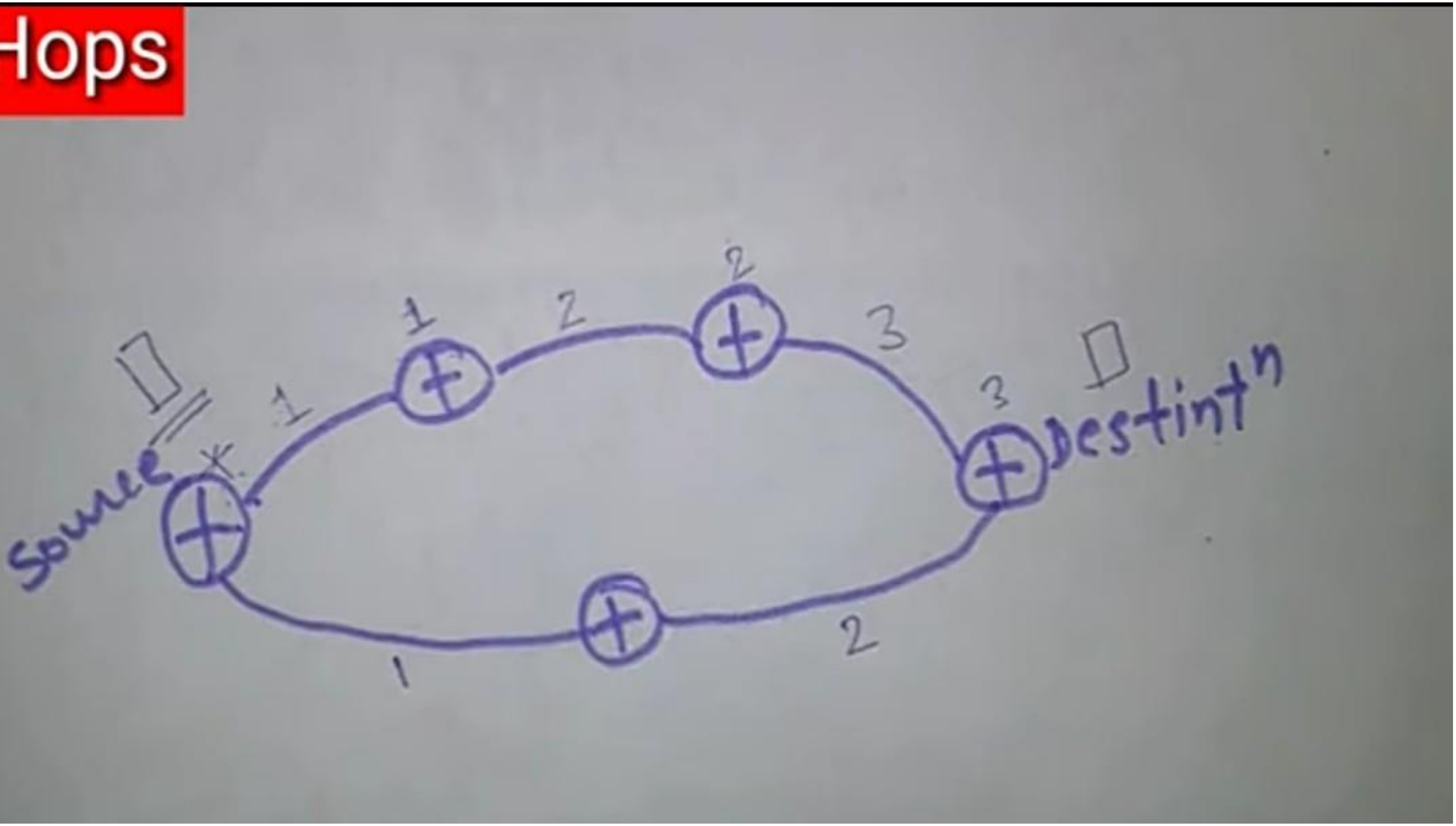
- It is easier to configure.
- It is more effective in selecting the best route in response to the changes in the condition or topology.

Disadvantages of Dynamic Routing:

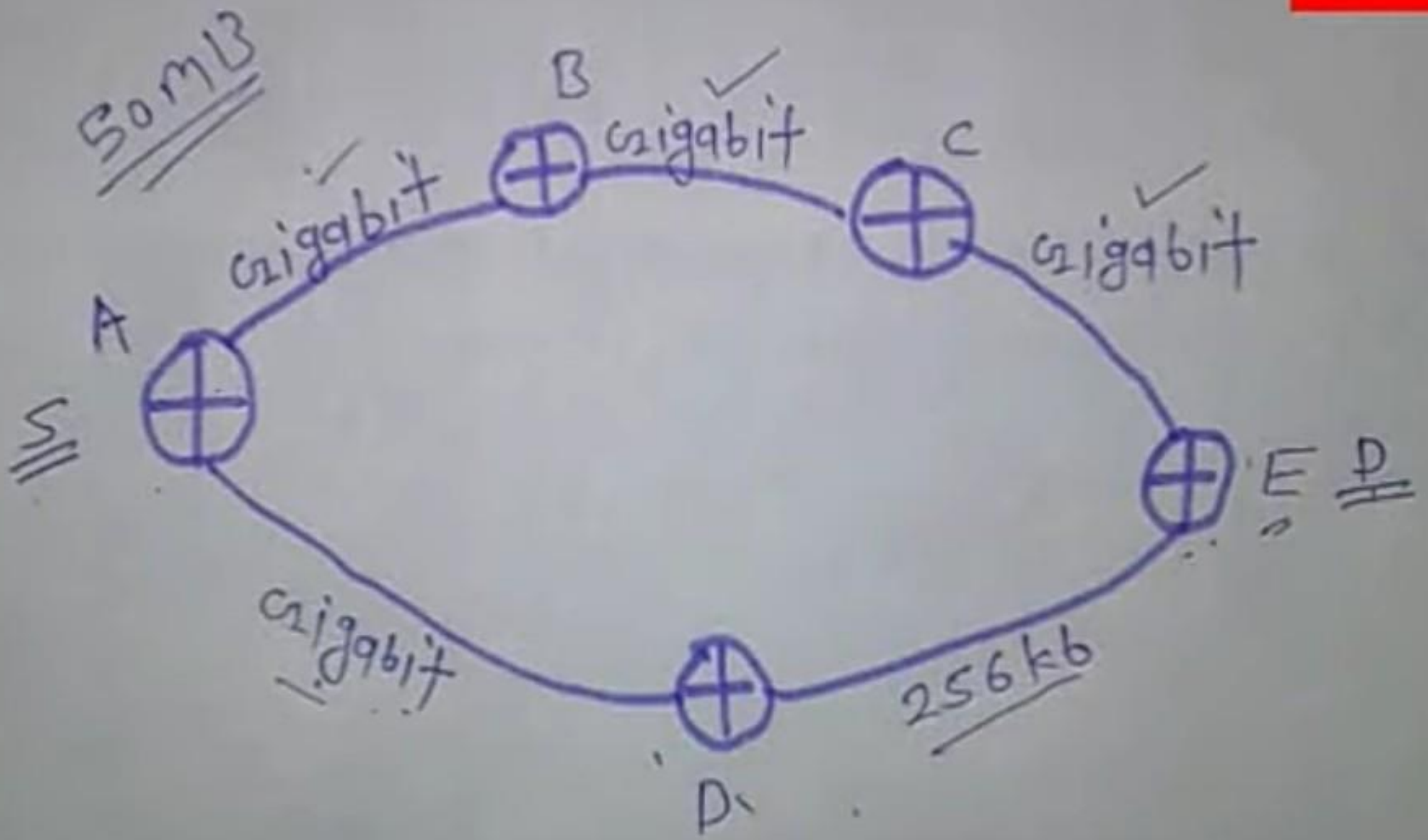
- It is more expensive in terms of CPU and bandwidth usage.
- It is less secure as compared to default and static routing.

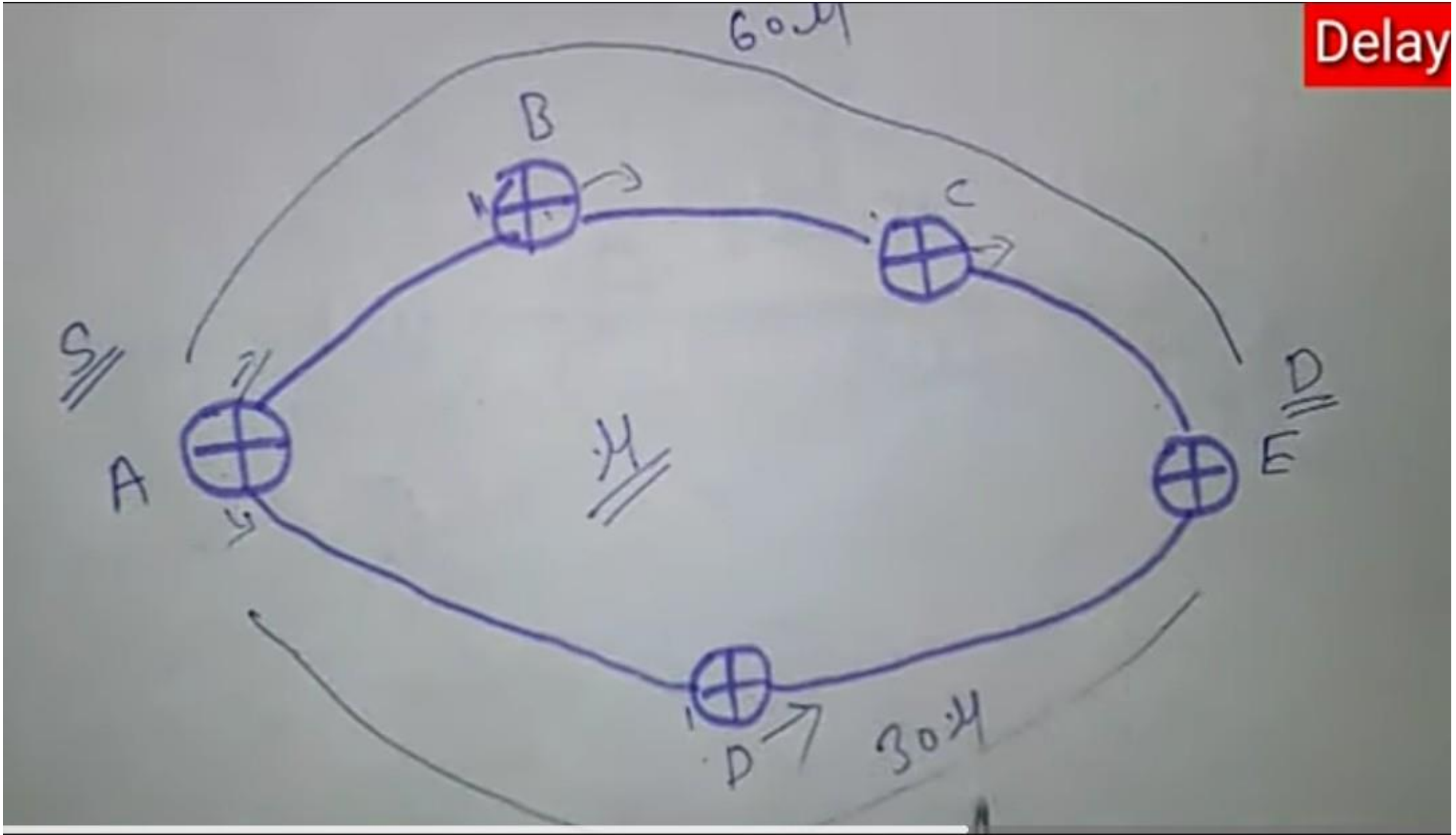

Hops
Bandwidth
Cost
Routing Metrics
Load
Reliability
Delay

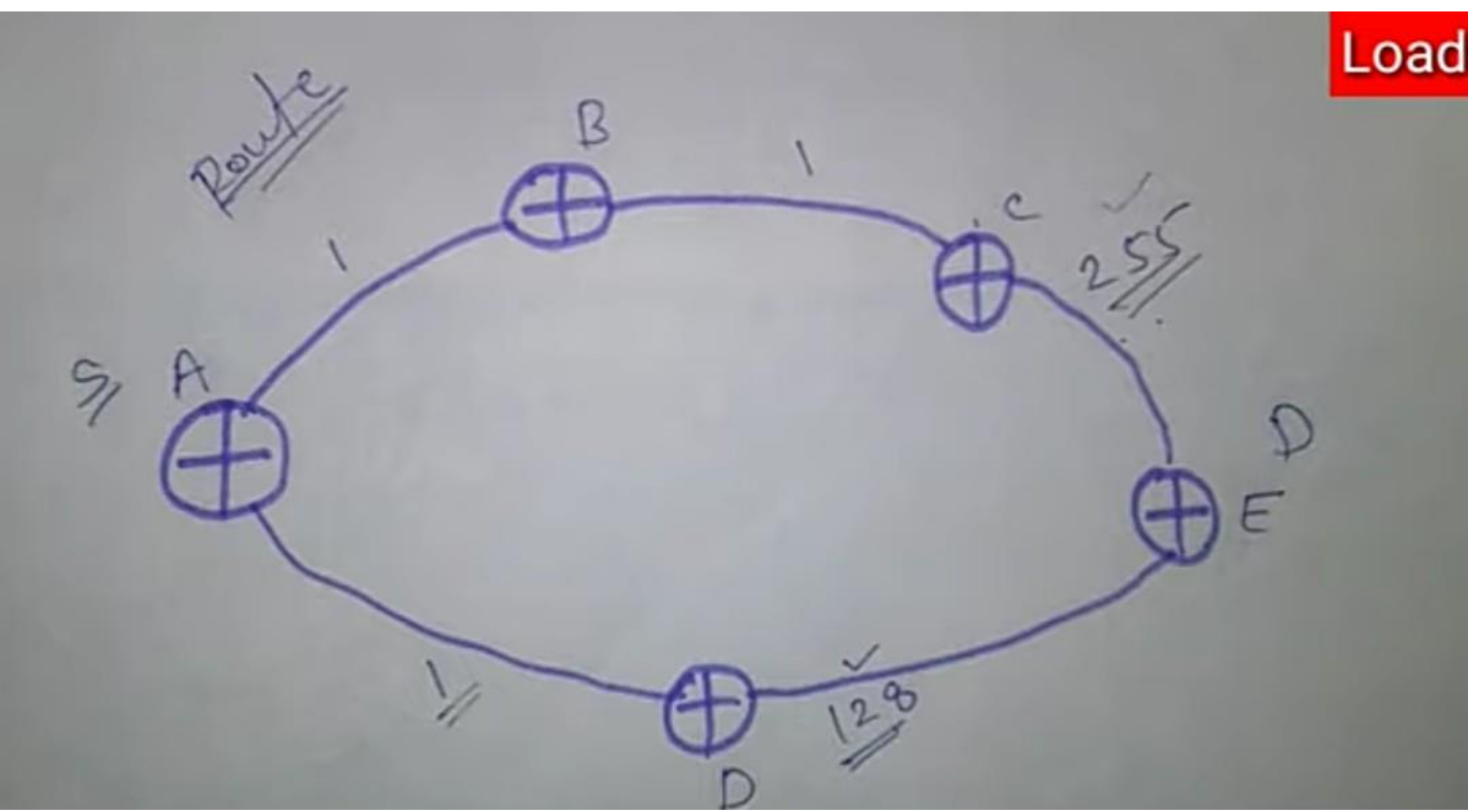
Hops

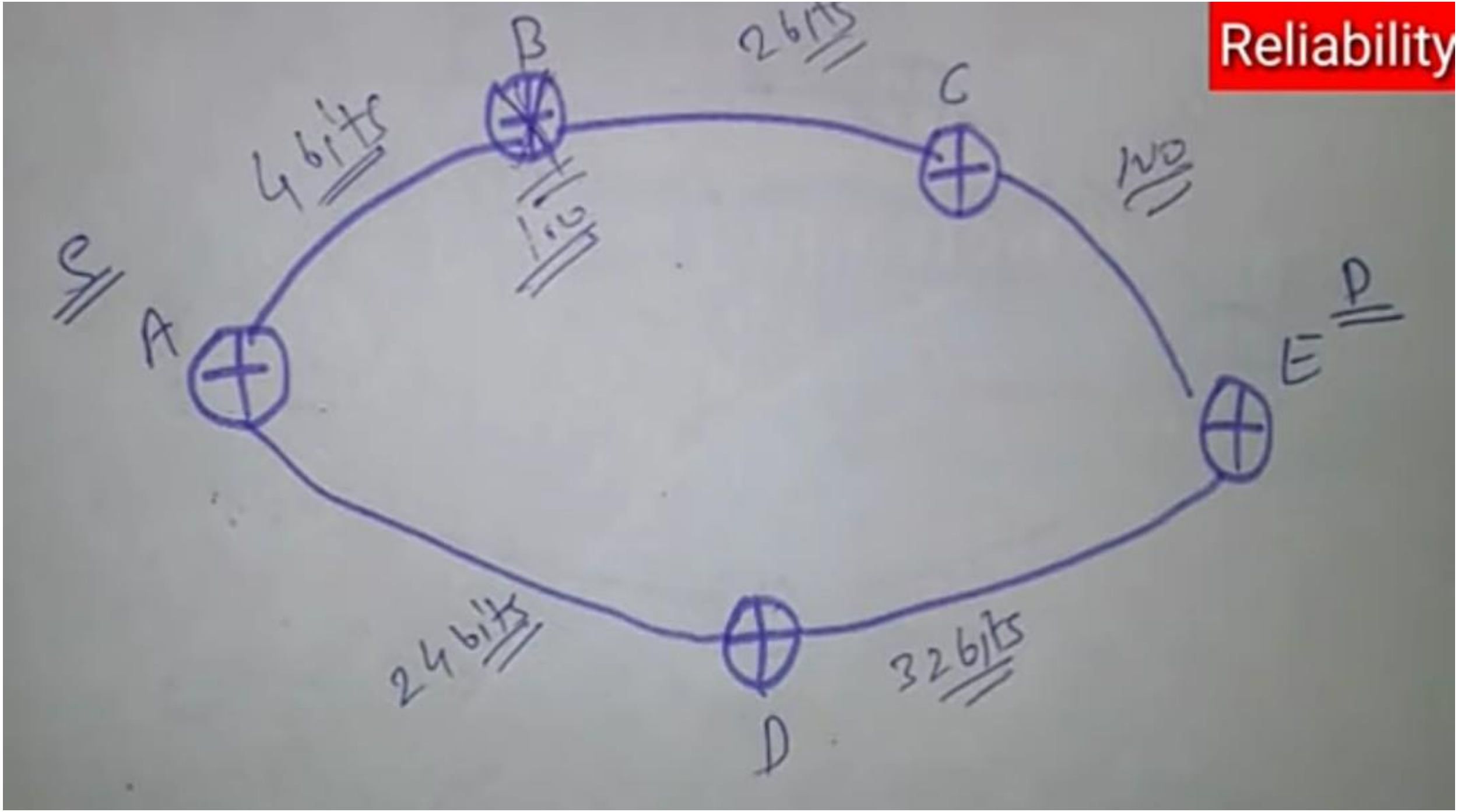


Bandwidth

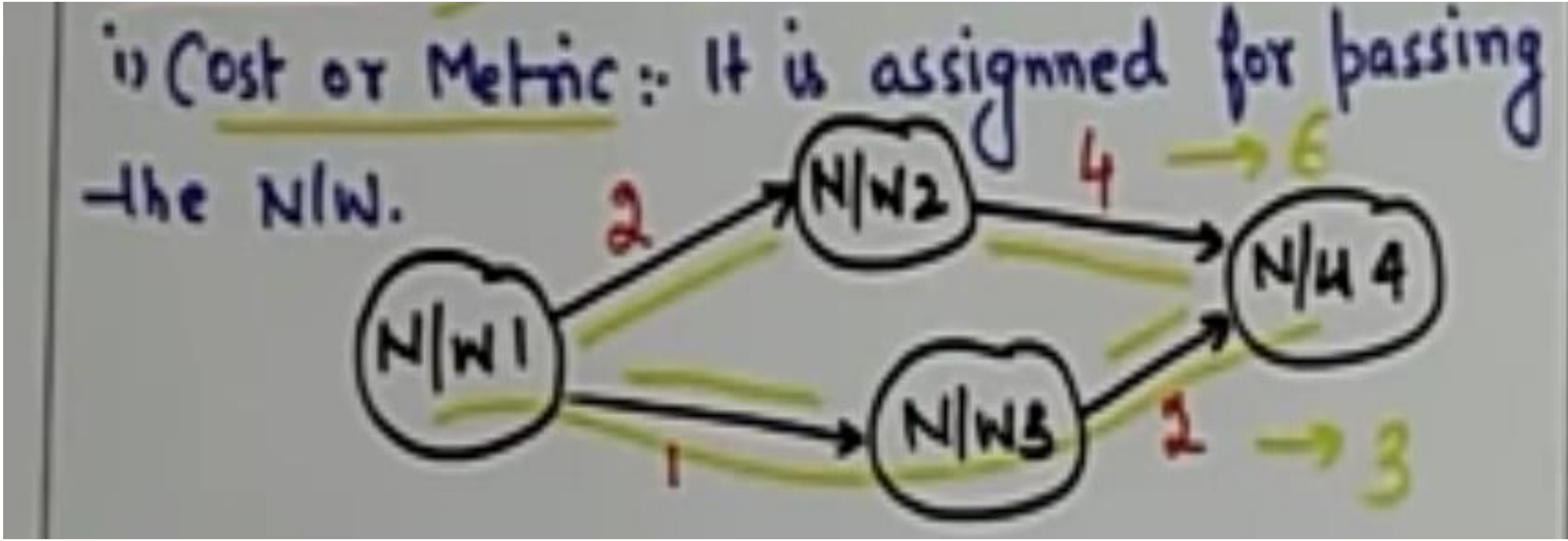



Delay
60 ms
B
C
S
A
D
E
4 ms
D
30 ms


Route
B
1
C
1
255
A
1
D
E
1
128
D


Reliability
B
C
S
A
E
D
P
ND

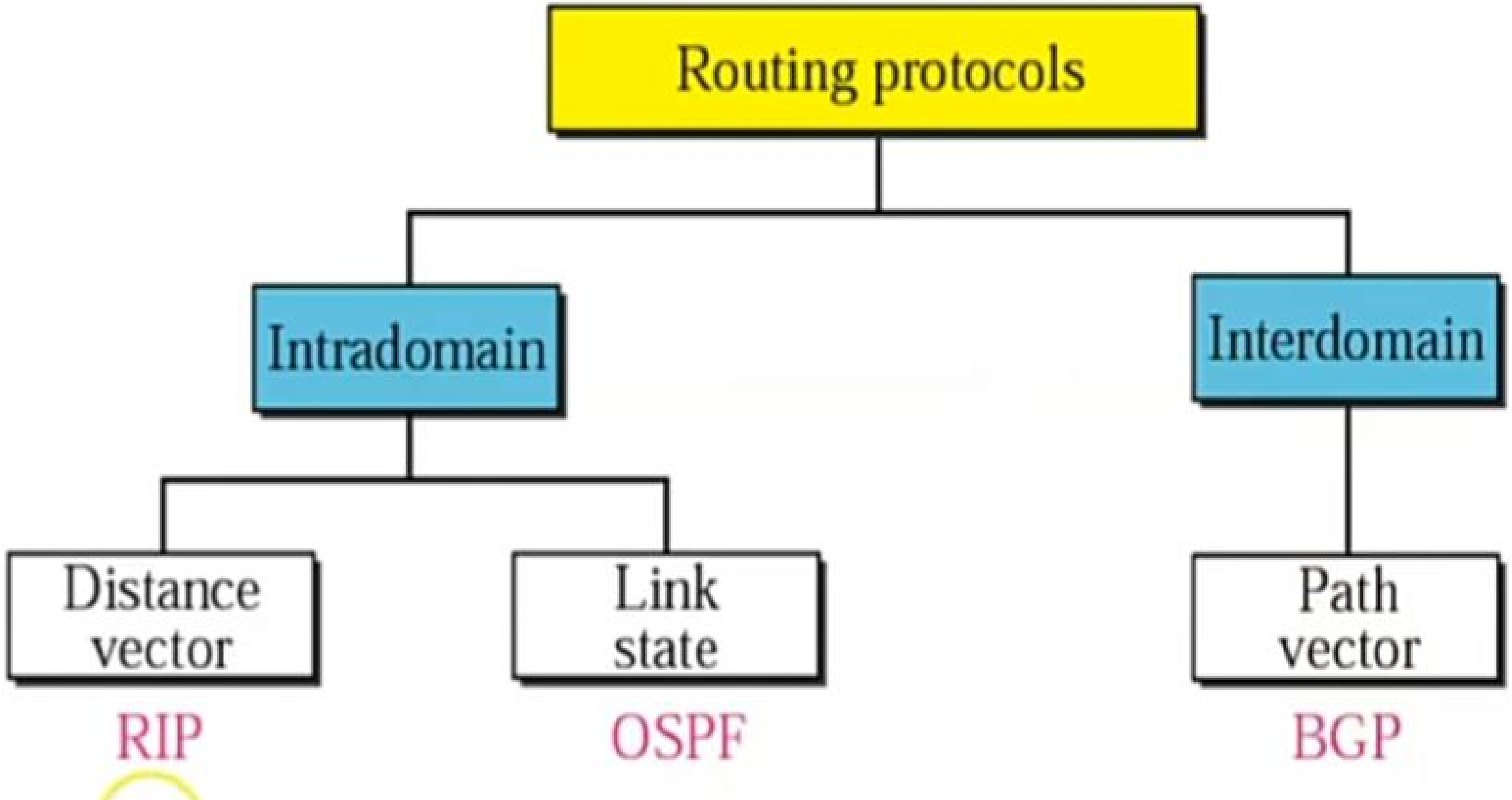
- **Cost** : - cost value is used to determine the best path to destination network
- Low value indicate better path.



Unicast – Unicast means the transmission from a single sender to a single receiver. It is a point-to-point communication between sender and receiver. There are various unicast protocols such as TCP, HTTP, etc.

There are three major protocols for unicast routing:

1. Distance Vector Routing
2. Link State Routing
3. Path-Vector Routing


Routing protocols
Intradomain
Interdomain
Distance vector
Link state
Path vector
RIP
OSPF
BGP

UNICAST ROUTING PROTOCOLS

three common protocols used in the Internet:

- Routing Information Protocol (RIP), based on the distance-vector algorithm
- Open Shortest Path First (OSPF), based on the link-state algorithm
- Border Gateway Protocol (BGP), based on the path-vector algorithm

iii) Routing Protocol:- → Combine info" received from other routers.

Rules Procedures

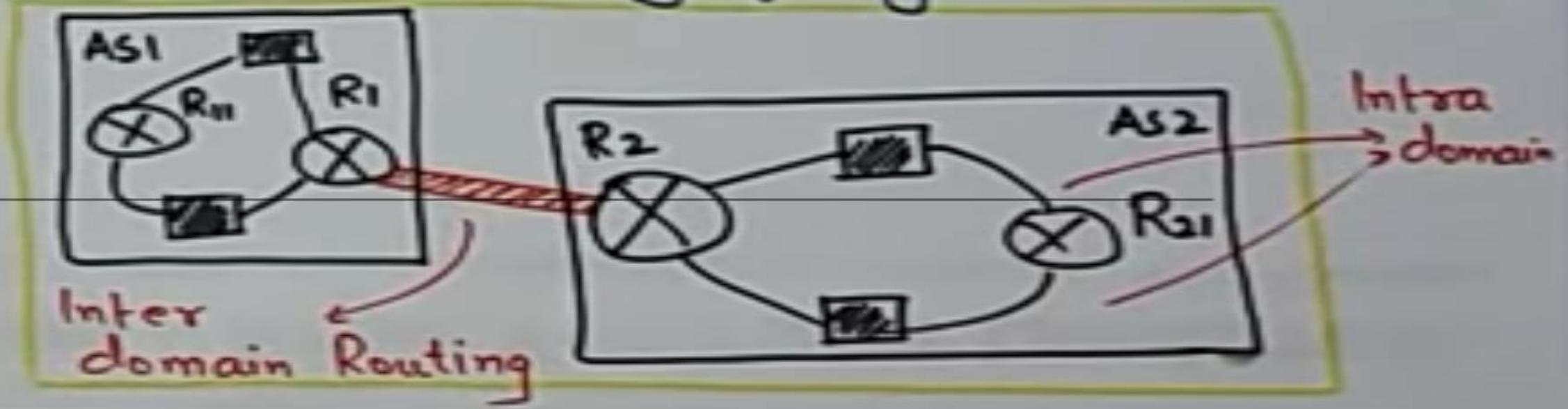
↓

Change in route info" is informed to other routers

R.P → Interior (Intra)

→ Exterior (Inter)

Intra-and Inter-Domain Routing:- Internet is divided into Autonomous System (AS) which is a group of NIW and Routers under authority of single administration.



Interdomain and Intradomain Routing

Intradomain Routing

- Routing within an AS
- Ignores the Internet outside the AS
- Protocols for intradomain routing are also called **Interior Gateway Protocols** or **IGP's**.
- Popular protocols are
  - RIP (simple, old)
  - OSPF (better)

Interdomain Routing

- Routing between AS's
- Assumes that the Internet consists of a collection of interconnected AS's
- Normally, there is one dedicated router in each AS that handles interdomain traffic.
- Protocols for interdomain routing are also called **Exterior Gateway Protocols** or **EGP's.**
- Routing protocols:
  - EGP
  - BGP (more recent)

Distance Vector Routing

- It's a Adaptive or Dynamic Algorithm.
- Each Router Maintains a Table called "Vector".
- Table has the Best Known Distance for Each Routers.
- Tables are Updated by exchanging Information with neighbours(Routers).
- Each Router knows the Best Distance to Reach another Router.
- Also Known as Bellman-Ford Routing Algorithm.

Distance Vector Routing

- Each Router's Table has one entry for one router.
- This entry has two parts
  - Preferred out going Line for each Router.
  - Estimated distance to destination Router.
- Distance is basically considered by no's of Hops.
- Delays basically measured by sending ECHO packets to another Routers.

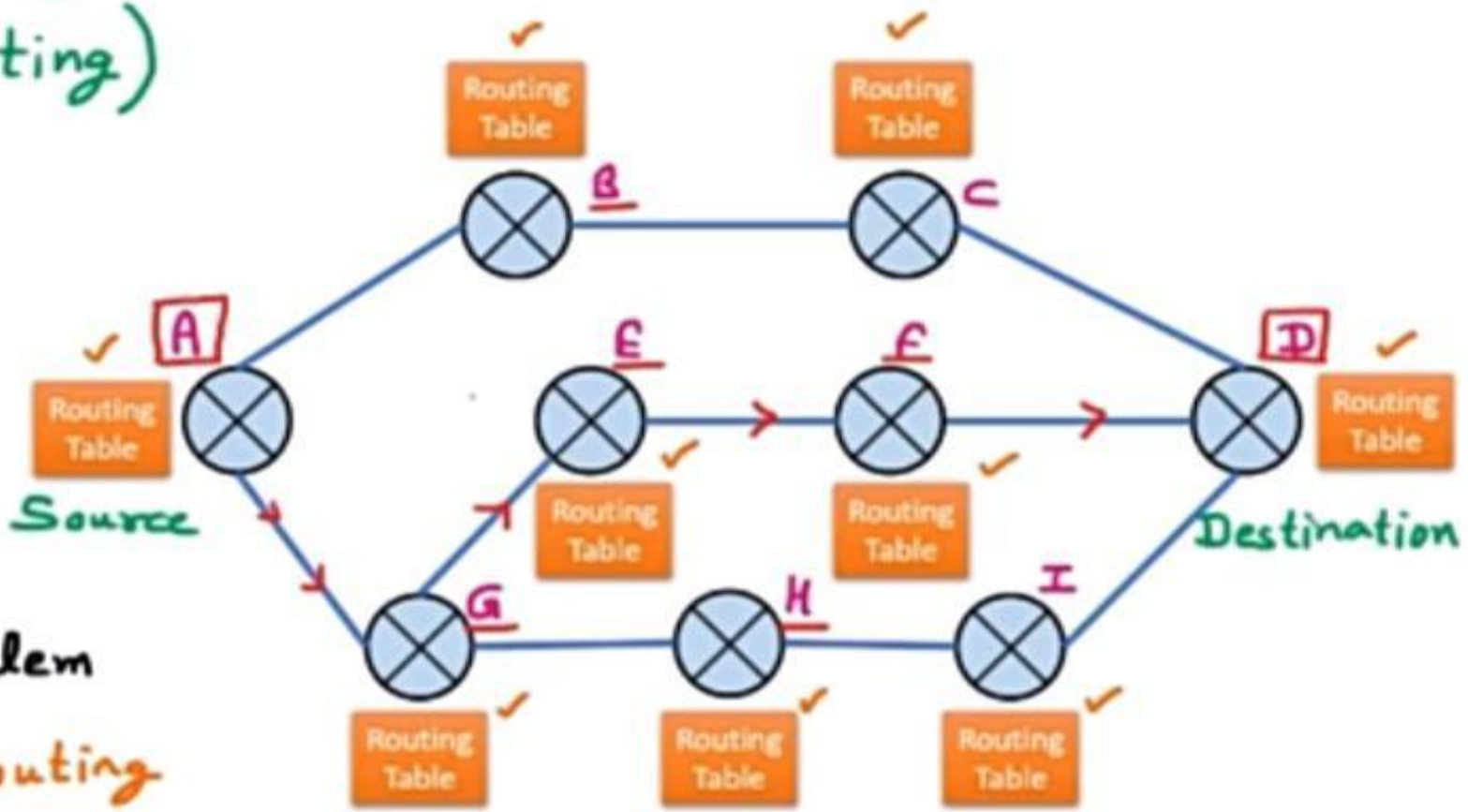
Routing Algorithms

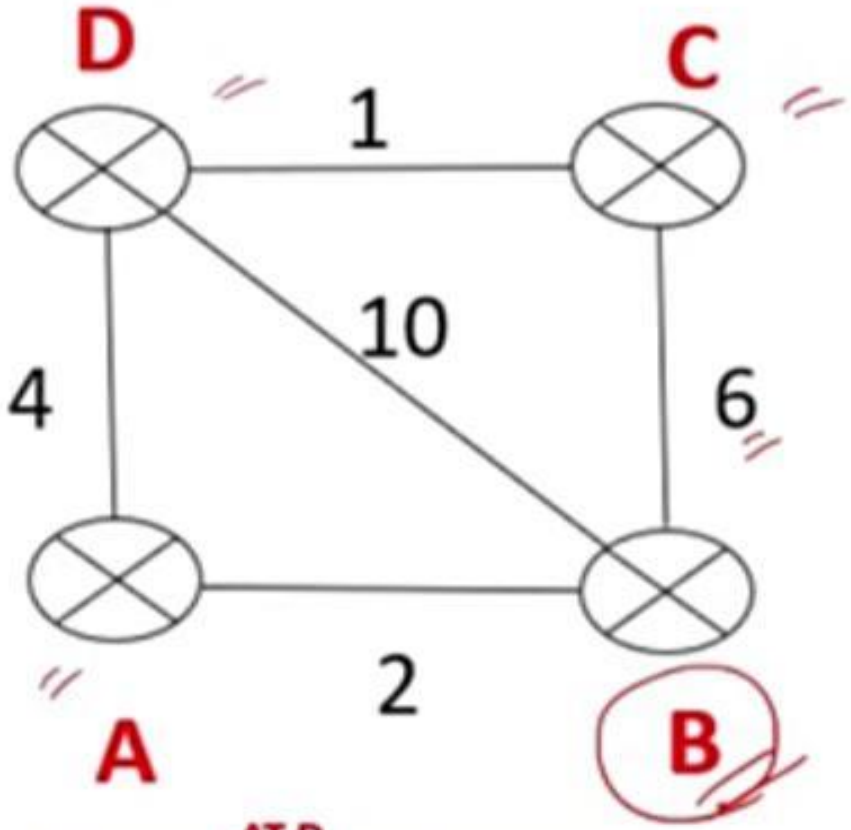
Distance Vector Routing (Bellman-Ford Routing or Ford-Fulkerson Routing)

Problems of DVR

- It's delay metric is queue length, it did not take line bandwidth into account while choosing Router
- Count to Infinity Problem

Solution: Link State Routing





steps

AT A

DESTINATION	DISTANCE	NEXT HOP
A	0	A
B	2	B
C	∞	-
D	4	D

AT B

DESTINATION	DISTANCE	NEXT HOP
A	2	A
B	0	B
C	6	C
D	10	D

AT C

DESTINATION	DISTANCE	NEXT HOP
A	∞	-
B	6	B
C	0	C
D	1	D

AT D

DESTINATION	DISTANCE	NEXT HOP
A	4	A
B	10	B
C	1	C
D	0	D

SECOND STEP

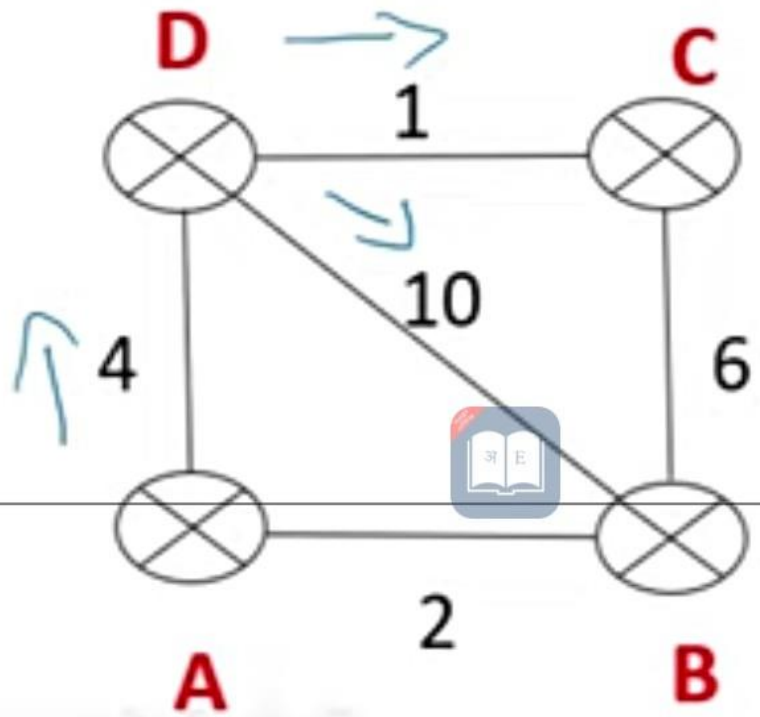
- Each router exchanges its distance vector with its neighboring routers.
- Each router prepares a new routing table using the distance vectors it has obtained from its neighbors.
- This step is repeated for (n-1) times if there are n routers in the network.

B
2
0
6
10

D
1
1
1
0

AT A

DESTINATION	DISTANCE	NEXT HOP
A	0	A
B	2	B
C		
D		



A ⇝ B min { A →(2) B + B ⇝(0) B = 2 ; A →(4) D + D ⇝(10) B = 14 }

A → B

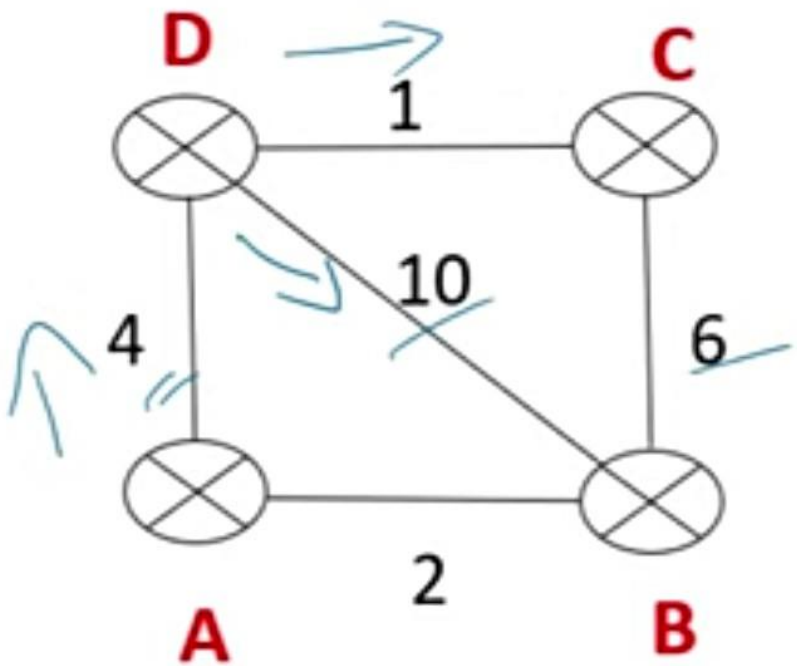
SECOND STEP

- Each router exchanges its distance vector with its neighboring routers.
- Each router prepares a new routing table using the distance vectors it has obtained from its neighbors.
- This step is repeated for (n-1) times if there are n routers in the network.

B	D
2	1
0	1
6	1
10	0

AT A

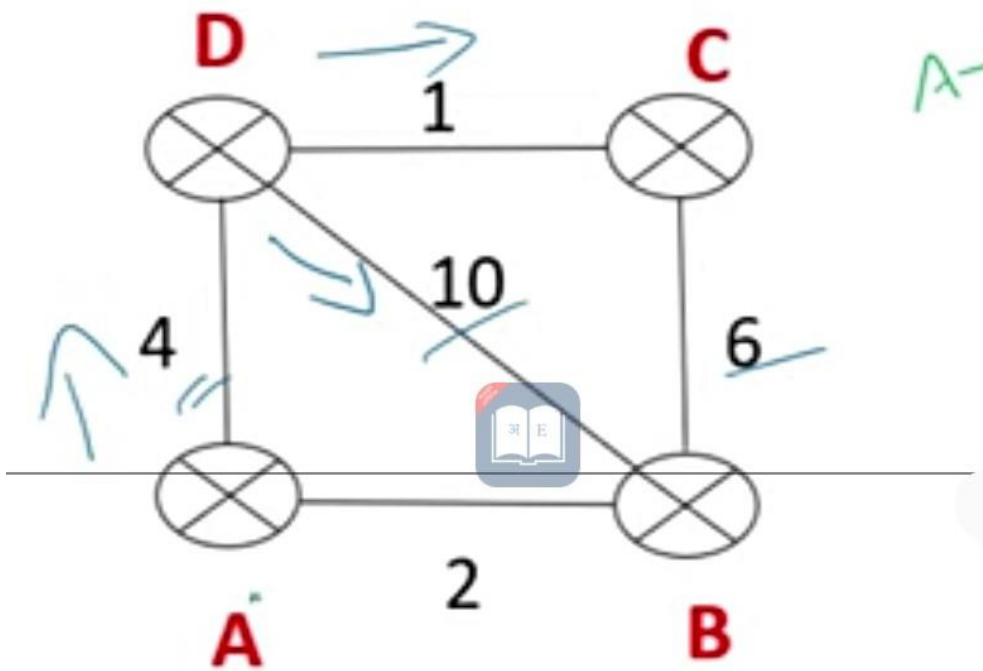
DESTINATION	DISTANCE	NEXT HOP
A	0	A
B	2	B
C	5	C
D		



A->C min { A -(2)-> B + B -6-> C = 8 ; A -(4)-> D + D -(1)-> C 5 }

SECOND STEP

- Each router exchanges its distance vector with its neighboring routers.
- Each router prepares a new routing table using the distance vectors it has obtained from its neighbors.
- This step is repeated for (n-1) times if there are n routers in the network.



B	D
2	4
0	1
6	1
10	0

AT A

DESTINATION	DISTANCE	NEXT HOP
A	0	A
B	2	B
C	5	C
D	4	D

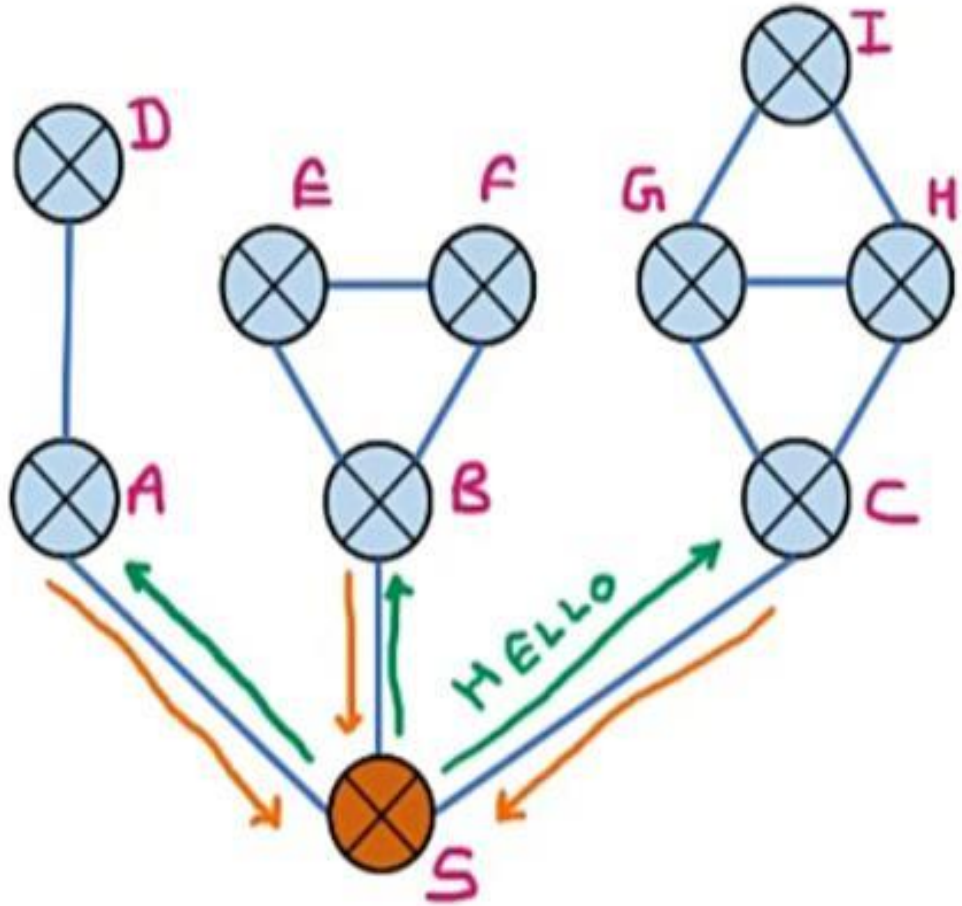
A → D = min { A → D + D ⇝ D = 5 ; A → B + B ⇝ D = 12 (2 + 10) }

Routing Algorithms

Link State Routing

Each Router do the following:

- Learn their Neighbours & Network Addresses
- Send HELLO Packets



Routing Algorithms

Link State Routing

Each Router do the following:

- Learn their Neighbours & Network Addresses

  Send HELLO Packets

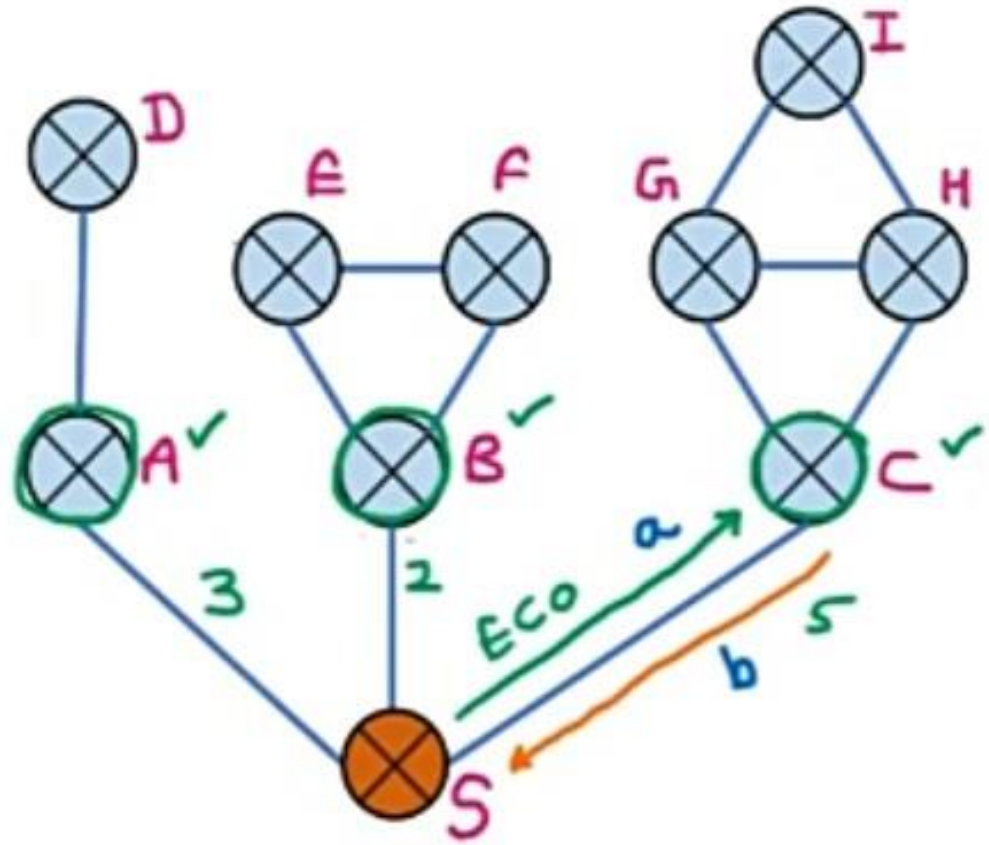
- Measure Delay or Cost to each of its Neighbours

  Send ECO Packets

  Round Trip Time = $a + b$

  Estimated Delay = $\frac{a+b}{2}$

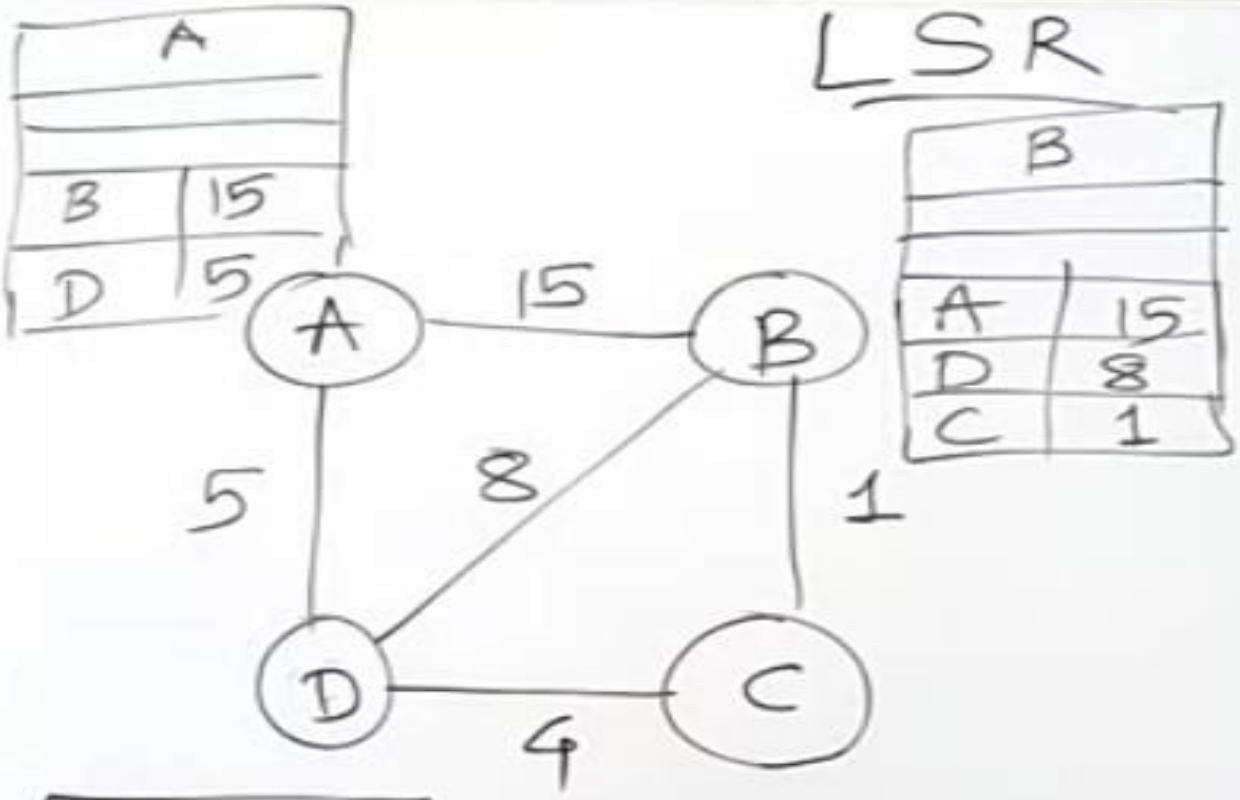
- Construct Packet telling all it has learned



S	
Seq	
Age	
A	3
B	2
C	5

- Send this Packet to all other Routers
- Compute Shortest Path to every other Router

LSR



A	
B	15
D	5

B	
A	15
D	8
C	1

D	
A	5
B	8
C	4

C	
D	4
B	1

Distance Vector Routing	Link State Routing
--> Bandwidth required is less due to local sharing, small packets and no flooding.	--> Bandwidth required is more due to flooding and sending of large link state packets.
--> Based on local knowledge since it updates table based on information from neighbors.	--> Based on global knowledge i.e. it have knowledge about entire network.
--> Make use of Bellman Ford algo	--> Make use of Dijkastra's algo
--> Traffic is less	--> Traffic is more
--> Converges slowly i.e. good news spread fast and bad news spread slowly.	--> Converges faster.
--> Count to infinity problem.	--> No count to infinity problem.
--> Persistent looping problem i.e. loop will there forever.	--> No persistent loops, only transient loops.
--> Practical implementation is RIP and IGRP.	--> Practical implementation is OSPF and ISIS.

Path Vector Routing

- There is a need for a third routing protocol which we call path vector routing.
- Path vector routing proved to be useful for interdomain routing.
- The principle of path vector routing is similar to that of distance vector routing.

Path Vector Routing

- Initialization

- At the beginning, each speaker node can know only the reachability of nodes inside its autonomous system.

- Node A1 is the speaker node for AS1, B1 for AS2, C1 for AS3, and D1 for AS4.

- Node A1 creates an initial table that shows A1 to A5 are located in ASI and can be reached through it.

- Node B1 advertises that B1 to B4 are located in AS2 and can be reached through B1 and so on.

path vector routing (BGP)

There is at least one node, called the speaker node, in each AS that creates a routing table and advertises it to speaker nodes in the neighboring ASs.

Only speaker nodes in each AS can communicate with each other.

Speaker node advertises the path, not the metric.

- **Sharing:**
  - A speaker in an autonomous system shares its table with immediate neighbors.
- **Updating:**
  - When a speaker node receives a table from its neighbor, it updates its own table by adding the nodes that are not in its routing table.
  - It also adds its own AS and the AS that sent the table.

The difference between the distance vector routing and path vector routing can be compared to the difference between a national map and an international map.

A national map can tell us the road to each city and the distance to be travelled if we choose a particular route; an international map can tell us which cities exist in each country and which countries should be passed before reaching that city.

Figure Initial routing tables in path vector routing

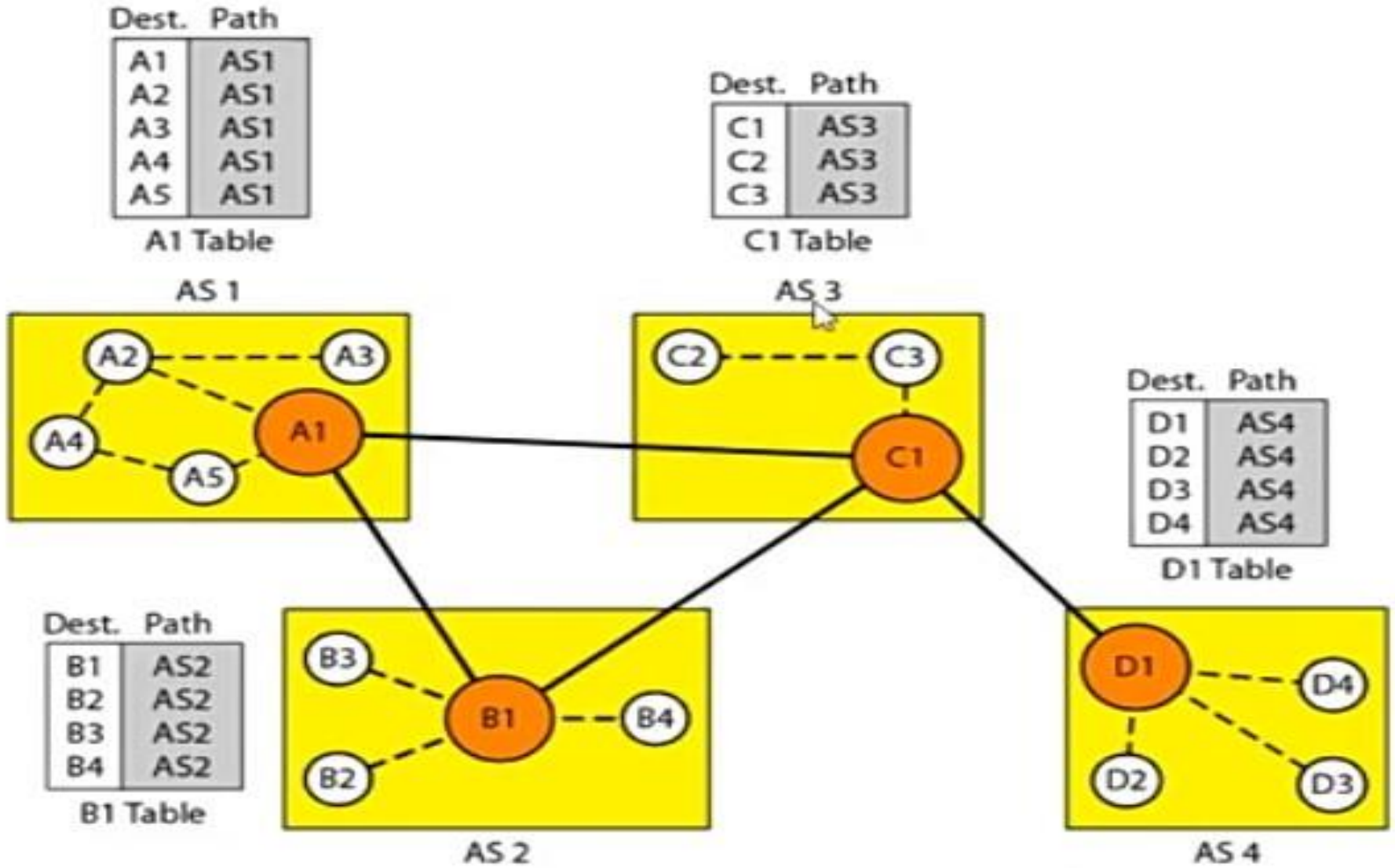


Figure Stabilized tables for three autonomous systems

Dest.	Path
A1	AS1
...	...
A5	AS1
B1	AS1-AS2
...	...
B4	AS1-AS2
C1	AS1-AS3
...	...
C3	AS1-AS3
D1	AS1-AS2-AS4
...	...
D4	AS1-AS2-AS4

A1 Table

Dest.	Path
A1	AS2-AS1
...	...
A5	AS2-AS1
B1	AS2
...	...
B4	AS2
C1	AS2-AS3
...	...
C3	AS2-AS3
D1	AS2-AS3-AS4
...	...
D4	AS2-AS3-AS4

B1 Table

Dest.	Path
A1	AS3-AS1
...	...
A5	AS3-AS1
B1	AS3-AS2
...	...
B4	AS3-AS2
C1	AS3
...	...
C3	AS3
D1	AS3-AS4
...	...
D4	AS3-AS4

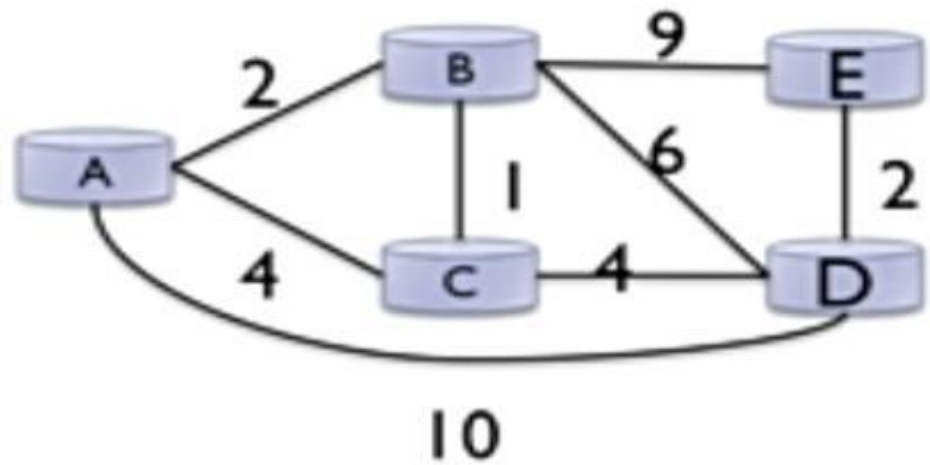
C1 Table

Dest.	Path
A1	AS4-AS3-AS1
...	...
A5	AS4-AS3-AS1
B1	AS4-AS3-AS2
...	...
B4	AS4-AS3-AS2
C1	AS4-AS3
...	...
C3	AS4-AS3
D1	AS4
...	...
D4	AS4

D1 Table

Graphs

- Graph
  - G = (Nodes, Edges)
- Nodes
  - Routers
  - { A, B, C, D, E }
- Edges
  - Links
  - { (A,B), (A,C), (A,D), (B,C), (B,D), (B,E), (C,D), (D,E) }



- Graphs are used to model connections between objects, people, or entities. They have two main elements: nodes and edges. Nodes represent objects and edges represent the connections between these objects.
- Dijkstra's Algorithm finds the shortest path between a given node (which is called the "source node") and all other nodes in a graph.
- This algorithm uses the weights of the edges to find the path that minimizes the total distance (weight) between the source node and all other nodes.

- In computer networks, the shortest path algorithms aim to find the optimal paths between the network nodes so that routing cost is minimized.

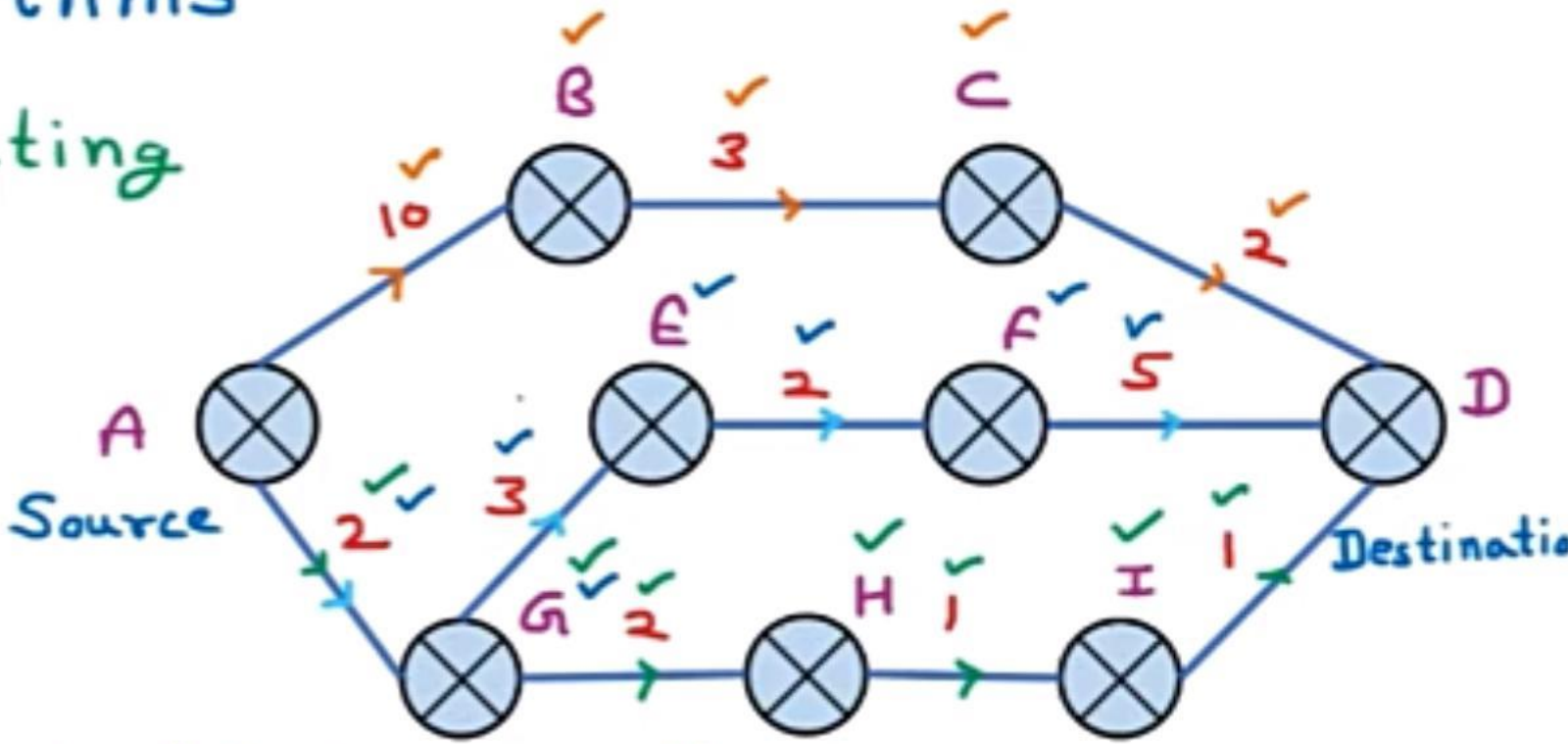
- They are direct applications of the shortest path algorithms proposed in graph theory.

- **Common Shortest Path Algorithms**

- Bellman Ford’s Algorithm
- Dijkstra’s Algorithm
- Floyd Warshall’s Algorithm

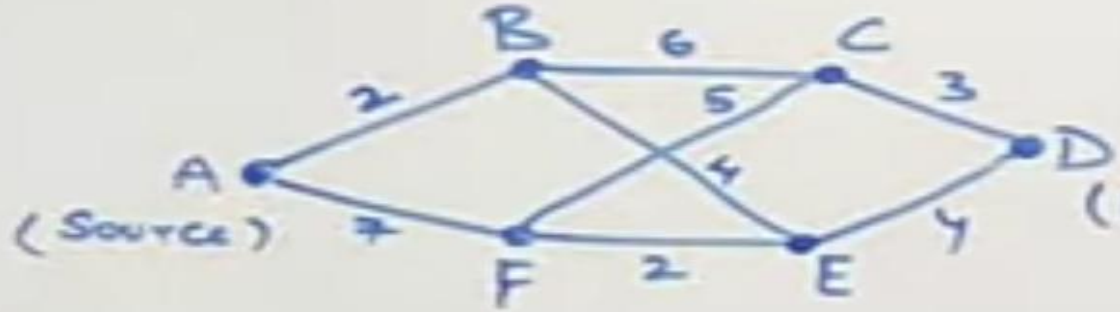
Routing Algorithms

Shortest Path Routing



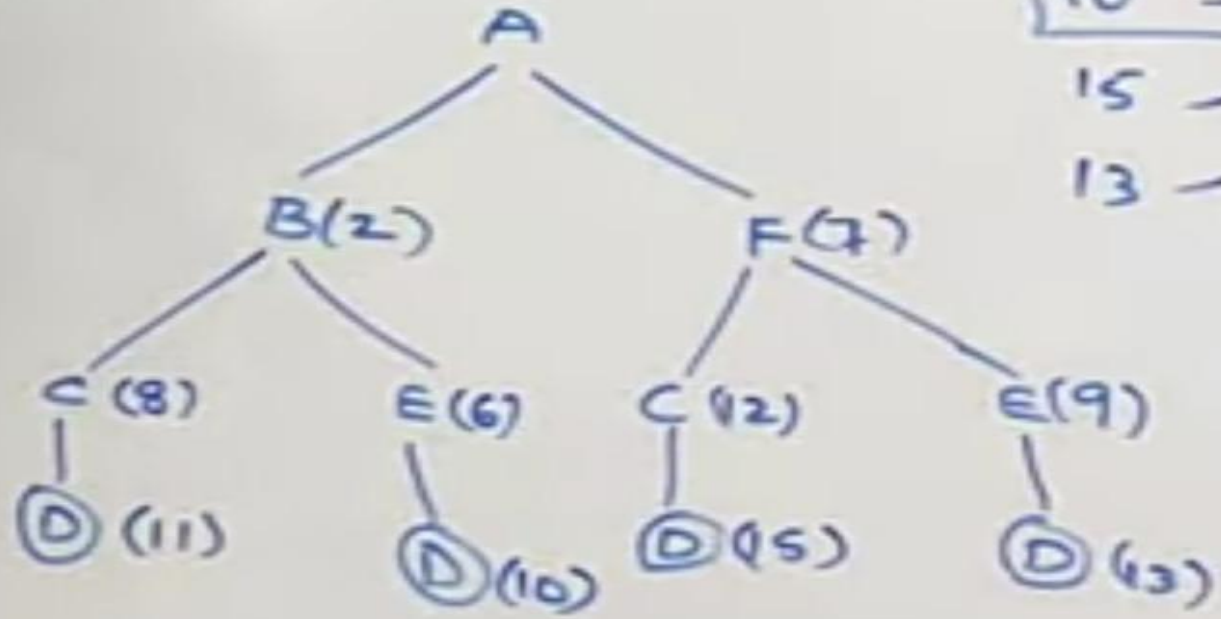
Paths	Geographical Distance	Number of Hops
A → B → C → D	10 + 3 + 2 = 15	2
A → G → H → I → D	2 + 2 + 1 + 1 = 6	3
A → G → E → F → D	2 + 3 + 2 + 5 = 12	3

Shortest Path Routing Algorithm



Time

Tree



11 — A B C D

10 — A B E D

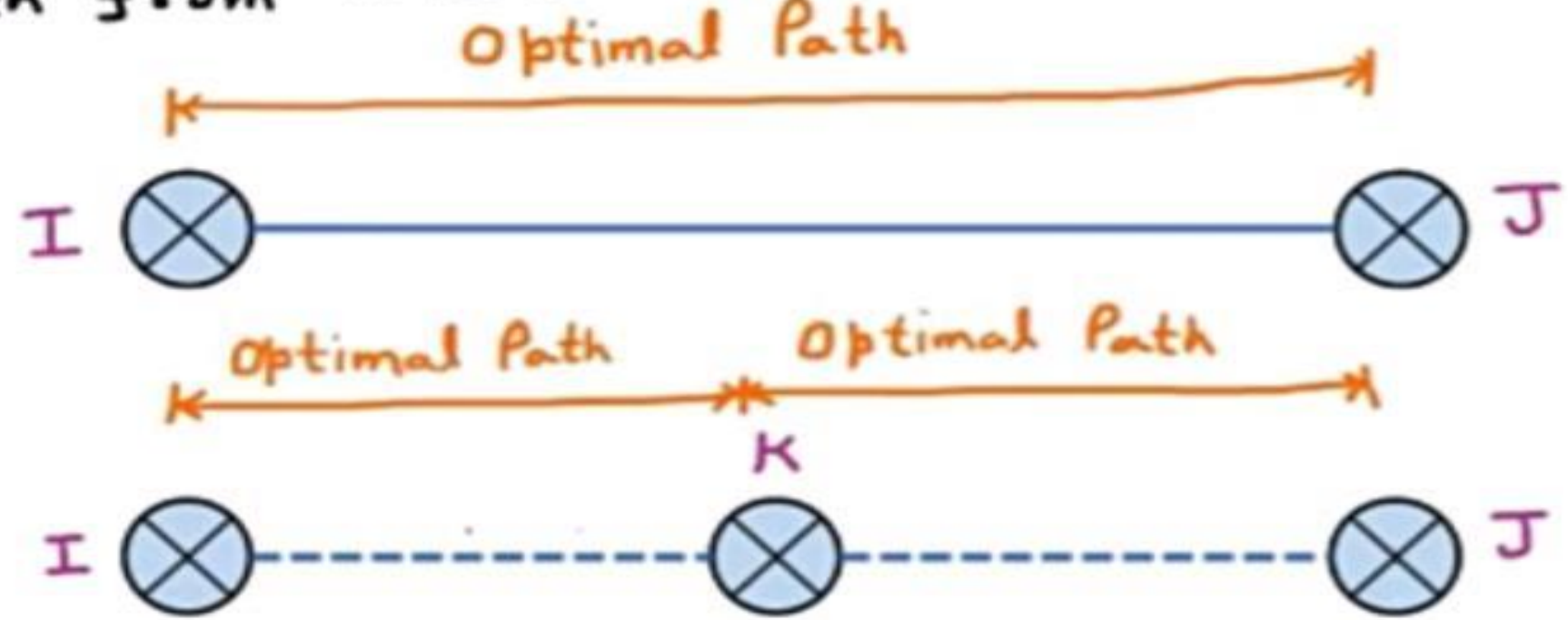
15 — A F C D

13 — A F E D

Routing Algorithms

Optimality Principle

- If path from I to J is optimal then if any Router exist between I & J ie. K then path from I to K and K to J will be optimal

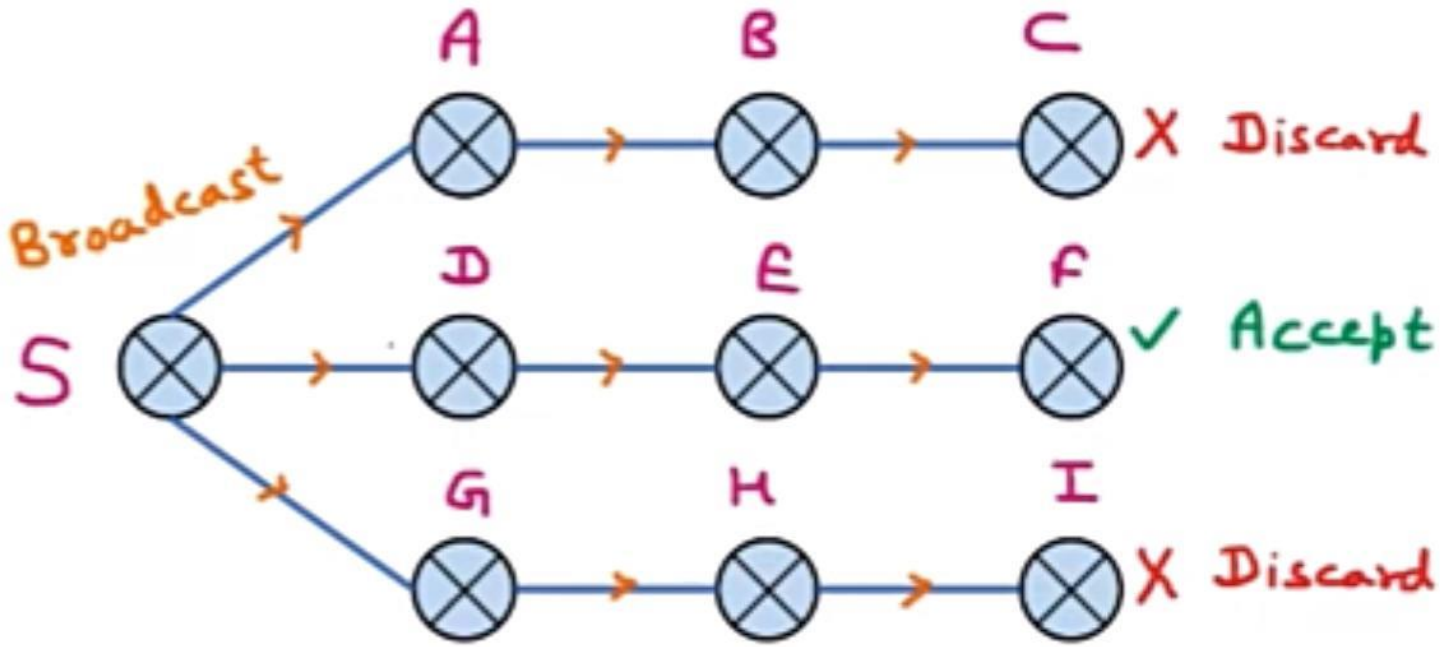


Routing Algorithms

Flooding

- Source do not having idea about destination

- Every incoming packet is sent out on every outgoing line except the one it arrived on



Disadvantage

- Duplicate Packet

Applications

- Military, Distributed Database

Types of Routing Protocol:

Various types of routing protocols are :

- Routing Information Protocols (RIP) :
- Interior Gateway Routing Protocol (IGRP) :
- Open Shortest Path first (OSPF) :
- Exterior Gateway Protocol (EGP) :
- Enhanced Interior Gateway Routing Protocol (EIGRP) :
- Intermediate System-to-Intermediate System (IS-IS) :

Types of Routing Protocols

- Internal Gateway Protocol (IGP)
  - RIP
  - OSPF
  - EIGRP
- External Gateway Protocol (EGP)
  - BGP
  - EGP

IGP (Interior Gateway Protocol)
OSPF – EIGRP - RIP

Interior Gateway Protocol

- Routing protocols used within an autonomous system
- All routers will be routing within the same Autonomous boundary
- RIP, IGRP, EIGRP, OSPF, IS-IS

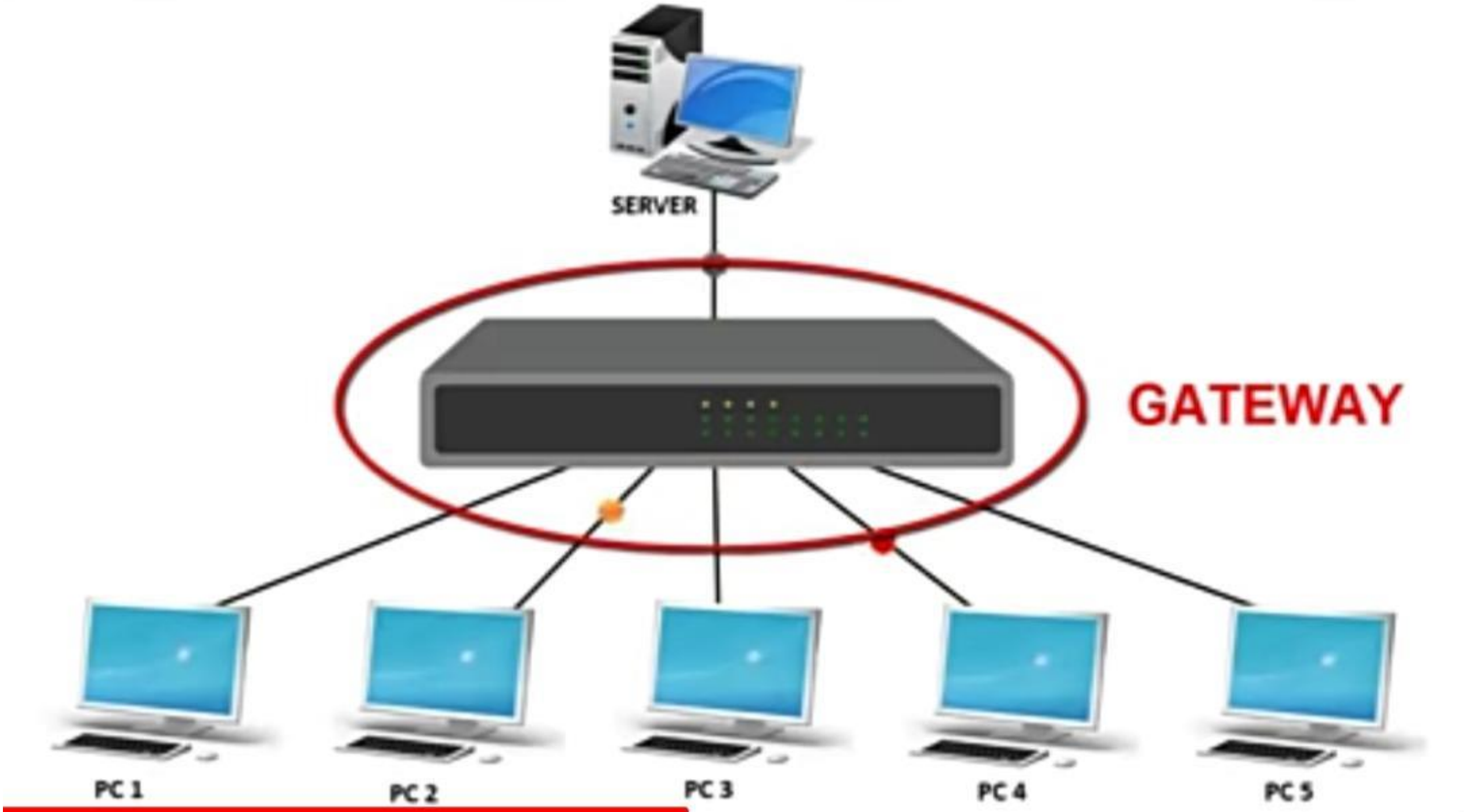
Exterior Gateway Protocol (BGP)

- Routing protocol used between different autonomous systems
- Routers in different AS need an EGP
- Border Gateway Protocol is extensively used as EGP

What is Gateway

- A gateway is a network node that connects two networks using different protocols together.

- it also acts as a "gate" between two networks. It may be a router, firewall, server, or other device that enables traffic to flow in and out of the network.


SERVER
GATEWAY
PC 1
PC 2
PC 3
PC 4
PC 5

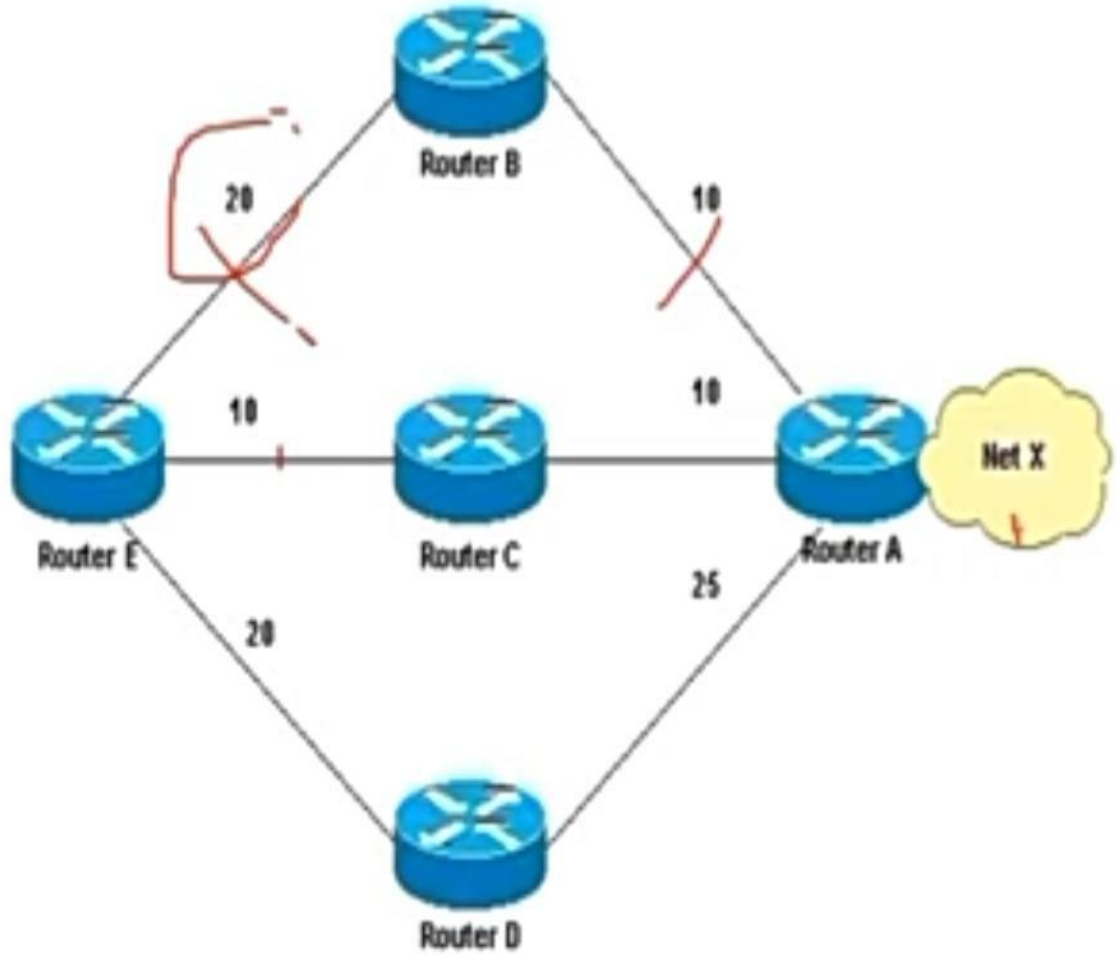
HUB	SWITCH	ROUTER
HUB works in Physical Layer of OSI Model.	SWITCH works in Data Link Layer of OSI Model.	ROUTER works in Network Layer of OSI Model
HUB is a broadcast device	SWITCH is a multicast device	ROUTER is a routing device use to create route for transmitting data packets.
HUB is use to connect devices in the same network.	SWITCH is use to connect devices in the same network	ROUTER is use to connect two or more different network.
HUB sends data in the form of packets.	SWITCH sends data in the form of frames.	ROUTER sends data in the form packets.
HUB only works in half duplex.	SWITCH works in full duplex.	ROUTER works in full duplex.
Only one device can send data at a time.	Multiple devices can send data at the same time.	Multiple devices can send data at the same time.
HUB does not store any mac/ IP address to transfer data.	SWITCH stores and uses MAC address of a devices to transfer data.	ROUTER uses IP address to transfer data.

Difference between Router and Gateway

ROUTER	GATEWAY
Network device that forwards packets from one network to another. Based on internal routing tables, routers read each incoming packet and decide how to forward it. Routers work at the network layer (layer 3) of the protocol	Device that converts one protocol or format to another. A network gateway converts packets from one protocol to another. The gateway functions as an entry/exit point to the network.
Route traffic from one network to other.	Translate from one protocol to other
Routers provide additional features like DHCP server, NAT, Static Routing, and Wireless Networking/IPv6 address , Mac address	Protocol conversion like VoIP to PSTN or Network Access Control etc.
Supports dynamic routing	Does not support dynamic routing
Works on Layer 3 and Layer 4 of OSI Model	Works up to Layer 5 of OSI Model

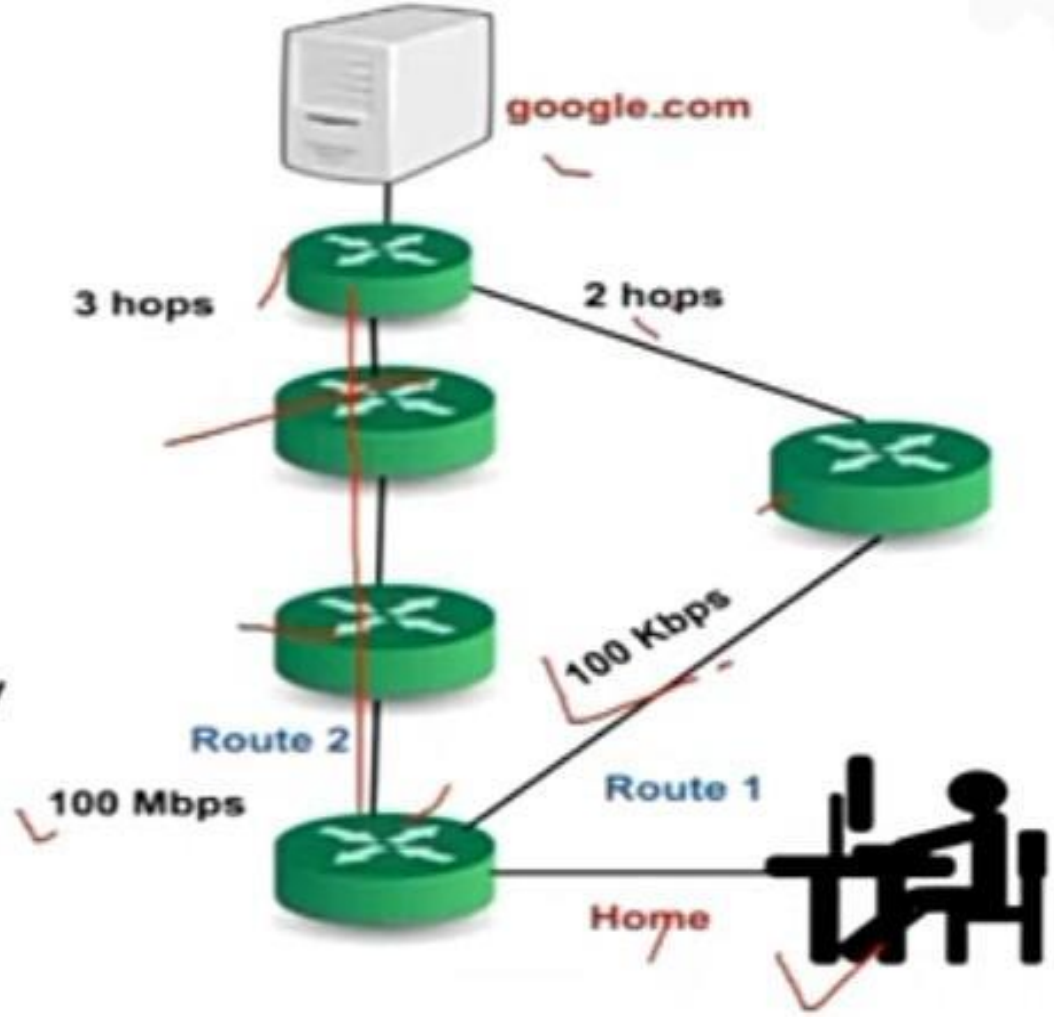
Interior Gateway Routing Protocol (IGRP) :

- It is distance vector Interior Gateway Routing Protocol (IGRP).
- It is used by router to exchange routing data within an independent system.
- Interior gateway routing protocol created in part to defeat the confines of RIP in large networks.
- It maintains multiple metrics for each route as well as reliability, delay load, and bandwidth.
- It measured in classful routing protocol, but it is less popular because of wasteful of IP address space.



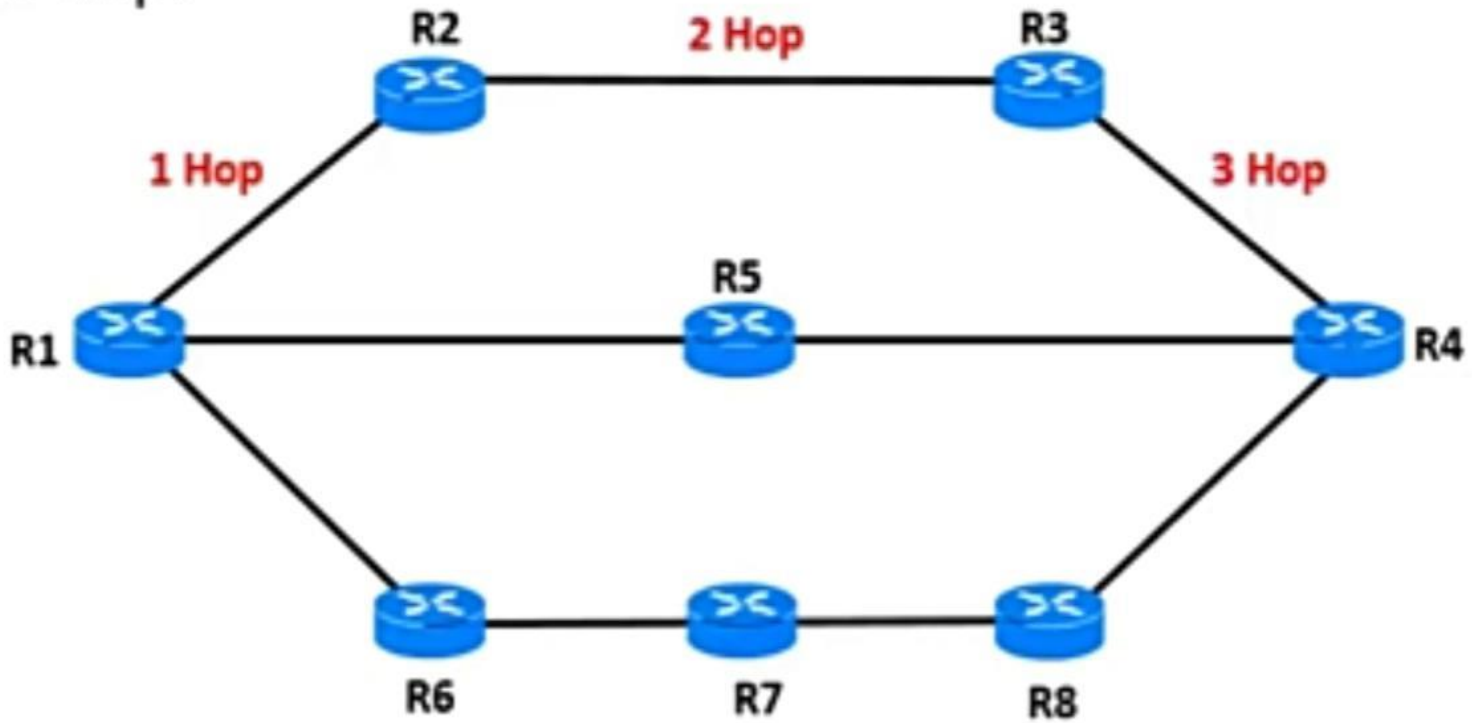
Routing Information Protocols (RIP) :

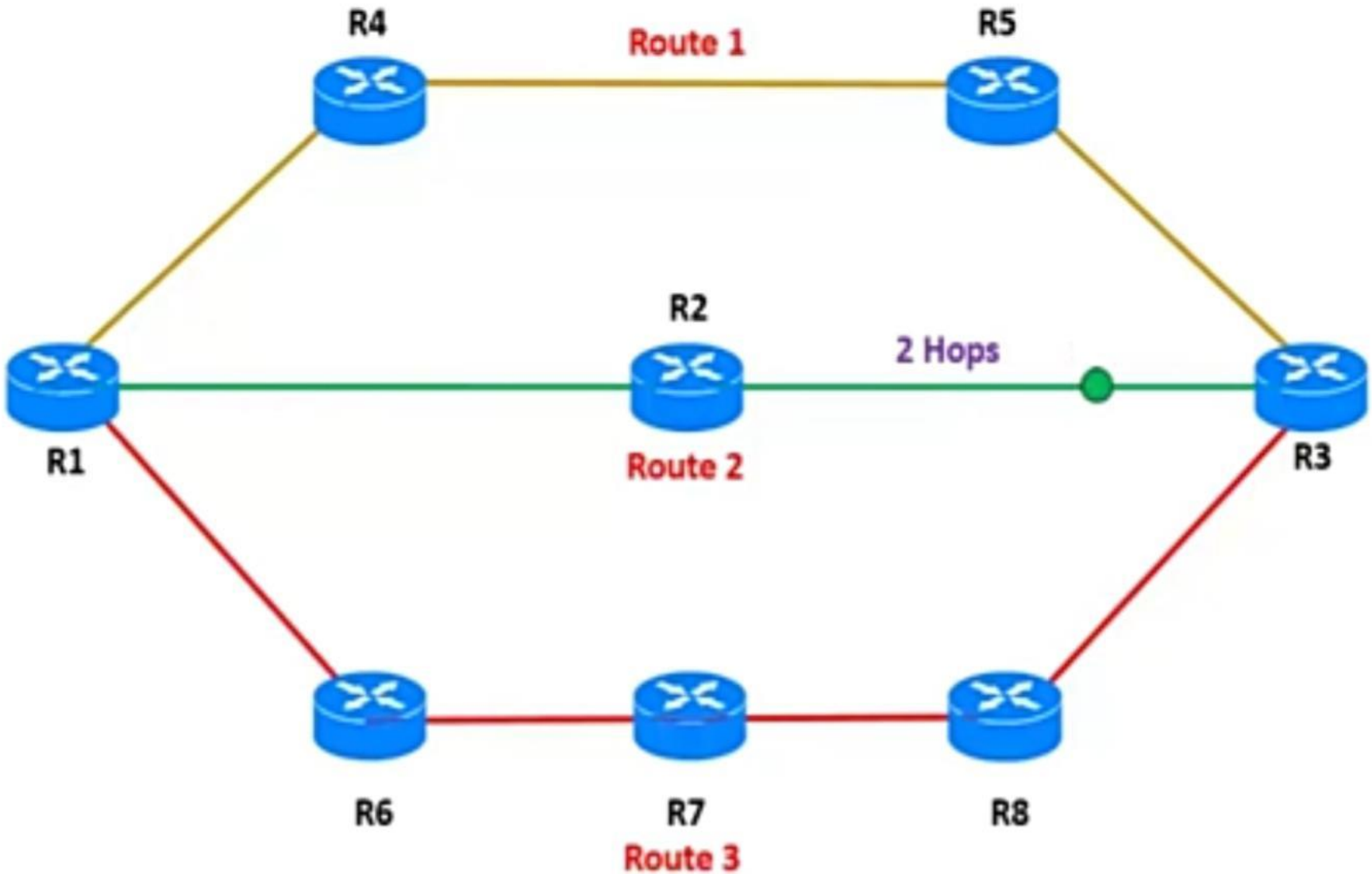
- RIP is dynamic routing protocol which uses hop count as a routing metric to find best path between the source and destination network.
- RIP (Routing Information Protocol) is a forceful protocol type used in local area network and wide area network.
- RIP is categorized as an interior gateway protocol within the use of distance vector algorithm.

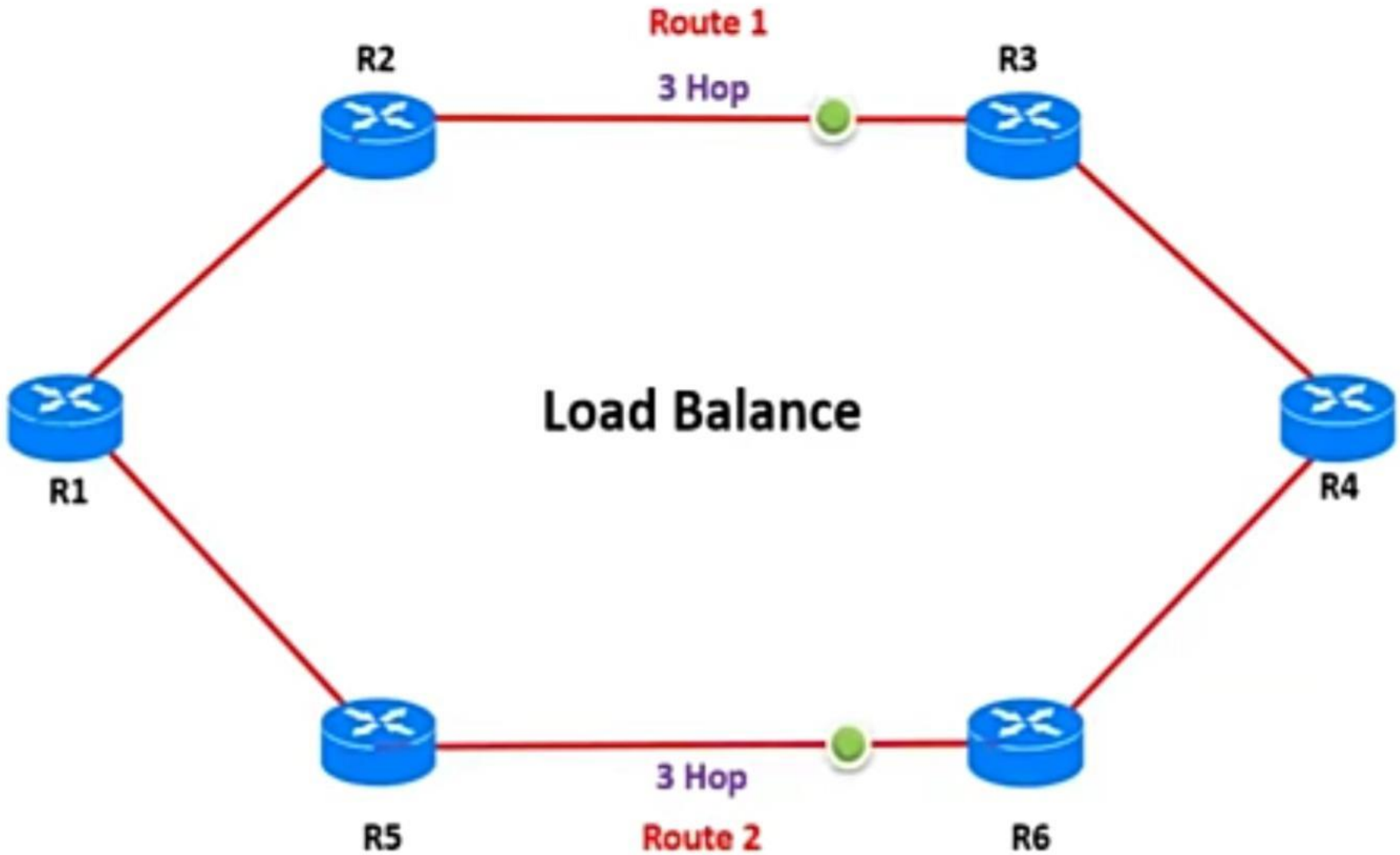


RIP (ROUTING INFORMATION PROTOCOL)

- RIP stands for Routing Information Protocol. It is a distance vector protocol based on hop count matrix.
- When a router forward a data packet to a network segment, it is counted as a single hop.




R4
Route 1
R5
R2
2 Hops
R1
Route 2
R3
R6
R7
R8
Route 3

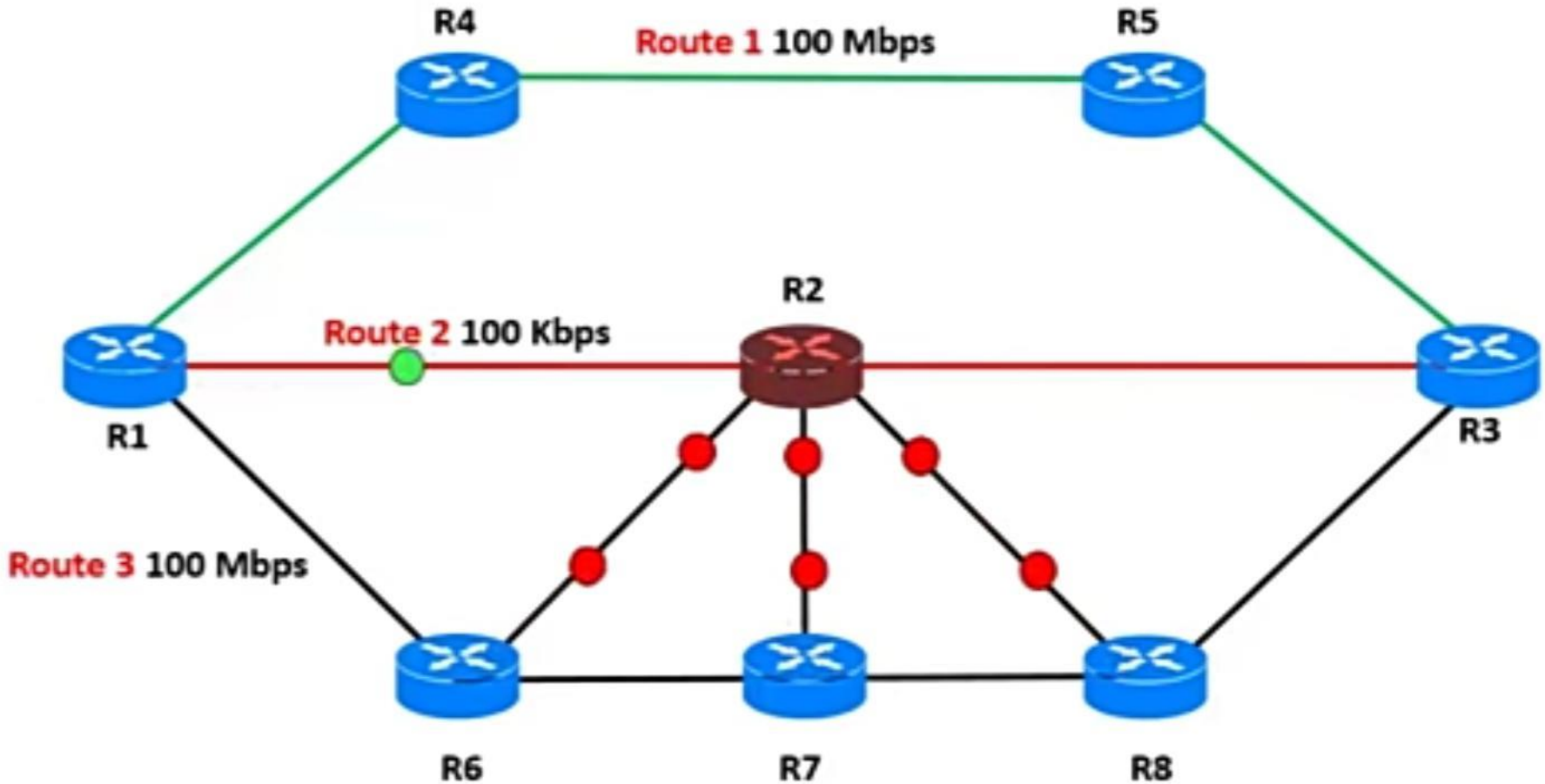

Route 1
R2
3 Hop
R3
Load Balance
R1
R4
3 Hop
R5
Route 2
R6

Advantages of RIP

- *It is easy to configure*
- *There is no Complexity*
- *Less CPU utilization.*

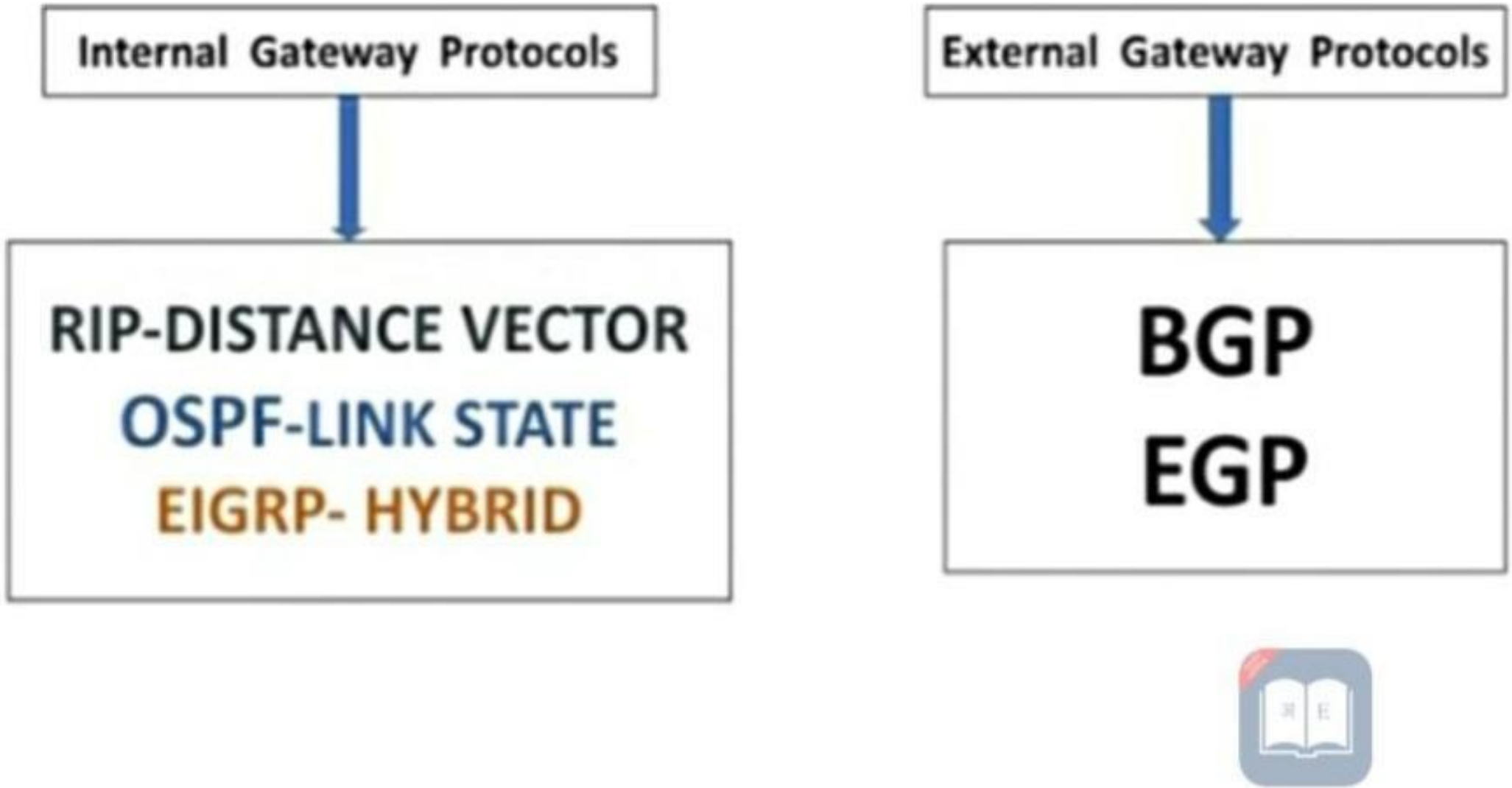
Disadvantages of RIP

- It is only based on hop count matrix. So if there is better route available with more bandwidth, RIP is not going to choose that particular route.

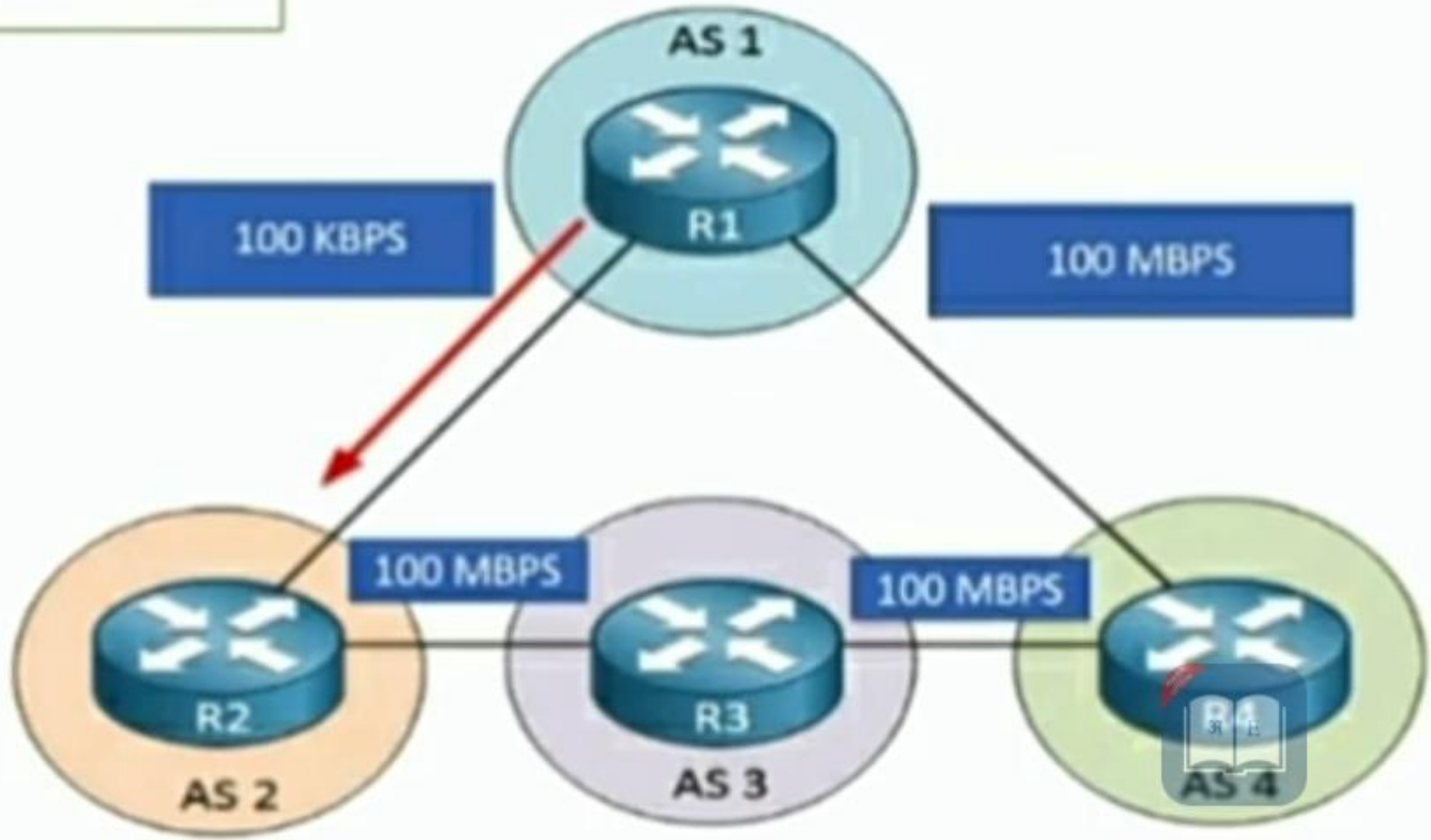


Disadvantages of RIP

- *It is only based on hop count matrix. So if there is better route available with more bandwidth, RIP is not going to choose that particular route.*
- *RIP is a class full routing protocol and it does not support VLSM.*
- *It broadcast the updates to the entire network and simply creates a lots of traffic.*
- *Bandwidth utilization is very high as it broadcast its update in every 30 second.*
- *RIP supports maximum 15 hops (0-15), means maximum 16 routers can be configured in RIP not more than that.*
- *Slow convergence. (It means, the time any link goes down it should quickly choose an alternate route but in RIP it takes long time)*

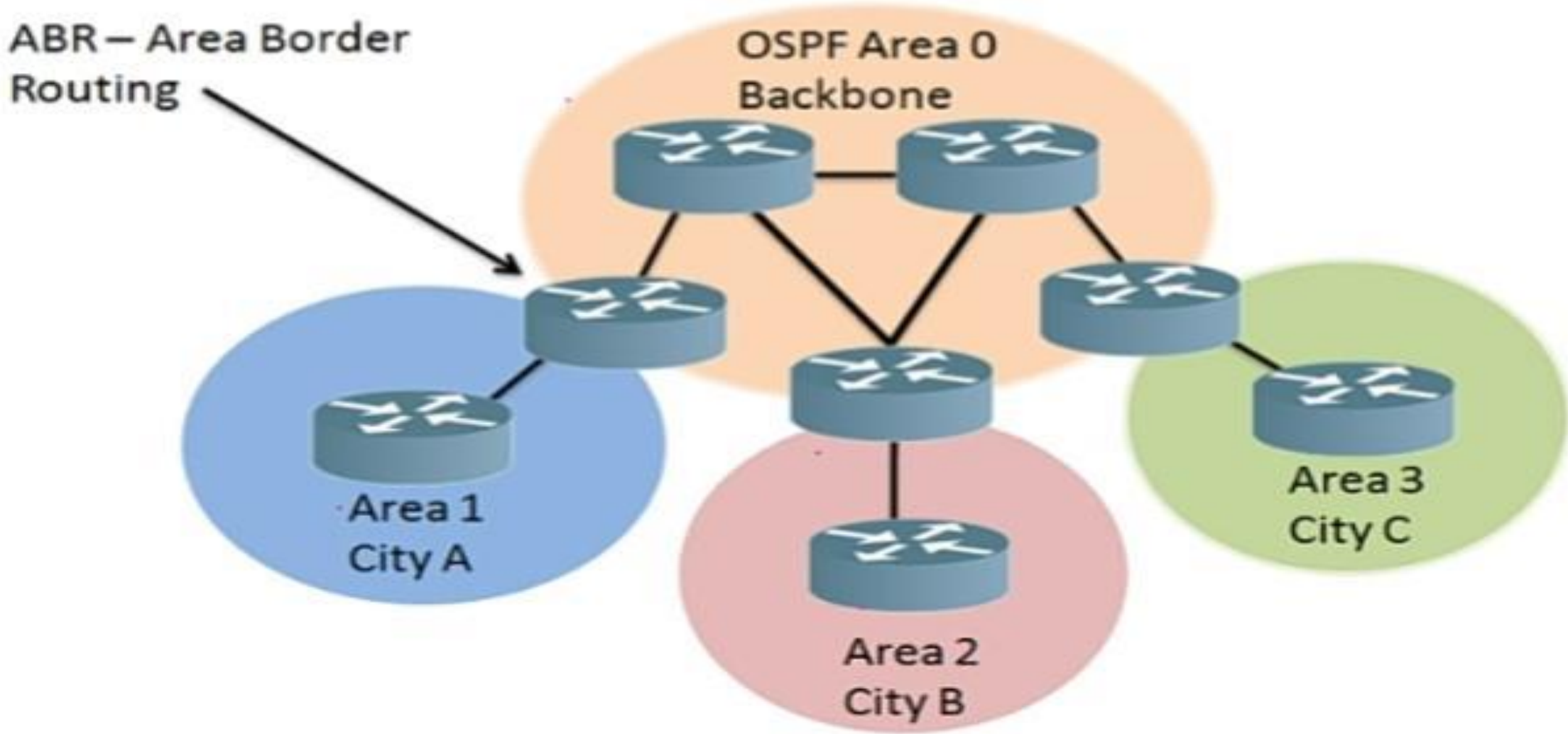

Internal Gateway Protocols
RIP-DISTANCE VECTOR
OSPF-LINK STATE
EIGRP- HYBRID
External Gateway Protocols
BGP
EGP

LINK STATE



OSPF – Open Shortest Path First

- OSPF stand for open shortest path first
- Standard Protocol
- sends hello packet every 10 seconds
- it's a link state protocol
- Unlimited hop count
- Metric is cost
- Administrative distance is 110
- It is a classless routing protocol


ABR – Area Border Routing
OSPF Area 0 Backbone
Area 1 City A
Area 2 City B
Area 3 City C

EIGRP(Enhanced Interior Gateway Routing Protocol)

EIGRP is hybrid protocol, it has advantages of both link state and distance vector protocol.

It sends partial or full update only when something is change in network.

It maintains three tables as follows.

- Neighbor Table
- Topology Table
- Routing Table

EIGRP Tables

EIGRP Neighbor Table

- *Lists all directly connected neighbors*
- Next Hop of the Router
- Interface connected to the Neighbor

EIGRP Topology Table

- *Lists all learned routes from all EIGRP neighbors*
- Metric
- Feasible distance / Advertise distance

Routing Table

- *Best routes from EIGRP topology table will be copied to the routing table.*

Neighbour Table

The neighbour table is used to store the condition of the directly connected neighbours, it means whether the directly connected router is in active or non active status, the neighbour table is going to store this information.

For example, router 1 and router 2 are directly connected to each other. Here both the routers are going to sends the hello packets after every 5 seconds.

The two routers consider each other alive as long as they continue to exchange the packets. If the router unable to receive a hello packets in 5 seconds, it understand that the link is down and forward this information to another connected router and like this all the router are getting up to date about the link failure of a particular router in a network.

Topology Table

The topology table is used to store the advertisements of the destinations by the neighbours.

The advertisement consist of:

- The destination address
- The neighbour that are linked with the destination.
- The metrics used by the neighbour to reach the destination.

For example, router 1 wants to reach to the router 3. It is not going to receive any advertisement from the router 3 instead of this it will received the advertisement from the router 2. Because Router 2 knows the best route to reach the Router 3 and Router 1 knows the best route to reach the router 2 and like this all the routers configured with EIGRP do the calculations and update the route to their routing table.

Routing Table

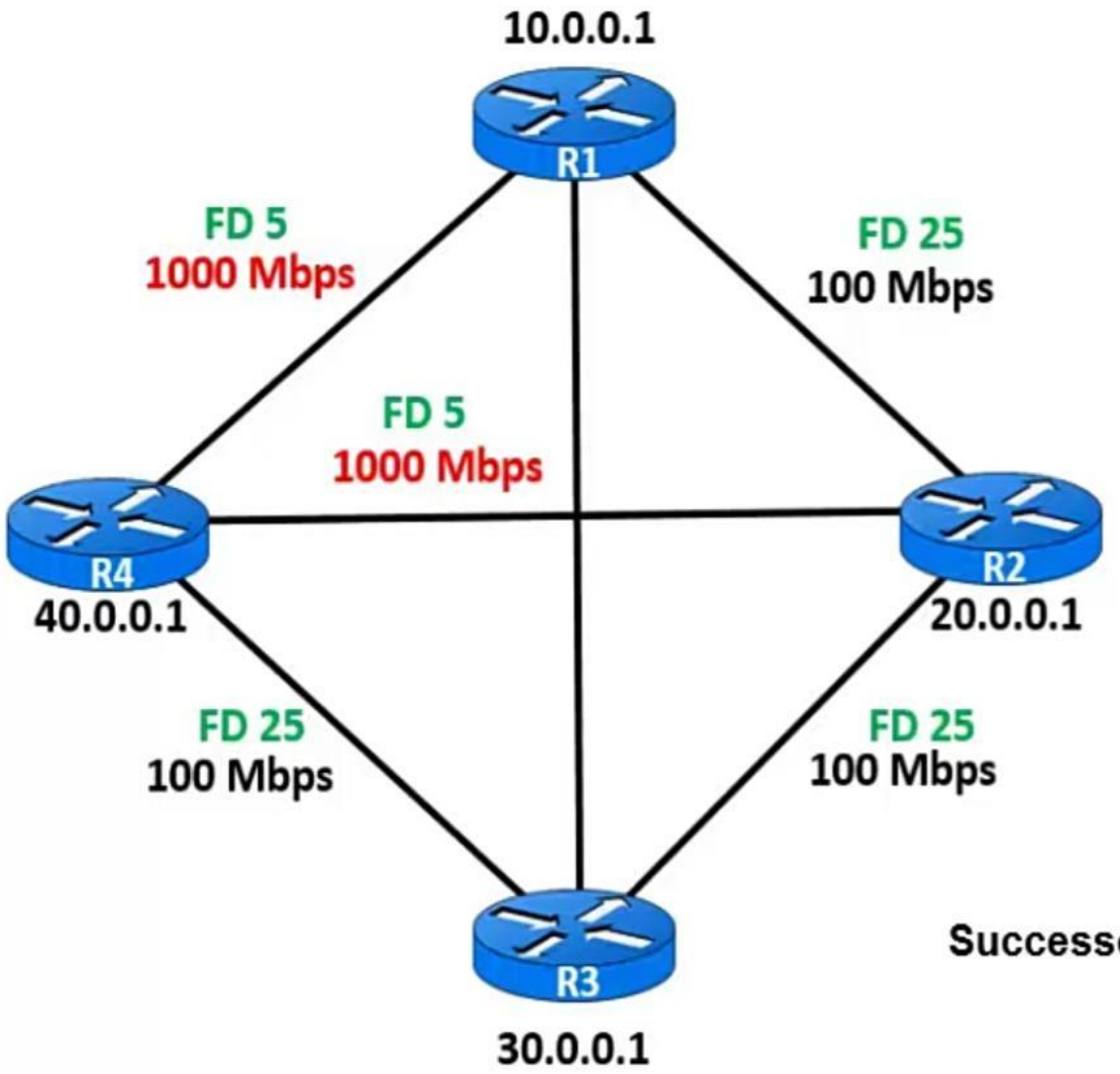
The Routing table is used to store all the possible route to reach the destination.

Successors

The successor is the path with the best metric. It means, the successors is the best available route in the routing table to reach the destination and the router is going to choose this route first.

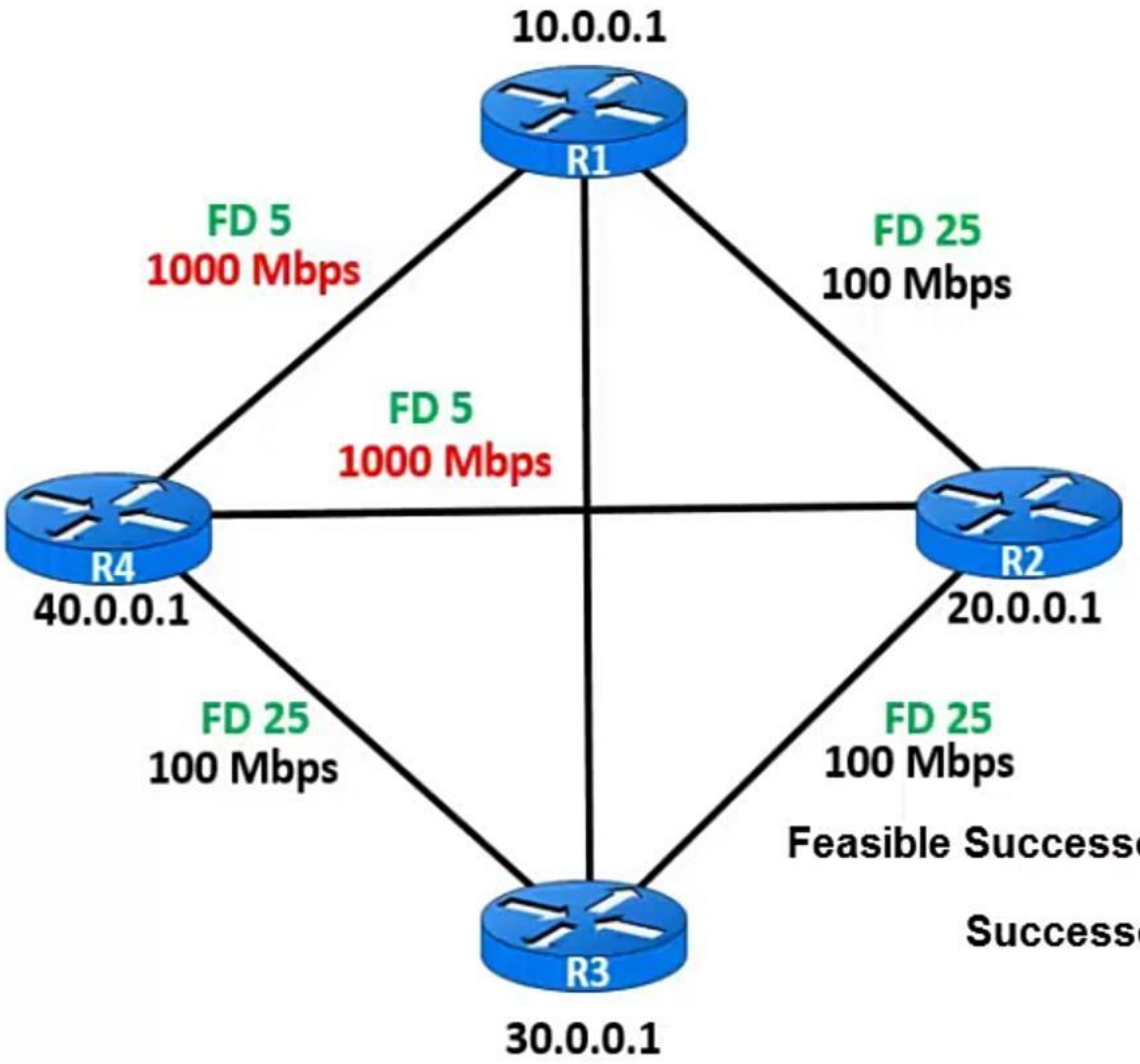
Feasible Successors

A feasible successor is the backup route. A path is considered as feasible, if the path distance is less than the original path to reach the destination. It becomes the first choice, when the successor path is inactive or in the invalid status. or



ROUTER 1 ROUTING TABLE

	Route	Bandwidth	Total FD
	R1 – R2	100 Mbps	25
Successor	R1 – R4 – R2	1000 Mbps – 1000 Mbps	10
	R1 – R4 – R3 – R2	1000 Mbps – 100 Mbps – 100 Mbps	55
	R1 – R3 – R2	1000 Mbps – 100 Mbps	30



Feasible Successor

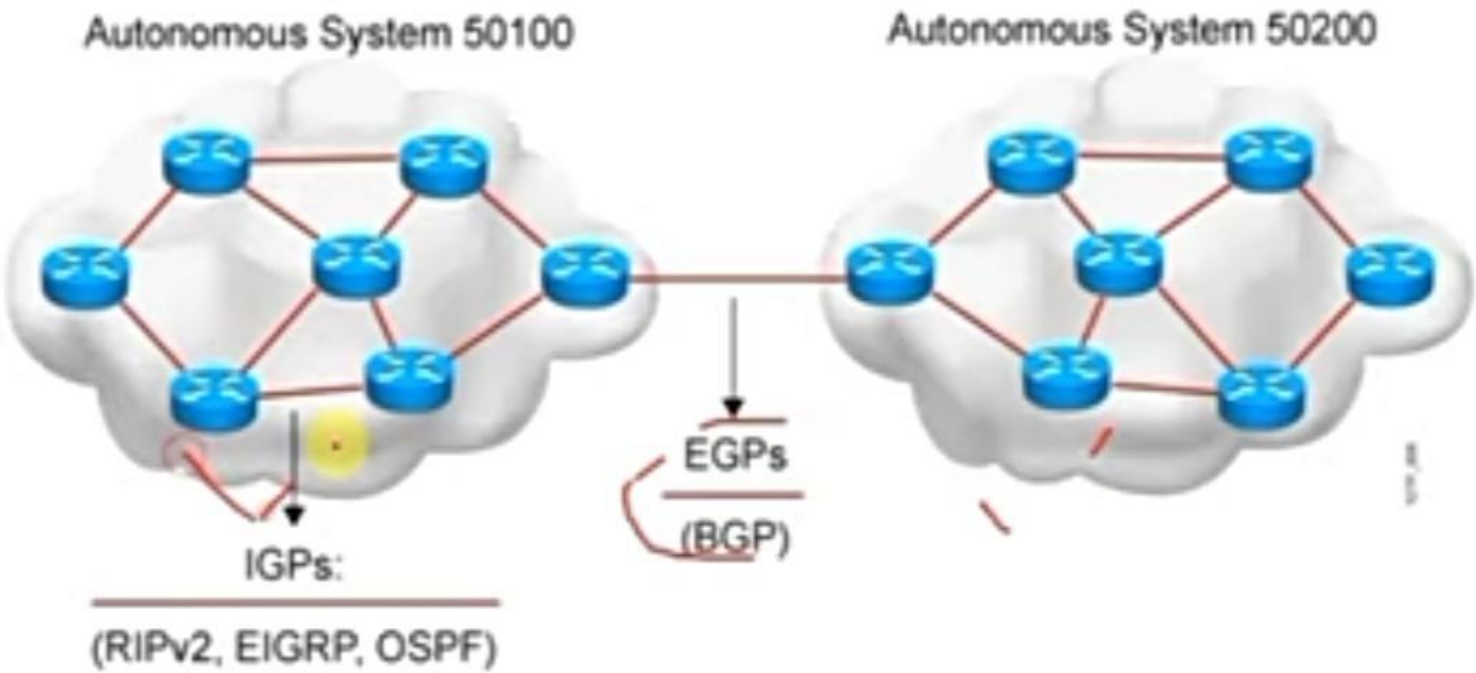
Successor

ROUTER 1 ROUTING TABLE

Route	Bandwidth	Total FD
R1 – R2	100 Mbps	25
R1 – R4 – R2	1000 Mbps – 1000 Mbps	10
R1 – R4 – R3 – R2	1000 Mbps – 100 Mbps – 100 Mbps	55
R1 – R3 – R2	1000 Mbps – 100 Mbps	30

Exterior Gateway Protocol (EGP) :

- The absolute routing protocol for internet is exterior gateway protocol.
- EGP (Exterior Gateway Protocol) is a protocol for exchanging routing table information between two neighbor gateway hosts.
- The Exterior Gateway Protocol (EGP) is unlike distance vector and path vector protocol



WHAT IS BGP ?

- Border Gateway Protocol BGP-4.
- It's an Inter-Domain routing protocol.
- It uses a path vector algorithm for best path selection.
- It uses TCP port 179 for connection establishment.
- Neighbors are explicitly defined.
- Use routing policies to decide how to advertise networks.

BGP Autonomous Systems

- *An AS is a collection of networks under a single technical administration.*
- *IGPs operate within an AS.*
- *BGP is used between autonomous systems.*
- *Exchange of loop-free routing information is guaranteed.*