Course 4 : IP ROUTING

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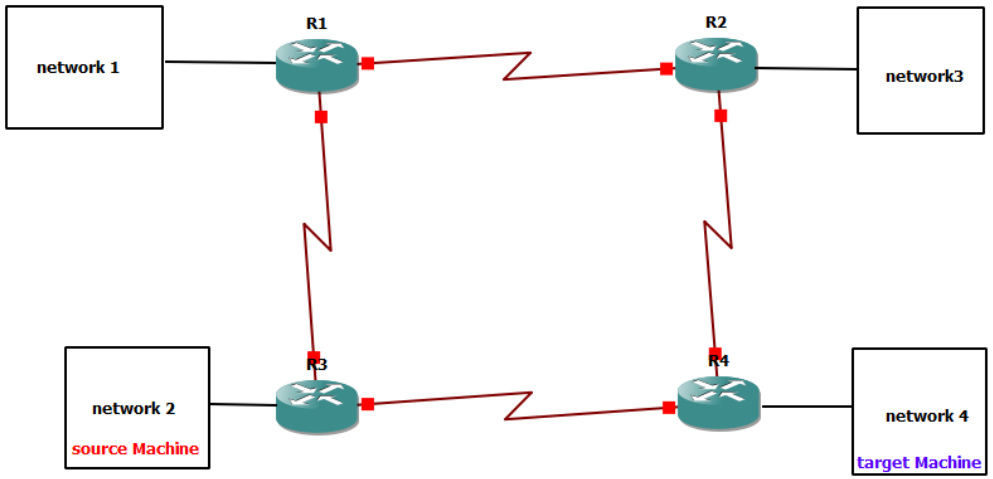
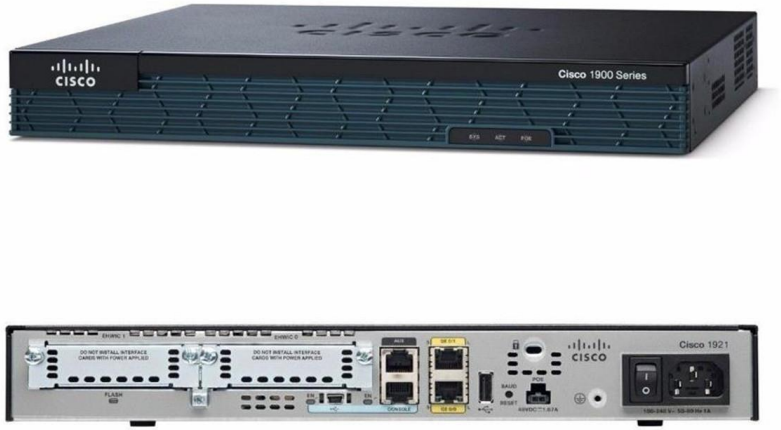
- IP routing is the process that defines the shortest path through which data travels to reach from source to destination in different networks.
- IP routing is done by Routers



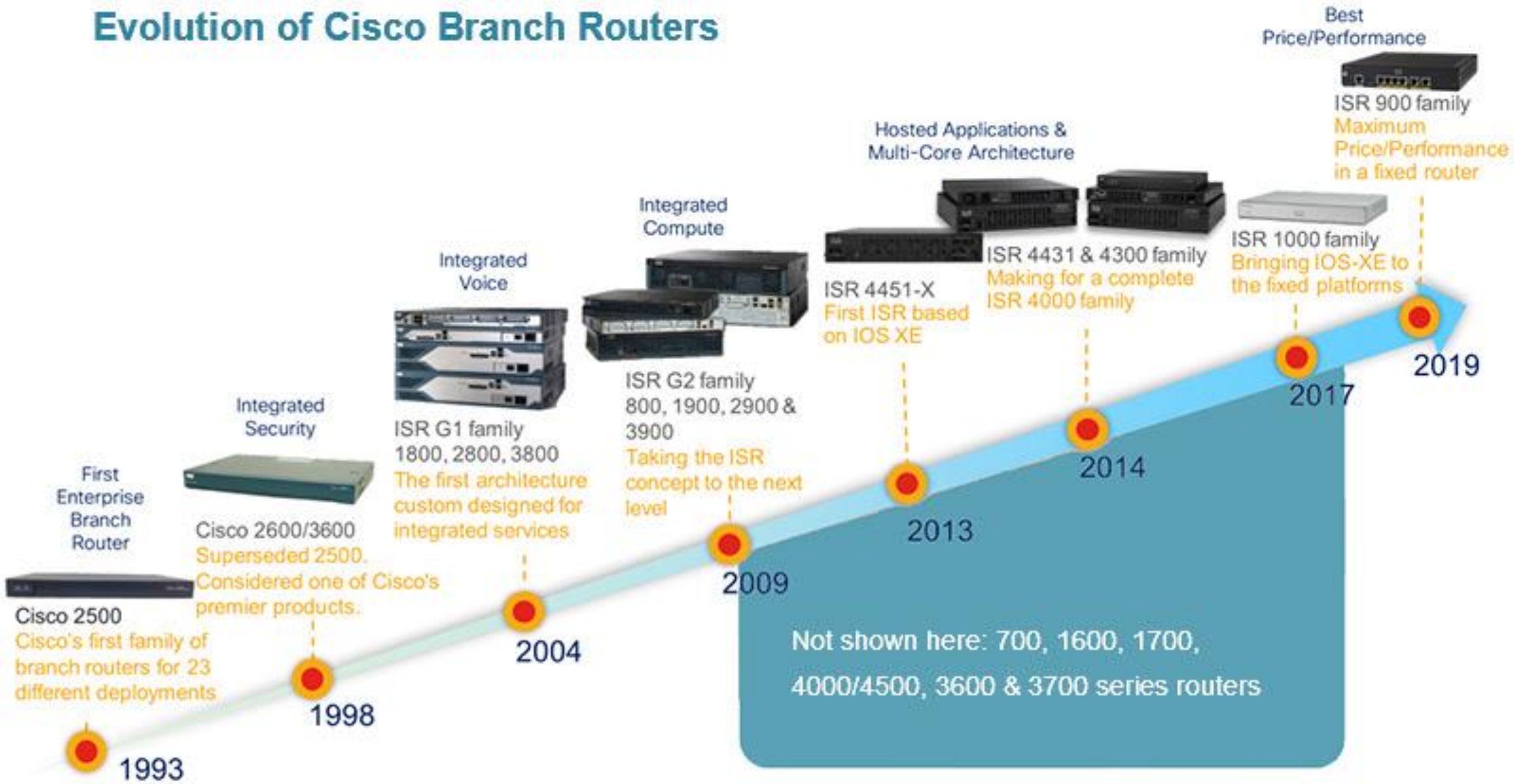
What is a Router ?

- A Router is a networking device that forwards data packets between computer network.
- Usually connected to two or more different networks



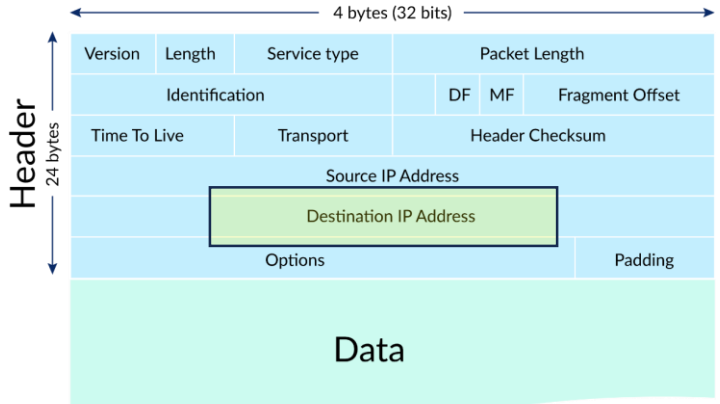
Some CISCO Routers

Evolution of Cisco Branch Routers



Routing Table

- Located in the router (RAM memory) and stores the routing information.
- When a packet arrives. The Router examines destination IP address of a received packet and make routing decisions accordingly.
- Routers use *Routing Tables* to determine out which interface the packet will be sent.
- A routing table lists all networks for which routes are known.



Destination	Subnet mask	Interface
128.75.43.0	255.255.255.0	Eth0
128.75.43.0	255.255.255.128	Eth1
192.12.17.5	255.255.255.255	Eth3
default		Eth2

Example of a routing table

Entries of an IP Routing Table

- Each entry in the routing table consists of the following entries :
  1. **Network ID:** The network ID or destination corresponding to the route.
  2. **Subnet Mask:** The mask that is used to match a destination IP address to the network ID.
  3. **Next Hop:** The IP address to which the packet is forwarded
  4. **Outgoing Interface:** Outgoing interface the packet should go out to reach the destination network.
  5. **Metric:** A common use of the metric is to indicate the *minimum number of hops* (routers crossed) to the network ID.

How does IP routing work?

- The router gets the destination address from the IP packet.
- Through its routing table identifies the next router information to which the data packet has to be passed.
- Different packets can be sent through different paths but all the packets reach their intended destination.

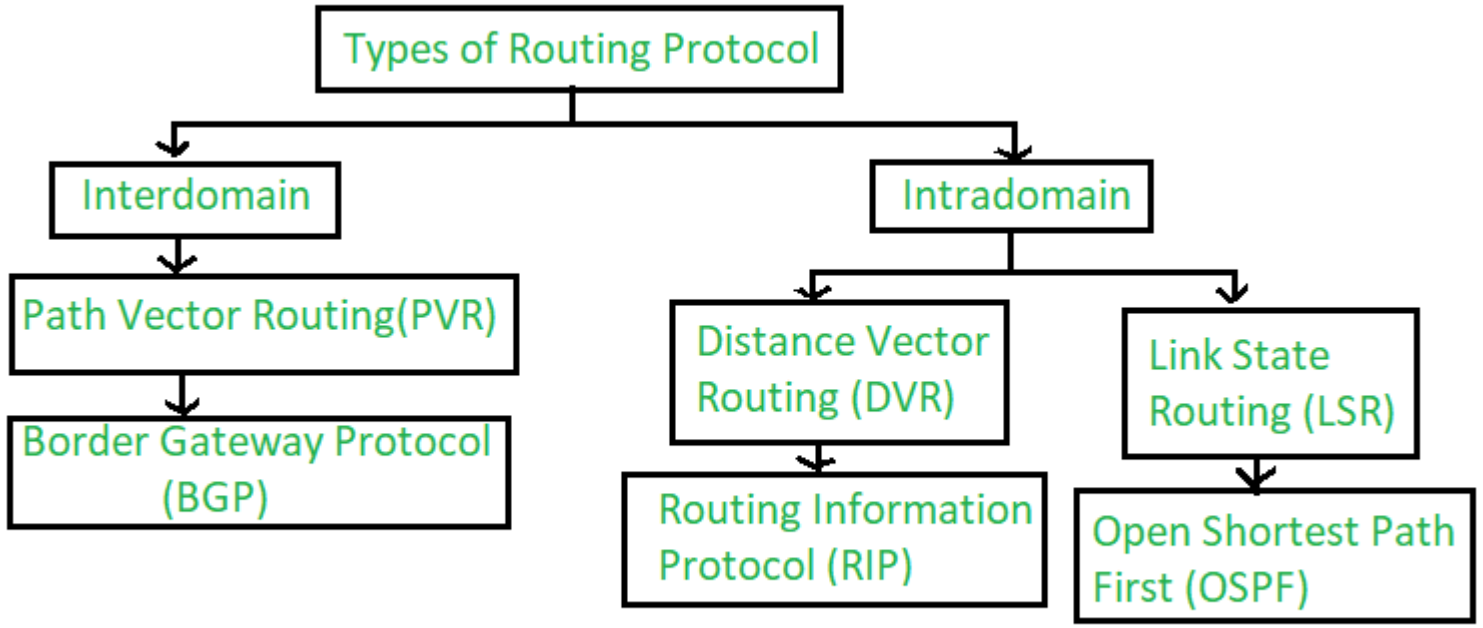
Different Types of Routing

There are three different types of routing:

1. **Static Routing :** The routing table is updated by the network administrator.
2. Dynamic Routing : The routing table is automatically updated using routing protocols.
3. Default Routing : The router is configured to send all the data towards a specific router.

Routing Protocols

- For taking routing decisions router needs various routing protocols and a routing table. The routing protocols are divided into two domains
  1. Interdomain Routing protocols
  2. Intradomain Routing protocols



Distance Vector Routing

- Distance vector routing uses **distance vectors** for routing.
- It uses the Bellman-Ford algorithm for the computation of various distances.
- **Routing Information Protocol(RIP)** is used in DVR for making routing decisions.
- DVR suffers from **count to infinity problem** which can be solved using split-horizon or route poisoning.

Link State Routing

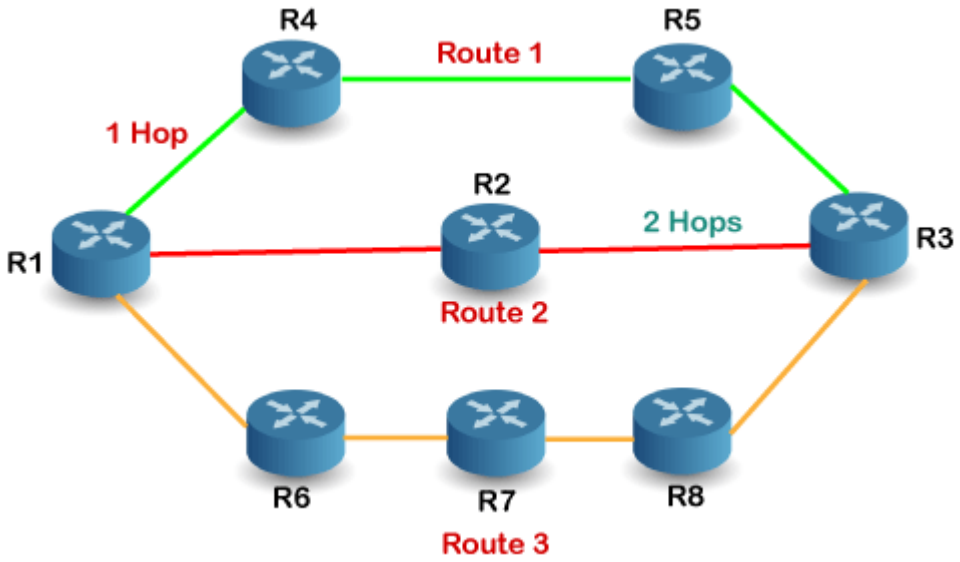
- Link State routing uses the state of the link for routing.
- It uses the Dijkstra algorithm for the computation of various distances.
- Open Shortest Path First(OSPF) is used in LSR for making routing decisions.
- LSR suffers from heavy traffic due to flooding.

RIP (Routing Information Protocol)

- RIP is a standardized Distance Vector protocol
- The network is a graph where nodes are the routers, and the edges are the links between them.
- Designed for use on smaller networks.
- The cost metric is the number of hops to reach the destination.
- In RIP, infinity is defined as 16

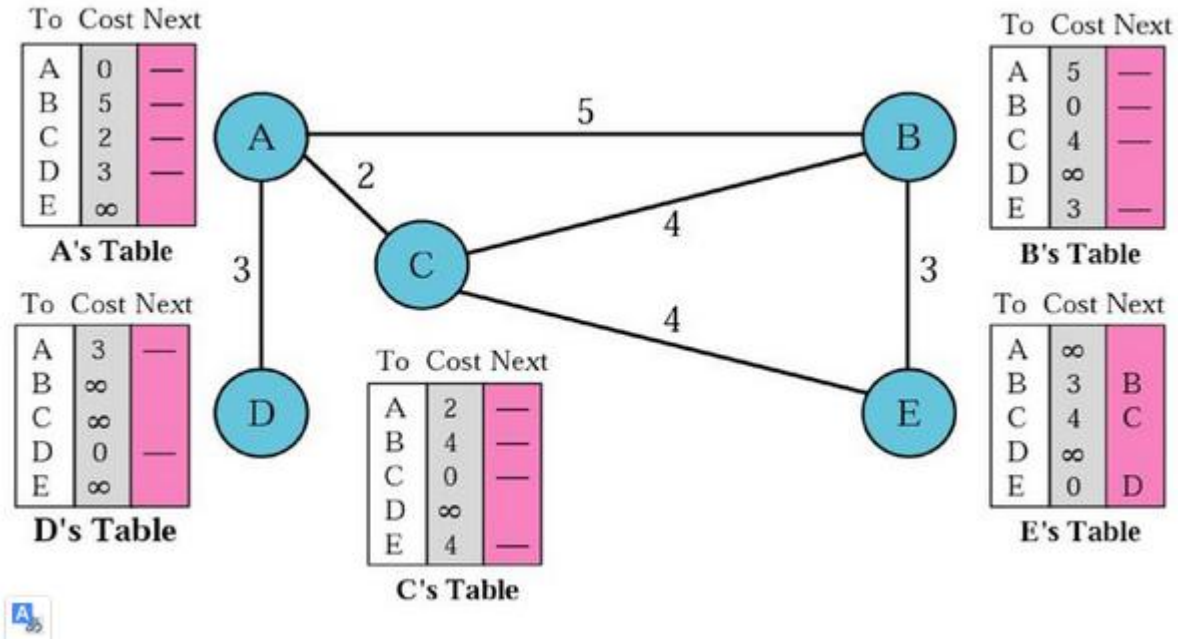
How does the RIP work?

- there are 8 routers in a network where Router 1 wants to send the data to Router 3.
- There are three routes in the above network.
- The Route 2 contains the least number of hops
- so RIP will choose Route 2.



RIP initialization

- At the beginning, each node can know only the distance between itself and its immediate neighbors, those directly connected to it



RIP : Sharing

- The whole idea of distance vector routing is the sharing of information between neighbors
- A node A does not know about node E, node C does.
- So if node C shares its routing table with A, node A can also know how to reach node E
- Note: In distance vector routing, each node shares its routing table with its immediate neighbors periodically and when there is a change.

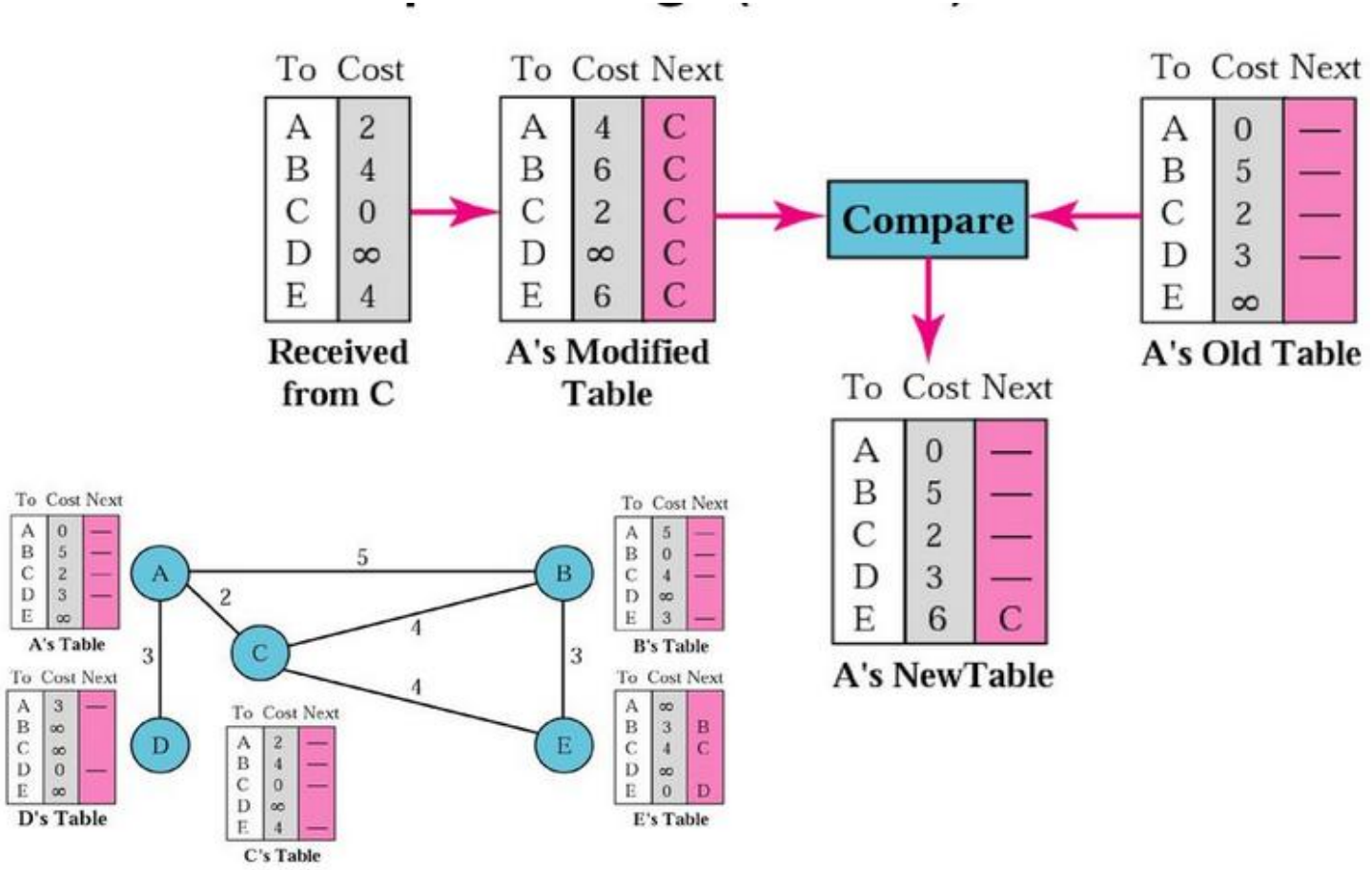
RIP : Updating

- When a node receives a 2-column table from a neighbor,
- it needs to update its routing table.
- Updating takes 3 steps:
  - The receiving node needs to add the cost between itself and the sending node to each value in the second column
  - The receiving node needs to add the name of the sending node to each row as the 3rd column if the receiving node uses information from any row. The sending node is the next node in the route

RIP : Updating (Continue)

- The receiving node needs to compare each row of its old table with the corresponding row of the modified version of the received table.
  - If the next-node entry is different, the receiving node chooses the row with the smaller cost.
  - If there is a tie, the old one is kept If the next-node entry is the same, the receiving node chooses the new row. For example, if node C has previously advertised a route to node X with distance 3. Suppose that now there is no path between C and X; node C now advertises this route with a distance of infinity. Node A must not ignore this value even though its old entry is smaller.

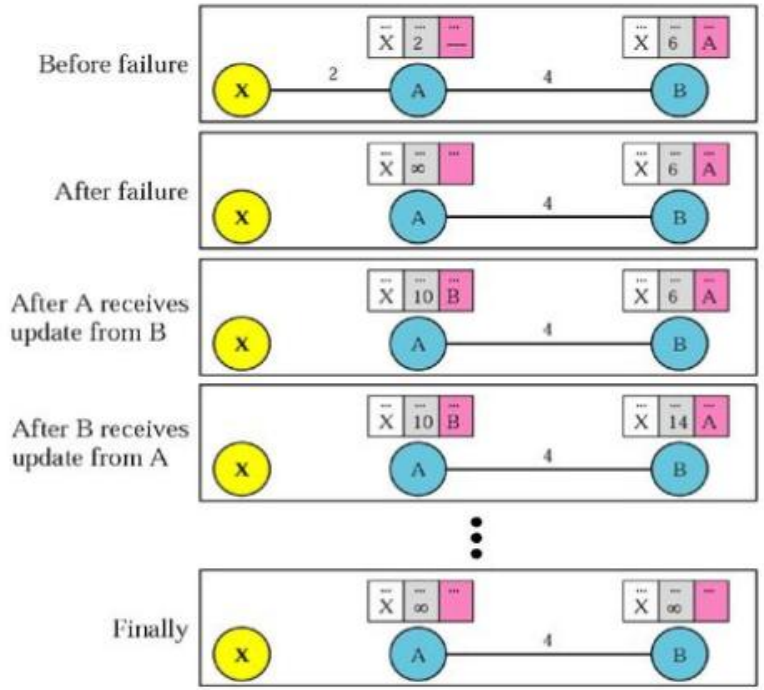
RIP : Updating (Continue)

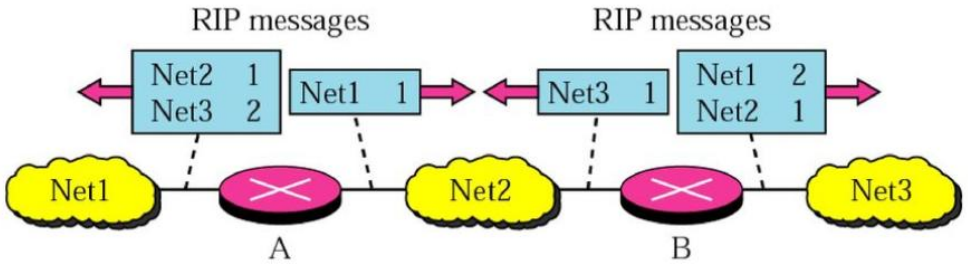


When to Share ?

- **Periodic Update.** A node sends its routing table, normally every 30 seconds, in a periodic update. The period depends on the protocol that is using distance vector routing
- **Triggered Update.** A node sends its 2-column routing table to its neighbors any time there is a change in its routing table.
- The change can result from the following.
  - A node receive a table from a neighbor resulting in changes in its own table after updating
  - A node detects some failure in the neighboring links which results in a distance change to infinity

Two-Node Loop Instability



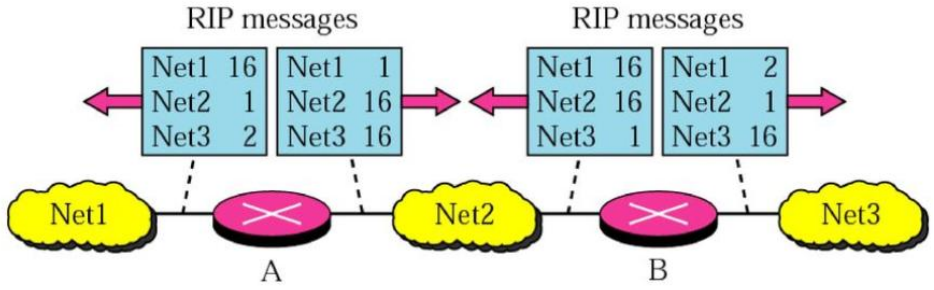


Solutions

Defining Infinity. Most implementation of the distance vector protocol define the distance between each node to be 1 and define 16 as infinity. Therefore, the distance vector cannot be used in large systems

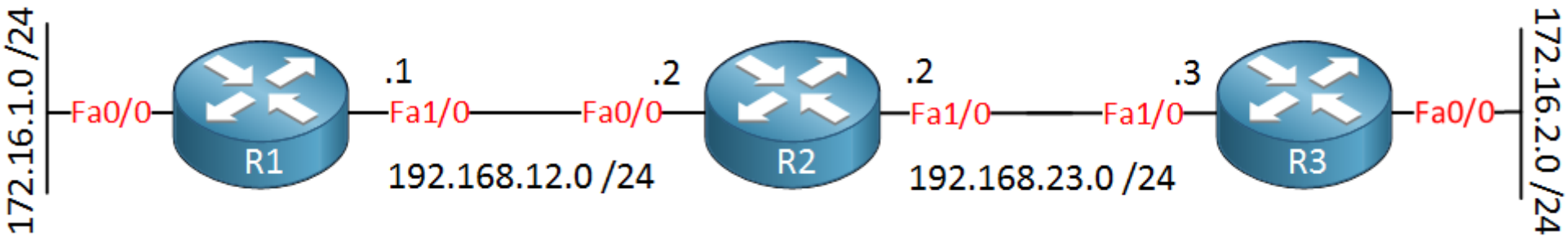
Split Horizon. In this strategy, instead of flooding the table through each interface, each node sends only part of its table through each interface. If node B thinks that the optimum route to reach X is via A, it does not need to advertise this piece of information to A.

Split Horizon and Poison Reverse. This strategy is a combination between split horizon and poison reverse where node B can still advertise the value of X, but if the source of information is A, it can replace the distance with infinity as a warning: “Don’t use this value; what I know about this route comes from you.”



Practical Work

- Configure the routing table both static and dynamic (RIP) methods for R1 , R2 and R3



Practical Work : Configuring static routes on Cisco Router

	Command	Purpose
Step 1	**configure terminal** **Example:** r1# configure terminal r1(config)#	Enters configuration mode.
Step 2	**ip route** {ip-prefix | ip-addr ip-mask} {[next-hop | nh-prefix] | [interface next-hop | nh-prefix]} [**tag** tag-value [pref] **Example**: r1(config)# ip route 192.0.2.0/8 ethernet 1/2 192.0.2.4	Configures a static route and the interface for this static route. You can optionally configure the next-hop address. The preference value sets the administrative distance. The range is from 1 to 255. The default is 1.
Step 3	**show ip static-route** **Example:** r1(config)# show ip static-route	(Optional) Displays information about static routes.
Step 4	**copy running-config startup-config** **Example:** r1(config)# copy running-config startup-config	(Optional) Saves this config

Practical Work : Configuring Dynamic routes on Cisco Router using RIP protocol

```
R1(config-if)#ip address 192.168.12.1 255.255.255.0
R1(config-if)#no shutdown
```

```
R2>enable
R2#configure terminal
R2(config)#interface fastEthernet 0/0
R2(config-if)#no shutdown
R2(config-if)#ip address 192.168.12.2 255.255.255.0
R2(config-if)#exit
R2(config)#interface FastEthernet 1/0
R2(config-if)#no shutdown
R2(config-if)#ip address 192.168.23.2 255.255.255.0
R2(config-if)#exit
```

```
R3>enable
R3#configure terminal
R3(config)#interface fastEthernet 0/0
R3(config-if)#no shutdown
R3(config-if)#ip address 172.16.2.3 255.255.255.0
R3(config-if)#exit
R3(config)#interface fastEthernet 1/0
R3(config-if)#no shutdown
R3(config-if)#ip address 192.168.23.3 255.255.255.0
R3(config-if)#exit
```

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - S-IS level-2
       ia - IS-IS inter area, * - candidate default,
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet1/0
     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.1.0 is directly connected, FastEthernet0/0
```

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - S-IS level-2
       ia - IS-IS inter area, * - candidate default,
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0
C    192.168.23.0/24 is directly connected, FastEthernet1/0
```

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type
2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - S-IS level-2
       ia - IS-IS inter area, * - candidate default,
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.2.0 is directly connected, FastEthernet0/0
C    192.168.23.0/24 is directly connected, FastEthernet1/0
```

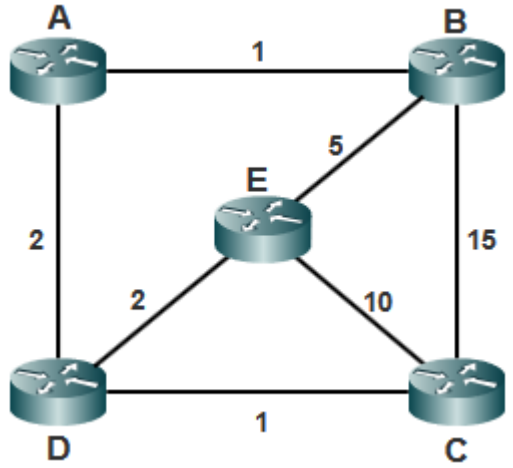
```
R1(config)#router rip
R1(config-router)#version 2
R1(config-router)#no auto-summary
R1(config-router)#network 192.168.12.0
R1(config-router)#network 172.16.1.0
```

```
R2(config)#router rip
R2(config-router)#version 2
R2(config-router)#no auto-summary
R2(config-router)# network 192.168.12.0
R2(config-router)#network 192,168,23,0
```

```
R3(config)#router rip
R3(config-router)#.....
```

Tutorial Work

- On considère le réseau (le coût des liens est indiqué) et on suppose qu'à l'initialisation, chaque nœud connaît le coût vers chacun de ses voisins. L'algorithme utilisé par le protocole de routage est de type vecteur à distance.
    1. Donner les tables de routage initiales des différents routeurs du réseau.
    2. Les routeurs B et D viennent de recevoir le vecteur de distance de A. Donner les nouvelles tables de routage des routeurs B et D ?
    3. Donner l'évolution des tables de routage des routeurs C et E jusqu'à la convergence.



Les tables de routage initiales des différents nœuds

Nœud **A**

Dest.	Pass.	Coût
A	Direct	0
B	Direct	1
C	?	∞ (=16)
D	Direct	2
E	?	∞ (=16)

Nœud **B**

Dest.	Pass.	Coût
A	Direct	1
B	Direct	0
C	Direct	15
D	?	∞ (=16)
E	Direct	5

Nœud **C**

Dest.	Pass.	Coût
A	?	∞ (=16)
B	Direct	15
C	Direct	0
D	Direct	1
E	Direct	10

Nœud **D**

Dest.	Pass.	Coût
A	Direct	2
B	?	∞ (=16)
C	Direct	1
D	Direct	0
E	Direct	2

Nœud **E**

Dest.	Pass.	Coût
A	?	∞ (=16)
B	Direct	5
C	Direct	10
D	Direct	2
E	Direct	0

Les tables de routage des nœuds B et D après recaption du tableau du A

Nœud **B** A(0,1,16,2,16)+**1**

Dest.	Pass.	Coût
A	Direct	1
B	Direct	0
C	Direct	15
D	**A**	**3**
E	Direct	5

Nœud **D** A(0,1,16,2,16)+**2**

Dest.	Pass.	Coût
A	Direct	2
B	**A**	**3**
C	Direct	1
D	Direct	0
E	Direct	2

Les tables de finales de C et E

B(1,0,15,3,5)+15

Dest.	Pass.	Coût
A	B	16
B	Direct	15
C	Direct	0
D	Direct	1
E	Direct	10

D(2,3,1,0,2)+1

Dest.	Pass.	Coût
A	**D**	**3**
B	**D**	**4**
C	Direct	0
D	Direct	1
E	**D**	**3**

E(16,5,10,2,0)+10

Dest.	Pass.	Coût
A	**D**	**3**
B	**D**	**4**
C	Direct	0
D	Direct	1
E	**D**	**3**

Nœud **E**

B(1,0,15,3,5)+ 5

Dest.	Pass.	Coût
A	**B**	**6**
B	Direct	5
C	Direct	10
D	Direct	2
E	Direct	0

C(16,15,0,1,10)+10

Dest.	Pass.	Coût
A	**B**	**6**
B	Direct	5
C	Direct	10
D	Direct	2
E	Direct	0

D(2,3,1,0,2)+2

Dest.	Pass.	Coût
A	**D**	**4**
B	Direct	5
C	**D**	**3**
D	Direct	2
E	Direct	0

Soit la table de routage suivante d'un routeur R1:

```
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

       Gateway of last resort is not set

R       10.0.0.0/8 [120/1] via 195.195.195.1, 00:00:09, Serial2/0
S       20.0.0.0/8 [1/0] via 25.0.0.2
C       25.0.0.0/8 is directly connected, FastEthernet0/0
S       40.0.0.0/8 [1/0] via 204.40.0.2
R       50.0.0.0/8 [120/2] via 204.40.0.2, 00:00:22, FastEthernet1/0
R       130.130.0.0/16 [120/1] via 204.40.0.2, 00:00:22, FastEthernet1/0
S       166.66.0.0/16 [1/0] via 204.40.0.2
C       195.195.195.0/24 is directly connected, Serial2/0
C       204.40.0.0/24 is directly connected, FastEthernet1/0
S*   0.0.0.0/0 [1/0] via 25.0.0.2
```

1. Quelle commande a-t-on utilisé pour afficher cette table de routage ?
2. Quels sont les routes configurées manuellement ?
3. A quoi sert la route par défaut ?et quelle est la commende Cisco qui permette de la configurer ?
4. Que ferait le routeur s'il devait acheminer un paquet dont l'adresse de destination était :
    a. 155.22.176.2
    b. 25 .33.23.10
    c. 166 .66.66.66
5. Quelle commande permet de supprimer la dernière route de la table de routage.
6. Après cette suppression essayer de répondre de nouveau à la question 4.