Computer Networks (CIE 447)

Lab 6 : Network layer layer-Static Routing

Dr. Samy Soliman

T. A. :Eng. Menna Mohamed , Eng. Nourhan Tarek

Last Time we talked about:

- *Network layer*
- *IP Orientation*
- *IPV4*
- *Subnetting*
- *ICMP*
- *Static IP*
- *Directly connected subnets*
- *Static routing*
- *Lab Experiment*

Today we are talking about:

- *Dynamic Routing protocols*
- *RIP*
- *LINK STATE*
- *OSPF*
- *Lab Experiment*

Routed Vs Routing Protocols

Routed protocol: is a protocol by which data can be routed such as IPV4, IPV6, IPX

Routing protocols: are protocols that distribute routing information throughout all routers on a network. By knowing about all other routers connected to the network, each router can determine the best path to use to deliver your traffic such as OSPF, RIP, EIGRP or BGP.

ROUTING PROTOCOLS

IP Routing

- Routing is the process of sending packets from a host on one network to another host on another, remote network.
- A router has two main functions:
  - Determining the best path to available networks
  - Forwarding traffic to those networks
- Routers examine the destination IP address of a packet , determine the next-hop address, and forward the packet
- Routers use **routing tables** to determine a next hop address to which the packet should be forwarded.

Routing table

- Each router maintains a routing table and stores it in RAM.
- A routing table is used by routers to determine a path to a destination network.
- Each routing table consists of the following entries:
  - **Network destination and a network subnet mask**: specifies a range of IP addresses.
  - **Remote router**: IP address of the router used to reach that network
  - **Outgoing interface**: outgoing interface the packet should go out to reach the destination network
  - **Metrics and costs** can include:
    - number of hops (hop count)
    - speed of the path
    - packet loss (router congestion/conditions)
    - latency (delay)
    - path reliability
    - path bandwidth
    - throughput load
    - MTU

Active Routes:

Network Destination	Netmask	Gateway	Interface	Metric
0.0.0.0	0.0.0.0	192.168.1.1	192.168.1.250	20
127.0.0.0	255.0.0.0	127.0.0.1	127.0.0.1	1
192.168.1.0	255.255.255.0	192.168.1.250	192.168.1.250	20
192.168.1.250	255.255.255.255	127.0.0.1	127.0.0.1	20
192.168.1.255	255.255.255.255	192.168.1.250	192.168.1.250	20
224.0.0.0	240.0.0.0	192.168.1.250	192.168.1.250	20
255.255.255.255	255.255.255.255	192.168.1.250	192.168.1.250	1

Default Gateway: 192.168.1.1

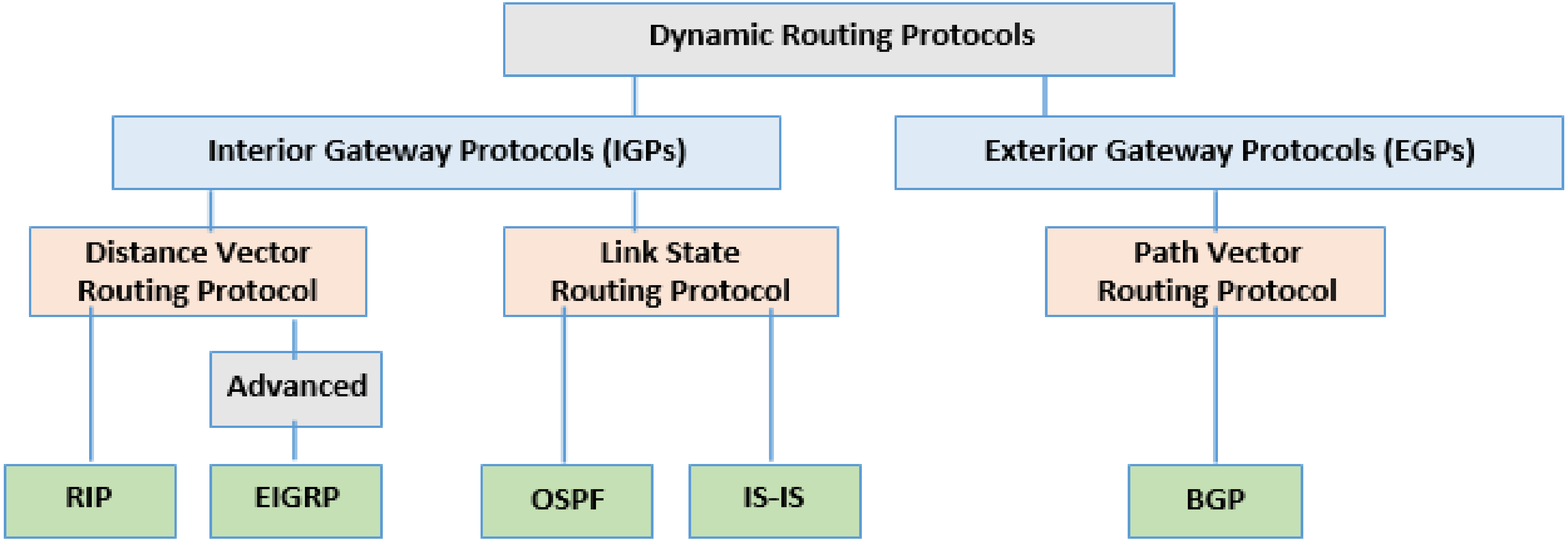
How Routing Tables are Created

There are three different methods for populating a routing table:

- Directly connected subnets
- Static routing
- **Dynamic routing**

Dynamic Routing

- When a routing protocol is used, routers **automatically advertise** their best paths to known networks to each other.
- Routers use this information to determine their own best path to the known destinations.
- When the state of the network changes, such as a link going down or a new subnet being added, the routers update each other.
- Routers will automatically calculate a new best path and **update** the routing table if the network changes.



RIP: Routing Information Protocol

EIGRP: Enhanced Interior Gateway Routing Protocol

OSPF: Open Shortest Path First

IS-IS: Intermediate System – Intermediate System

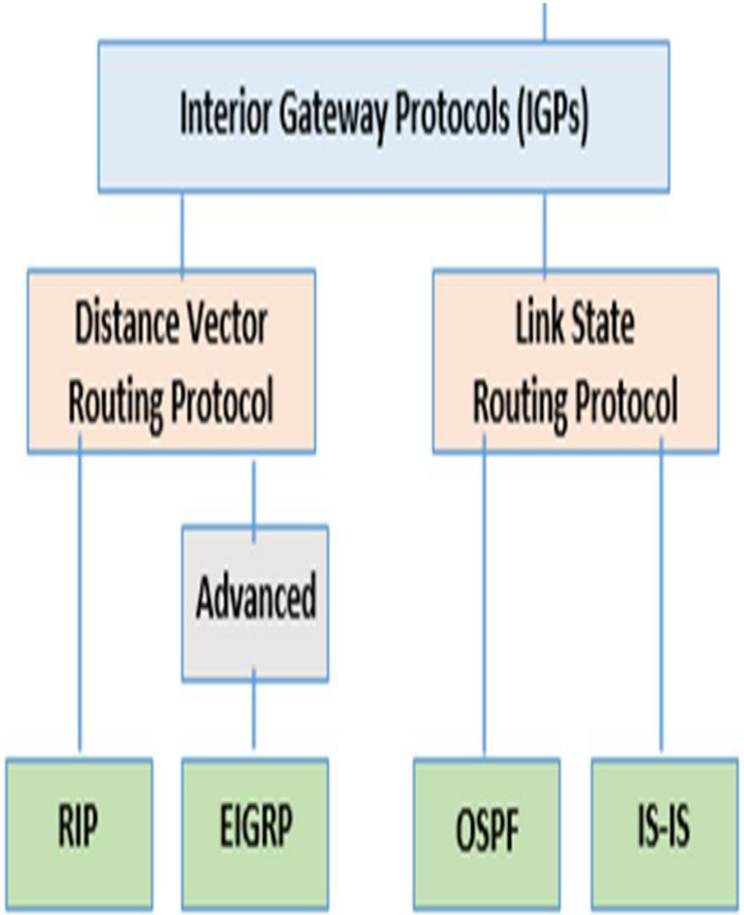
BGP: Border Gateway Protocol

Dynamic Routing protocol types

- **Routing protocols** can be split into **two** main types:
  1. Interior gateway protocols (IGPs)
  2. Exterior gateway protocols (EGPs)
- **Interior gateway protocols** are used for routing within an organization or Autonomous system (AS)
- **Exterior gateway protocols** are used for routing between organizations over the Internet
  - The only EGP in use today is BGP (Border Gateway Protocol)

Interior gateway protocols

- **Interior gateway protocols** can be split into two main types:
  1) Distance Vector routing protocols
  2) Link State routing protocols
- All of the IGPs do the same job, which is to **advertise routes within an organization** and **determine the best path** or paths
- An organization will typically pick one of the IGPs
- If an organization has multiple IGPs in effect (for example because of a merger), information can be redistributed between them. This should generally be avoided if possible.



Different Methods to choose the best route

- A router may receive multiple possible paths to get to a destination network
- Only the best path will make it into the routing table and be used
- The different IGPs use different methods to calculate the best path to a destination network

Administrative Distance

The Administrative Distance (AD) is used for :

- Administrative Distance is used to choose between multiple paths learned via different routing protocols
- The Administrative Distance is a **measure of how trusted the routing protocol is**
- If routes to the same destination are received via different routing protocols, the protocol with the best (lowest) AD wins

Administrative Distance
[x/y]

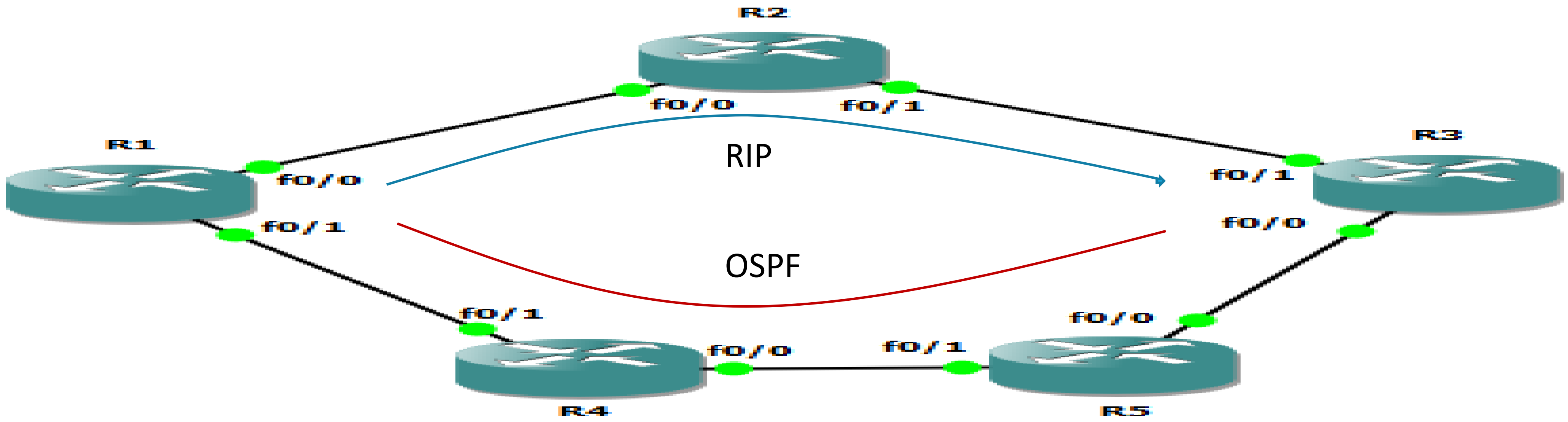
Measure of believability
The lower the better

These values are constant by default
However, they are tunable Network admiration can change it

Route Source	Default Distance Values
Connected interface	0
Static route	1
Enhanced Interior Gateway Routing Protocol (EIGRP) summary route	5
External Border Gateway Protocol (BGP)	20
Internal EIGRP	90
IGRP	100
OSPF	110
Intermediate System-to-Intermediate System (IS-IS)	115
Routing Information Protocol (RIP)	120
Exterior Gateway Protocol (EGP)	140
On Demand Routing (ODR)	160
External EIGRP	170
Internal BGP	200

Administrative Distance example

- Example: A router (R3) receives multiple routes to the 10.10.10.0/24 network AT (R1) from both OSPF and RIP
- When paths to the same destination are received from multiple routing protocols, the Administrative Distance is considered first
- OSPF (110) has **a better AD** than RIP (120) so the RIP routes will be discarded



Show ip route

```
R3#sh ip route
Codes: L - local, 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 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 12 subnets, 2 masks
C        10.0.0.0/24 is directly connected, FastEthernet0/0
L        10.0.0.1/32 is directly connected, FastEthernet0/0
R        10.1.0.0/24 [120/1] via 10.0.0.2, 00:00:00, FastEthernet0/0
R        10.1.1.0/24 [120/2] via 10.0.0.2, 00:00:00, FastEthernet0/0
```

Connected interfaces have an AD of 0

Administrative Distance

Metric

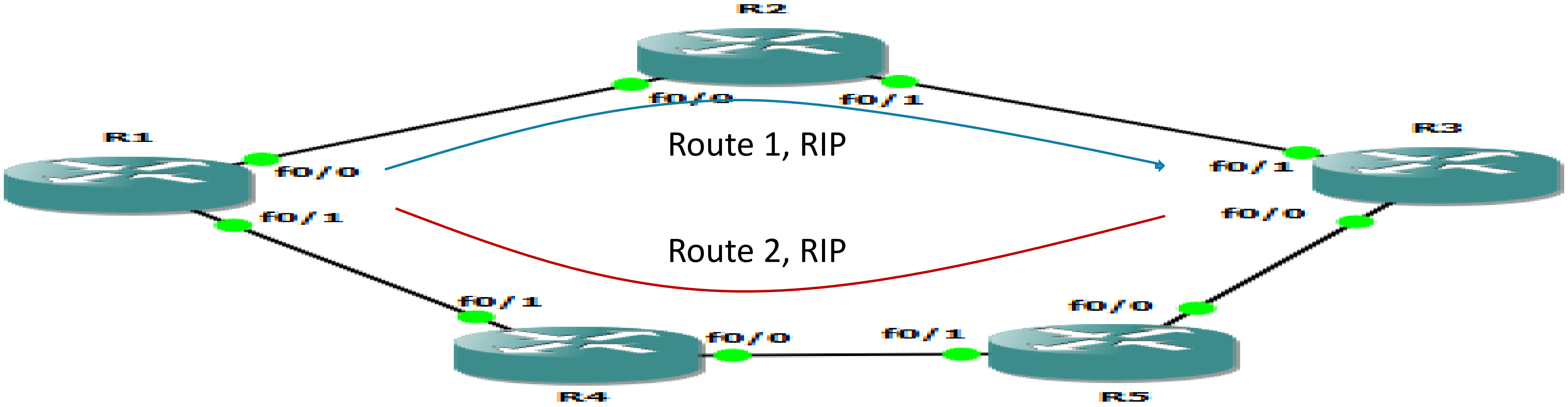
Metric [X/Y]

In case of Tie in administrative distance use the metric to decide.

- Metric is used to choose between multiple paths learned via the same protocol
- Each possible path will be assigned a 'metric' value by the routing protocol which indicates how preferred the path is
- The lowest metric value is preferred
- If the best path to a destination is lost (for example because a link went down) it will be removed from the routing table and replaced with the next best route
- Different routing protocols use different methods to calculate the metric
  - Number of hops: Such as RIP. Is this a good model?
  - Bandwidth
  - Delay
  - Reliability
  - Load

Metric example

- Example: A router (R3) receives multiple routes to the 10.10.10.0/24 network AT (R1) from RIP
- When paths to the same destination are received from the same routing protocols, the metric is considered RIP uses Hop Count as the metric.
- Route 1 has (2 hops) which has **a better metric** than Route 2 has (3 hops) so the Route 2 will be discarded



Equal Cost Multi Path

In case of tie in a administrative distance and metric: equal cost load balance

- If multiple paths to a destination have an equal metric, the router will enter all of the paths into the routing table
- Equal Cost Multi Path will load balance the outbound traffic to the destination over the different paths
- All IGP routing protocols will perform ECMP by default
- EIGRP is the only routing protocol which is capable of UnEqual Cost Multi Path. It must be manually configured to support this.

Distance Vector protocols

- each router sends its directly connected neighbors a list of all its known networks along with its own distance to each of those networks
- Distance vector routing protocols do not advertise the entire network topology
- A router only knows its directly connected neighbors and the lists of networks those neighbors have advertised. It doesn’t have detailed topology information beyond its directly connected neighbors

Routing Information Protocol (RIP) Routing protocol

- **At start up**: How the protocol chooses the best path? How will it build the routing table?
- **At stability (when converge):** What will happen after routing table is populated?
- **At change**: What will happen when node fails, down, up, appears?

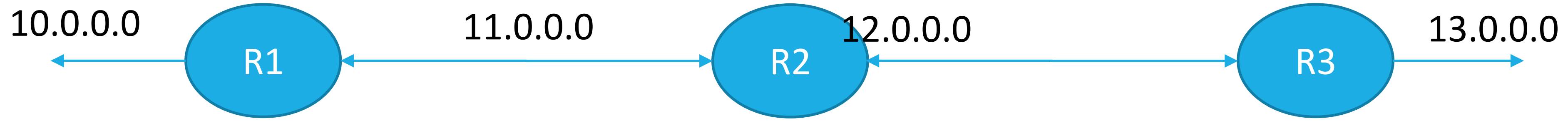
Routing Information Protocol (RIP) Routing protocol

- The Routing Information Protocol (RIP) is a Distance Vector routing protocol
- It uses **hop count** as its metric
- The maximum hop count is **15**, Paths which are more than 15 hops away are marked as unreachable
- It will perform Equal Cost Multi Path, for up to 4 paths by default
- RIP is typically used only in small or test environments
- It has two versions:
  - RIPv1 (classful)
  - RIPv2 (classless)
  - RIPng (for IPv6)

(RIP v1 VS RIP v2)

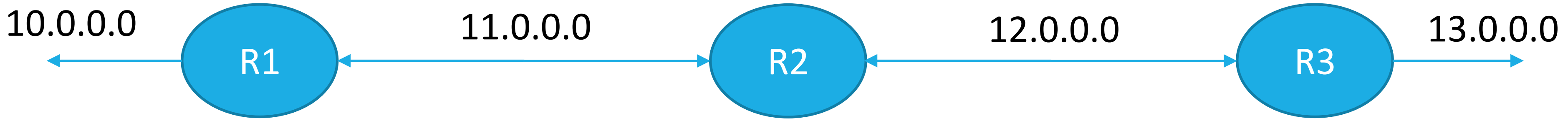
Feature	RIPv1	RIPv2
Routing update address	Broadcast (255.255.255.255)	Multicast (224.0.0.09)
Variable Length Subnet Mask (VLSM)	Does not support	Supports
Classless Inter Domain Routing (CIDR)	Does not support	Supports
Authentication	Does not support	Supports MD5 authentication
Discontinuous network	Does not support	Supports

At start up: How the protocol chooses the best path? How will it build the routing table?



protocol	Network	Hop metric	Network	Hop metric	Network	Hop metric
C	10	0	11	0	12	0
C	11	0	12	0	13	0
R			**10**	**1**	**10**	**2**
R			11	1	11	1
R					12	1
R	**12**	**1**	**12**	**1**		
R	13	2	13	1		
R	10	2	10	3		
R	11	1	11	2		

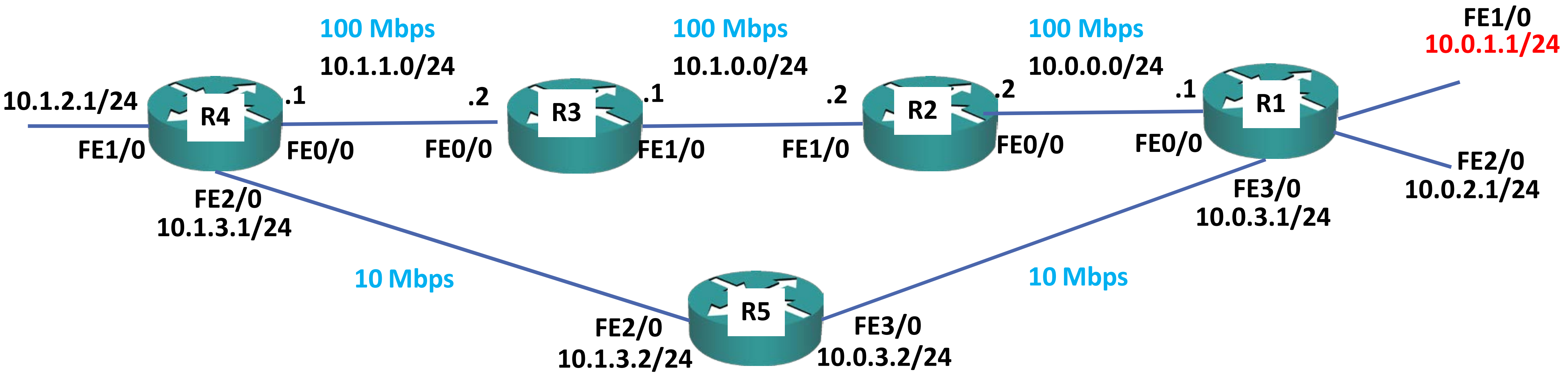
build the routing table in each router



protocol	Network	Hop metric	Network	Hop metric	Network	Hop metric
C	10	0	11	0	12	0
C	11	0	12	0	13	0
R	**12**	**1**	**10**	**1**	**11**	**1**
R	**13**	**2**	**13**	**1**	**10**	**2**

RIP Metric – Hop Count

- RIP uses Hop Count as the metric
- R4 has 2 paths to reach 10.0.1.0/24 network on R1
- Path R4>R5>R1 will be preferred for 10.0.1.0/24 in the example below



RIP Metric – Hop Count (P1)

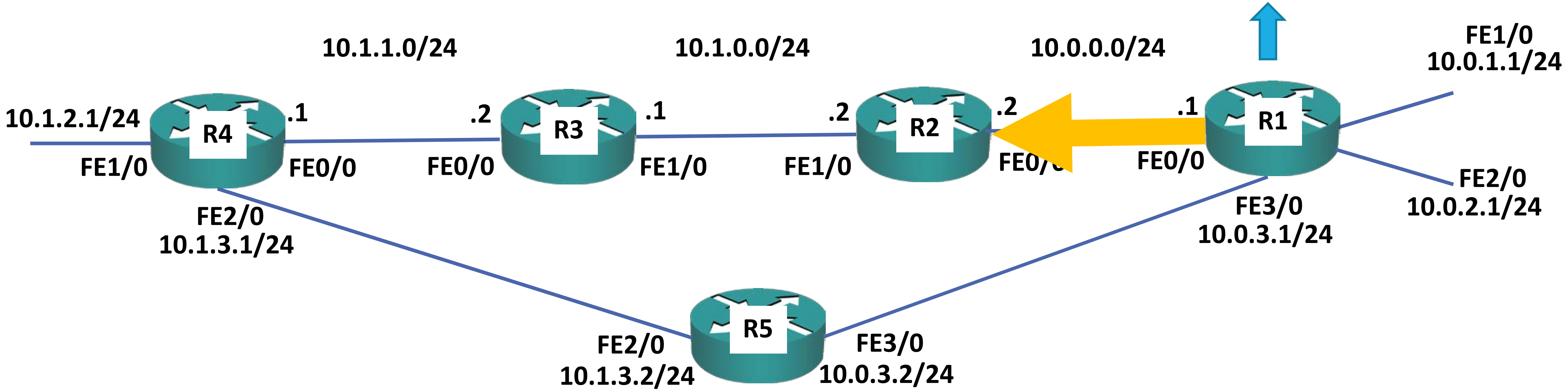
R1: “You can get to these networks via me”:

10.0.1.0/24 – 1 hop

10.0.0.0/24 – 1 hop

10.0.2.0/24 – 1 hop

10.0.3.0/24 – 1 hop



RIP Metric – Hop Count (P1)

R2: "You can get to these networks via me":

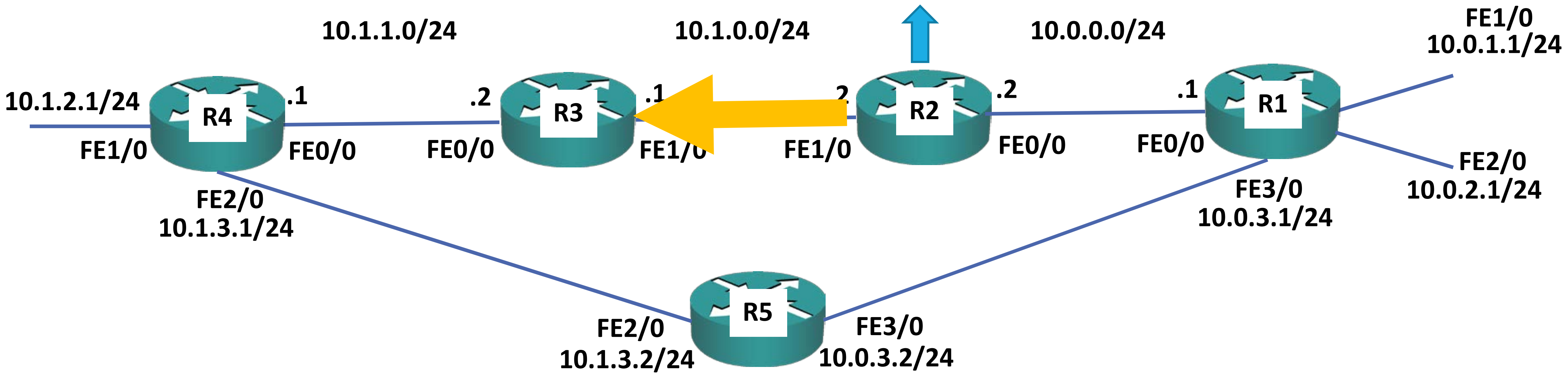
10.0.0.0/24 – 1 hop

10.1.0.0/24 – 1 hop

10.0.1.0/24 – 2 hops

10.0.2.0/24 – 2 hops

10.0.3.0/24 – 2 hops



RIP Metric – Hop Count(P1)

R3: "You can get to these networks via me":

10.1.0.0/24 – 1 hop

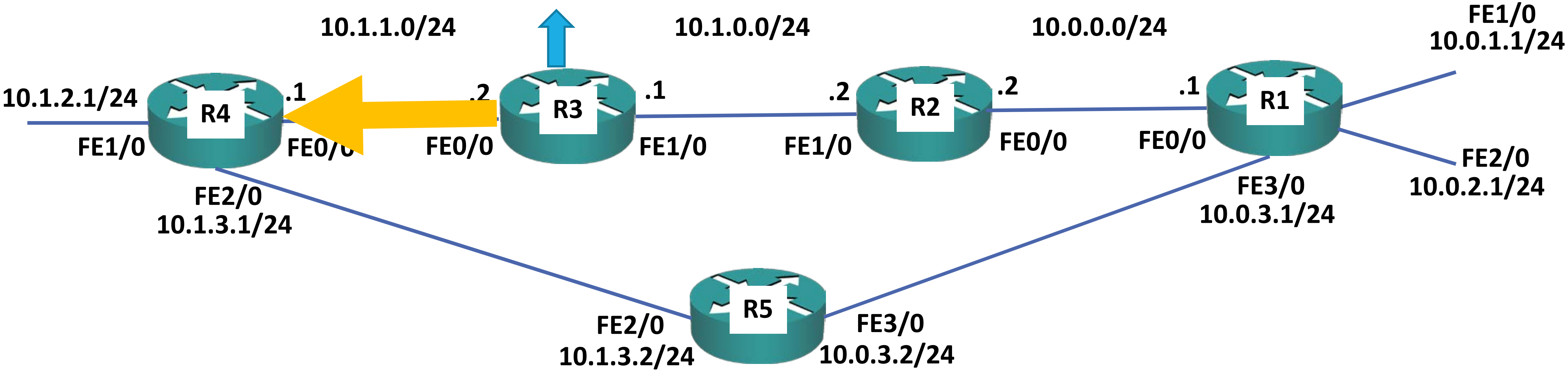
10.1.1.0/24 – 1 hop

10.0.0.0/24 – 2 hops

10.0.1.0/24 – 3 hops

10.0.2.0/24 – 3 hops

10.0.3.0/24 – 3 hops



RIP Metric – Hop Count (P1)

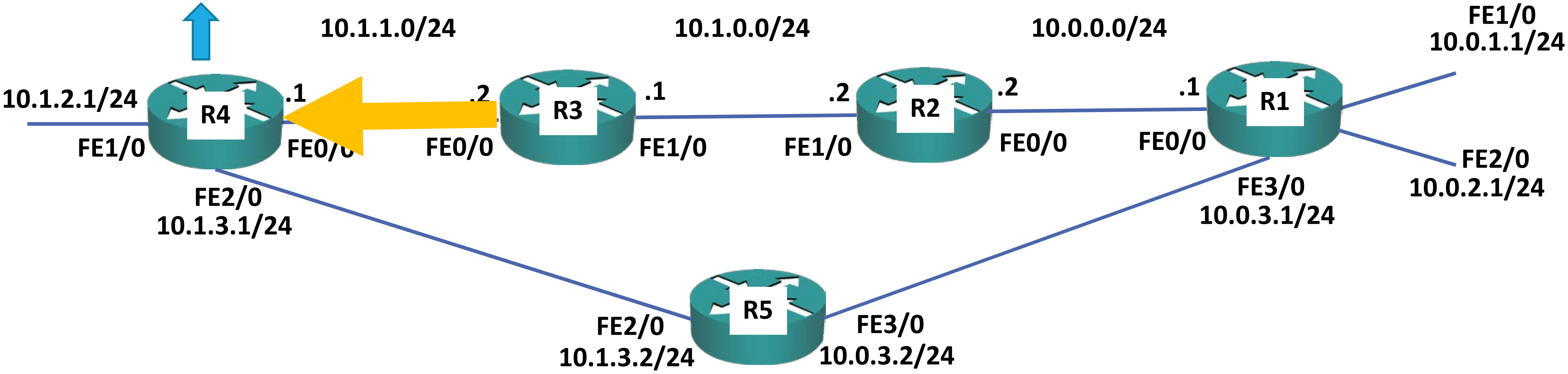
ON R4

10.0.0.0/24 – 2 hops

<u>10.0.1.0/24 – 3 hops FROM R3</u>

10.0.2.0/24 – 3 hops

10.1.0.0/24 – 1 hop



RIP Metric – Hop Count (P2)

R1: "You can get to these networks via me":

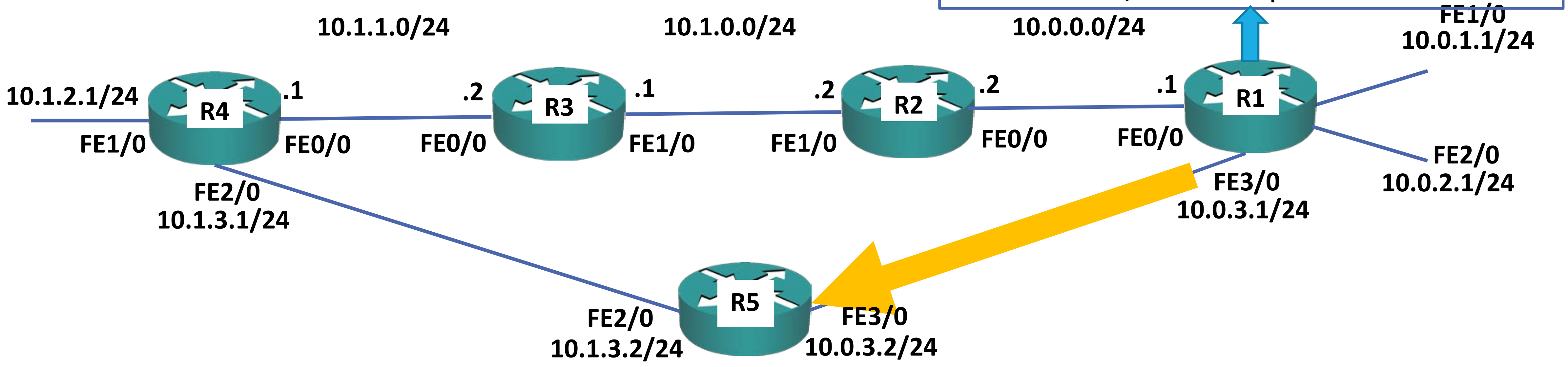
10.0.0.0/24 – 1 hop

10.0.1.0/24 – 1 hop

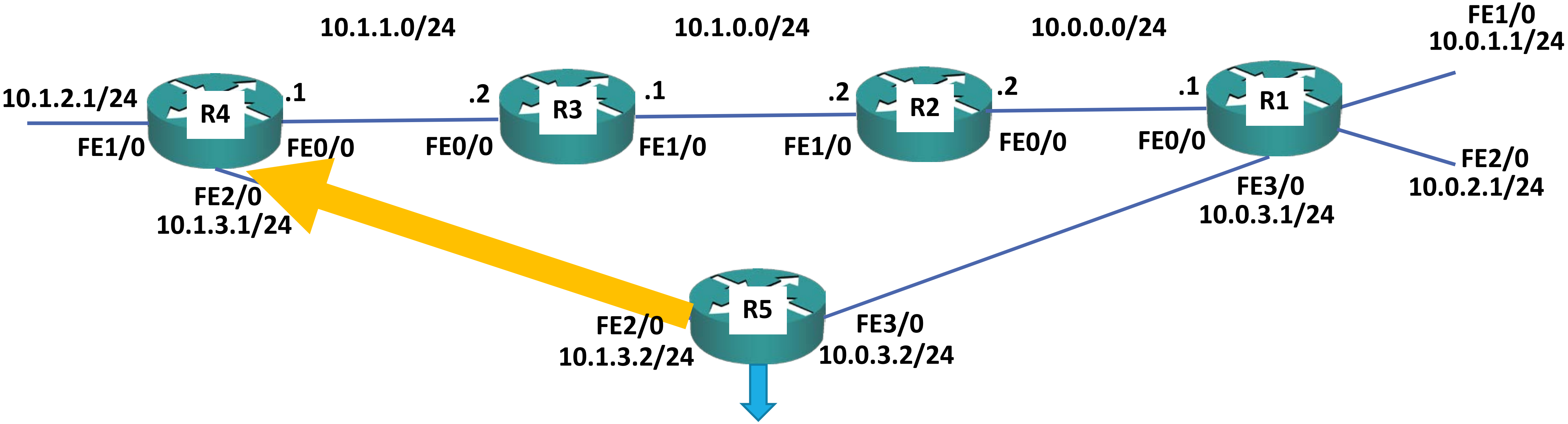
10.0.2.0/24 – 1 hop

10.0.3.0/24 – 1 hop

10.1.0.0/24 – 2 hops

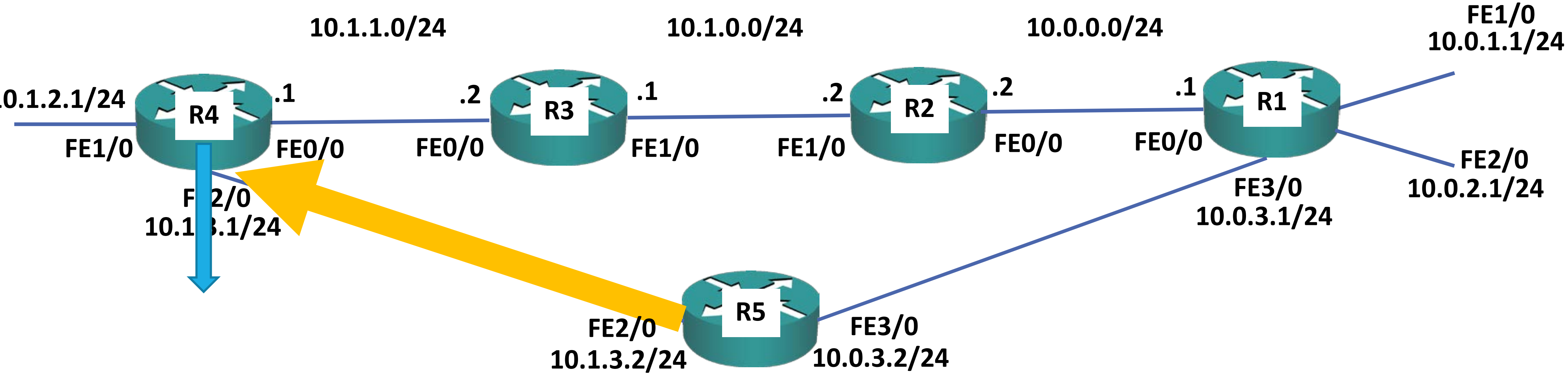


RIP Metric – Hop Count (P2)



R5: "You can get to these networks via me":
10.0.0.0/24 – 2 hops
10.0.1.0/24 – 2 hops
10.0.2.0/24 – 2 hops
10.0.3.0/24 – 1 hops

RIP Metric – Hop Count (P2)



ON R4

10.0.0.0/24 – 2 hops

<u>10.0.1.0/24 – 2 hops FROM R5</u>

10.0.2.0/24 – 2 hops

10.0.3.0/24 – 1 hops

RIP Metric – Hop Count ON R4

R4: I learned 2 possible routes to get to the 10.0.1.0/24 network:

3 hops via 10.1.1.2 out FE0/0

2 hops via 10.1.3.2 out F2/0

I'll put the best one in my routing table

ON R4 , show routing table

R4#sh ip route

```
    10.0.0.0/8 is variably subnetted, 11 subnets, 2 masks
R       10.0.0.0/24 [120/2] via 10.1.3.2, 00:00:06, FastEthernet2/0
                    [120/2] via 10.1.1.2, 00:00:16, FastEthernet0/0
R       10.0.1.0/24 [120/2] via 10.1.3.2, 00:00:06, FastEthernet2/0
R       10.0.2.0/24 [120/2] via 10.1.3.2, 00:00:06, FastEthernet2/0
R       10.0.3.0/24 [120/1] via 10.1.3.2, 00:00:06, FastEthernet2/0
R       10.1.0.0/24 [120/1] via 10.1.1.2, 00:00:16, FastEthernet0/0
C 10.1.1.0/24 is directly connected, FastEthernet0/0
L 10.1.1.1/32 is directly connected, FastEthernet0/0
C 10.1.2.0/24 is directly connected, FastEthernet1/0
L 10.1.2.1/32 is directly connected, FastEthernet1/0
C 10.1.3.0/24 is directly connected, FastEthernet2/0
L 10.1.3.1/32 is directly connected, FastEthernet2/0
    203.0.113.0/24 is variably subnetted, 2 subnets, 2 masks
C       203.0.113.0/24 is directly connected, FastEthernet3/0
L       203.0.113.1/32 is directly connected, FastEthernet3/0
```

RIP messages

- There are only two message types used by RIP. **Request message** and **Response message**.
- When a RIP enabled router interface comes up, it sends out a Request message.
- The other RIP enabled routers in the network are responding with Response messages.
- When the first router receives the Response messages,
- it installs the new received routes in it’s routing table.
- If the router already has a route in its table but it gets one with a better hop count, the old route is replaced.
- After that, the router sends its own routing table to its neighbors.

At stability

RIP V1: Each router **broadcast** its entire routing table every 30 seconds. After increasing the metric by one and check administrative distance and then metric.

- Host will receiver this data also !
- RIP packets sends 25 route per packet at max !

RIP V2: Each router **multicast** (224.0.0.9) its entire routing table every 30 seconds using. After increasing the metric by one and check administrative distance and then metric.

AT Change

- Link going down
- New subnet added
- the routers update each other

Poisoned Route: when route fails use metric 16. the poisoned route metric = 16

- Counting to infinity problem (till metric takes value 16..16*30 seconds)

.

Routing Loops

If you want to configure RIP protocol on your network, you have to be familiar with the routing loops.

Sometimes routing loops create a big issue on an RIP-based network. However, RIP protocol has some mechanisms that can be used to prevent the routing loops and maintain the network stability. These mechanisms are:

- **Split horizon:** In the split horizon, route information is not sent back out through the interface from which it was received. Thus, allowing to prevent routing loops.
- **Hop-count limit (TTL):** Limiting the hop-count prevents routing loops from continuing indefinitely.
- **Hold-down timers:** When the hold-down timers are set, routers ignore the routing update information for the set period of time.

RIP Timers

Routing protocols use timers to optimize the network performance.

The following table lists the various types of timers used by the RIP protocol to optimize the network performance.

Timers	Default Value	Uses
Hold down timer	180 seconds	Used to hold the routing information for the specified time.
Invalid route timer	180 seconds	Used to keep track of discovered routes
Route update timer	30 seconds	Used to update routing information
Route flush timer	240 seconds	Used to set time interval for any route that becomes invalid and its deletion from the routing table.

Link State

Link State Routing Protocols

The link-state protocol is performed by every routers.

Each router constructs a map of the connectivity to the network, in the form of a graph, showing which nodes are connected to which other nodes.

Each Router then independently calculates the next best logical path from it to every possible destination in the network. Each collection of best paths will then form each node's routing table.

This contrasts with distance-vector routing protocols, which work by having each node sharing its routing table with its neighbors.

In a link-state protocol the only information passed between nodes is connectivity related. Link-state algorithms are sometimes characterized informally as each router, "telling the world about its neighbors.

Link state vs Distance vector

Distance vector	Link state
sends the entire routing table	sends only link state information
slow convergence	fast convergence
susceptible to routing loops	less susceptible to routing loops
updates are sometimes sent using broadcast	always uses multicast for the routing updates
doesn't know the network topology	knows the entire network topology
simpler to configure	can be harder to configure
examples: RIP, IGRP	examples: OSPF, IS-IS

Link State Routing: Properties

Each node requires complete topology information

Link state information must be flooded to all nodes

Guaranteed to converge

Link State Routing: Basic Concepts

In order to understand the concepts of link state routing, we need to understand the following definitions:

1. Neighbors Vs. adjacency
2. Link State advertisement (LSA) and database (LSDB)
3. Designated router (DR) Vs Backup designated router (BDR)
4. Router Id
5. Areas

1. Neighbors Vs. adjacency

Neighbors

- Routers are **neighbors** if they are connected to the same subnet and share a series of common configuration information:
  - **Same Area ID,**
  - **same Area type,**
  - **same subnet mask,**
  - **same timers,**
  - **same authentication**
- They see their own OSPF Router ID in each other's Hello packet
- They **do not exchange any routing information** - the only packets they exchange is Hello packets.

Adjacency

- Two routers must first be neighbors, only then they can become adjacent. Two routers become adjacent if:
  - At least one of them is DR or BDR (on multi-access type networks), or
  - They are interconnected by a point-to-point or point-to-multipoint network type
- They do **exchange routing information**.

2. Link State Advertisement and Database

In link state routing protocols, nodes share:

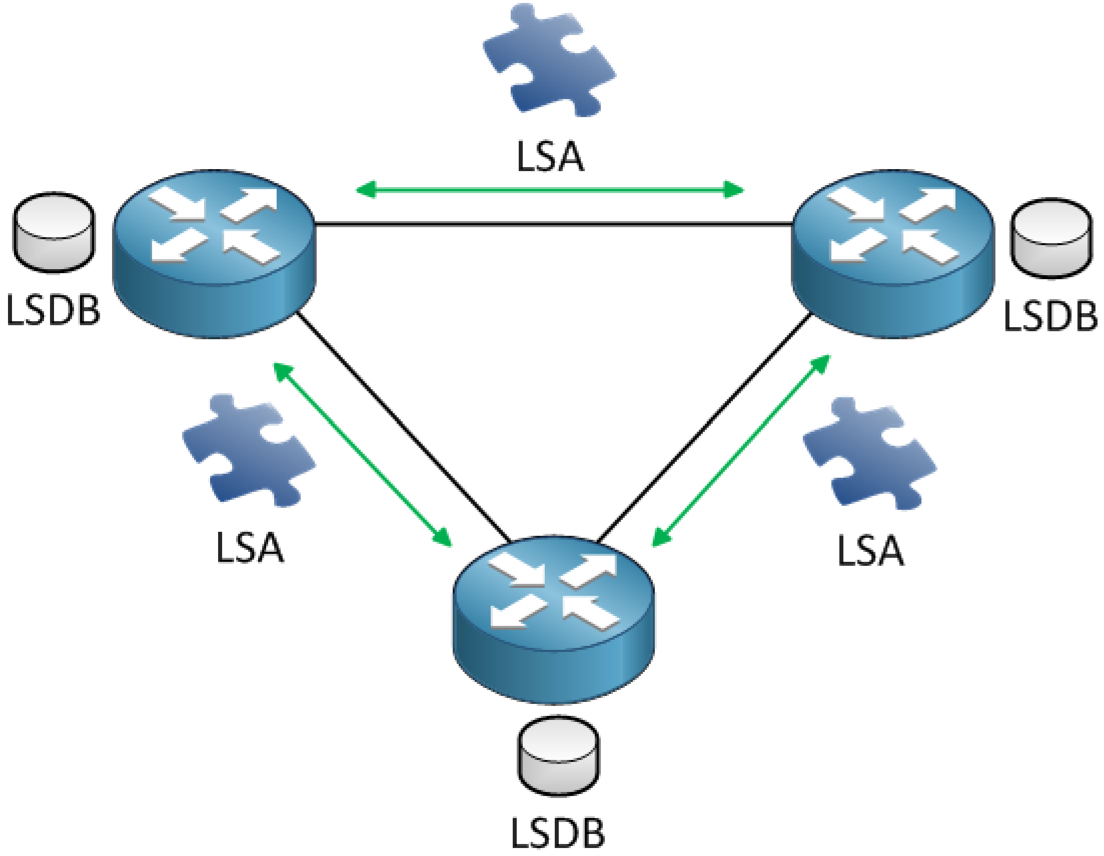
- **Link: That's the interface of our router.**
- **State: Description of the interface and how it's connected to neighbor routers**.

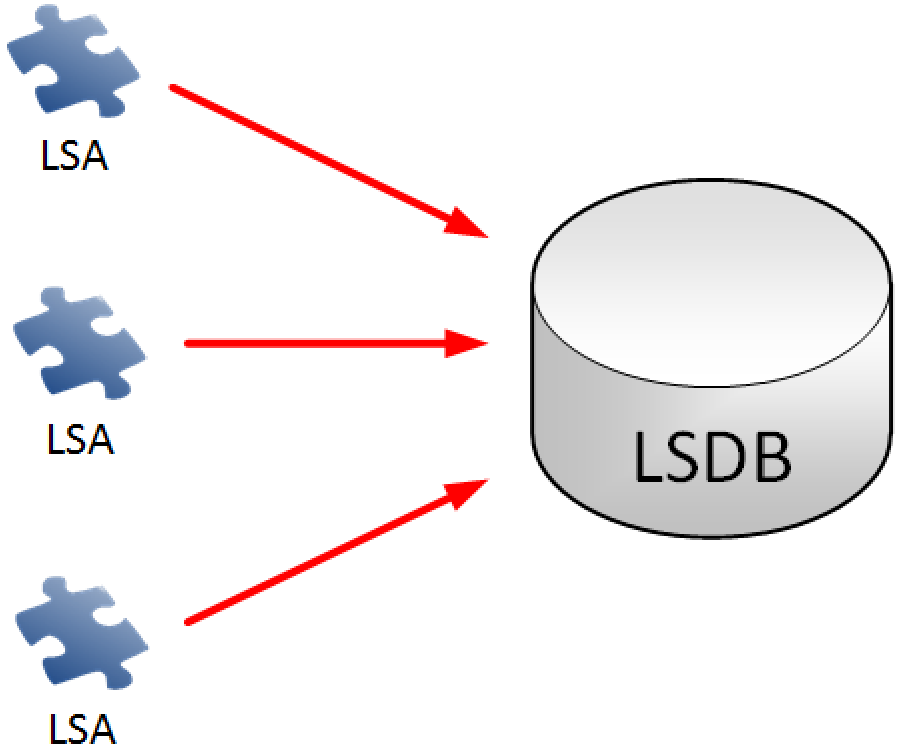
Link-state routing protocols operate by sending **link-state advertisements** (**LSA**) to all other link-state routers.

All the routers need to have these link-state advertisements so they can build their **link-state database** or **LSDB**. Basically all the link-state advertisements are a piece of the puzzle which builds the LSDB.

LSDB

Each node now will have LSDB and routing table (They are not the same)





LSA Types

LSA Type	LSA Name	LSA Description
Type 1	Router-LSA	Describes the link status and link cost of a router, generated and advertised in the area the router belongs.
Type 2	Network-LSA	Describes the link status of all routers in the local network segment, generated by DR and advertised in the area to which the DR belongs.
Type 3	Network-Summary-LSA	Describes the routes in a network segment and advertises the routes to the related non-totally STUB or NSSA area.
Type 4	ASBR-Summary-LSA	Describes routes to an ASBR, generated by an ABR and advertised in the related areas, except the area to which the ASBR belongs.
Type 5	AS-External-LSA	Describes routes to a destination outside the AS. Generated by an ASBR and advertised in all areas, except stub areas and Not-So-Stubby Areas (NSSA).
Type 7	NSSA-LSA	Describes routes to a destination outside the AS. Generated by an ASBR and advertised in NSSAs only.
Type 9/10/11	Opaque-LSA	OSPF extensions, graceful LSA used to support GR is type 9 LSA example, type 10 LSA is used to support TE.

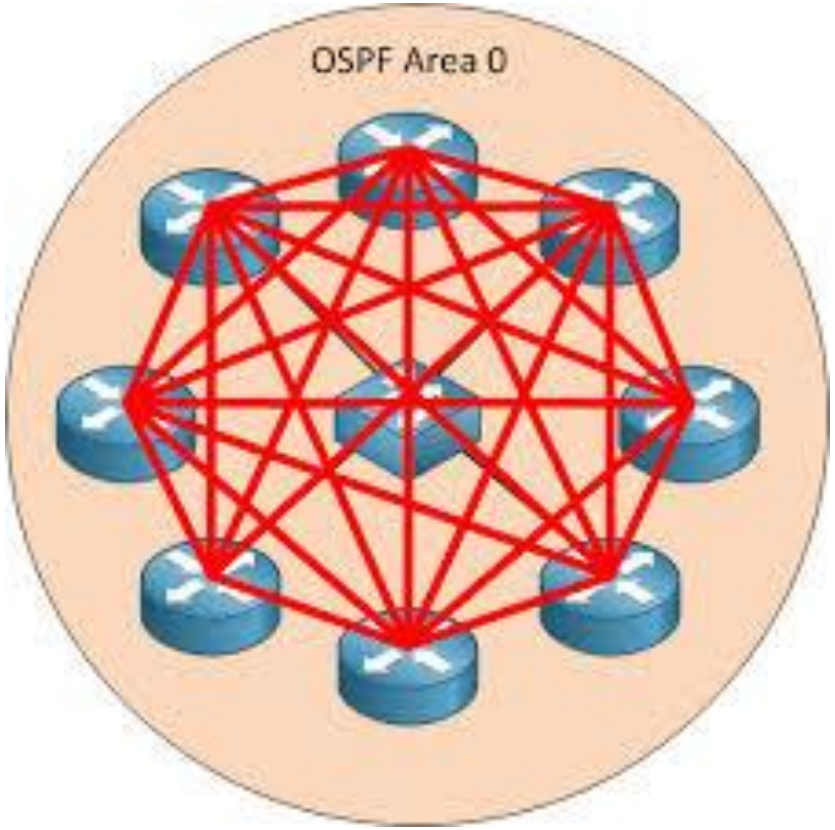
LSA Mesh

It might not be very efficient that each router floods its LSAs to all other routers.

Over flooding-Congestion- bandwidth inefficiency

Solution:

- Designated router and Backup designated routers



3. DR Vs. BDR

- Routers can elect one router to be a Designated Router (DR) and one router to be a Backup Designated Router (BDR).
- DR and BDR serve as the central point for exchanging routing information.
- Each non-DR or non-BDR router will exchange routing information only with the DR and BDR, instead of exchanging updates with every router on the network segment.
- DR will then distribute topology information to every other router inside the same area. This greatly reduces routing traffic.

How to elect DR and BDR?

Three rules are used to elect a DR and BDR:

1- first router comes up within 40 sec will be DR , then the second one will be BDR

2- router with the highest priority will become a DR.

- By default, all routers have a priority of 1

3- if there is a tie, a router with the highest **router ID** wins the election

- The router with the second highest OSPF priority or router ID will become a BDR.

4. Router ID

In Link State protocol such as OSPF, each router has its own ID.

A router ID is a 32-bit number assigned to each router running the OSPF protocol. This number uniquely identifies the router within an Autonomous System.

A router ID is assigned as follows:

- Manually configured
- If no router-id is configured manually, the highest IP of the loopback interfaces is used.
- If no loopback interfaces then the highest IP of physical interfaces is used)

5. Areas

A single autonomous system (AS) can be divided into smaller groups called *areas* (sub-domains)

An *area* is a set of networks and hosts within an AS that have been administratively grouped together.

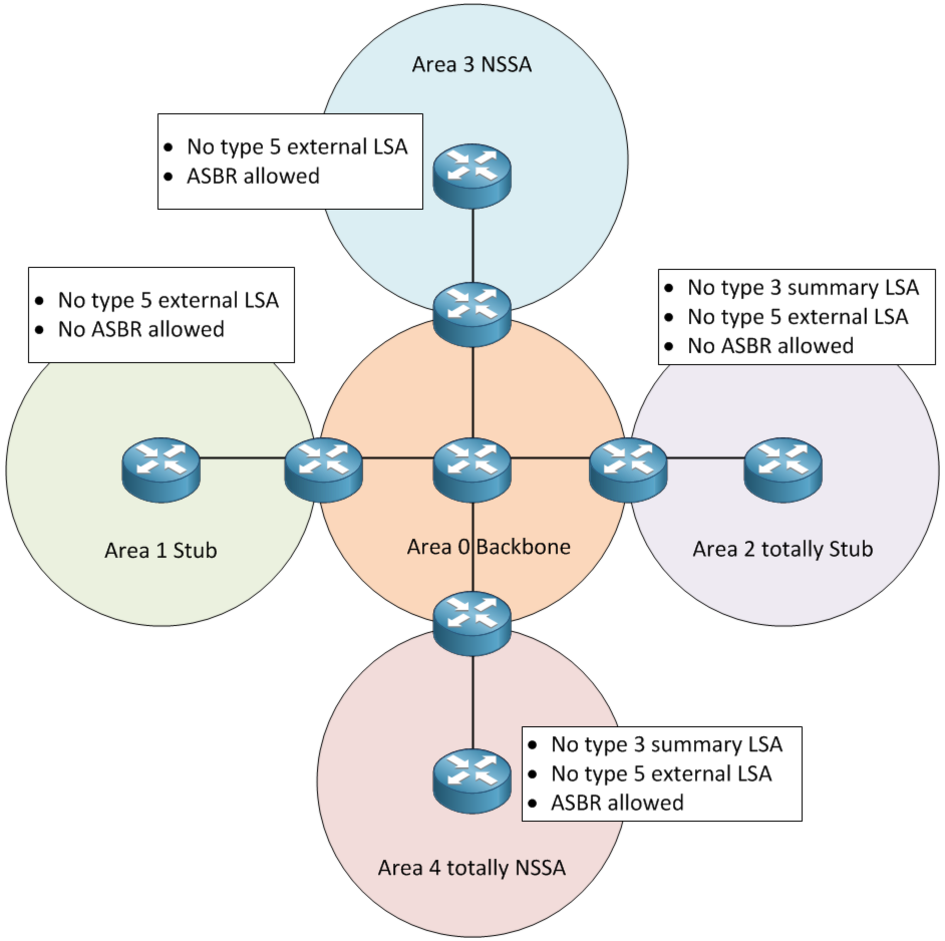
Routing devices that are wholly within an area are called *internal routers*

The topology of an area is hidden from the rest of the AS, thus significantly reducing routing traffic in the AS.

All routing devices within an area have identical topology databases.

Areas are identified by an area ID

Areas


Area 3 NSSA
No type 5 external LSA
ASBR allowed
No type 5 external LSA
No ASBR allowed
No type 3 summary LSA
No type 5 external LSA
No ASBR allowed
Area 1 Stub
Area 0 Backbone
Area 2 totally Stub
No type 3 summary LSA
No type 5 external LSA
ASBR allowed
Area 4 totally NSSA

Area Types

1-Backbone area (area 0):

The backbone area forms the core of network.

All other areas must connect to the backbone area

Backbone routers (**BR**) perform inter-area routing by distributing routing information between non-backbone areas.

To connect any other area with the backbone area, use the **area border router (ABR)**

ABR is a router with interfaces in two (or more) different areas

Area Types

2-Transit area

The Area carrying data traffic that neither originates nor terminates in the area itself.

An area with two or more area border routers and is used to pass network traffic from one adjacent area to another.

Can contain Autonomous System Boundary Routers **(ASBR).**

An Autonomous System Boundary Router (ASBR) is a router that is running multiple protocols and serves as a gateway to routers outside the protocol domain and those operating with different protocols. The ASBR is able to import and translate different protocol routes into OSPF for example through a process known as redistribution.

OSPF

OSPF

OPSF stands for open shortest path first protocol. It is an IGP which means it works inside autonomous systems.

Why OSPF?

- Open standard (works on Cisco-Huawei. Etc…)
- Suits larger network? Remember RIP maximum connectivity
- Converge faster

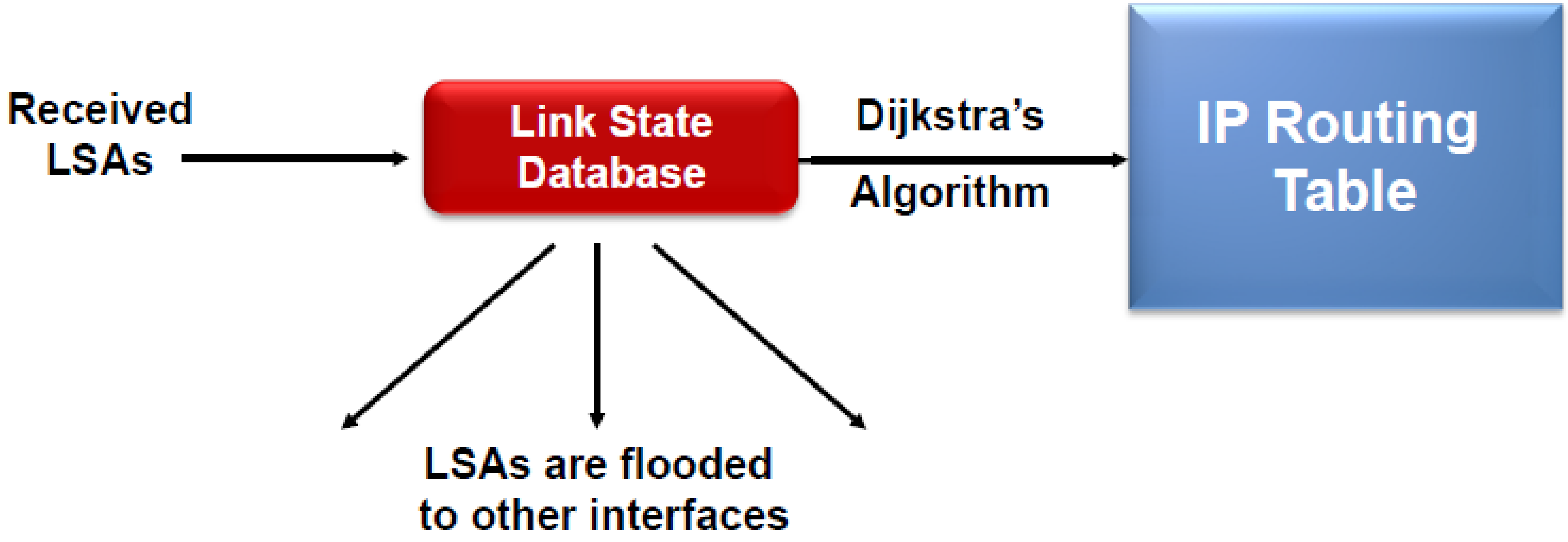
OSPF Cost

- OSPF uses a reference bandwidth of 100 Mbps for cost calculation. The formula to calculate the cost is reference bandwidth divided by interface bandwidth(in MbpS).
- For example, in the case of Ethernet, it is 100 Mbps / 10 Mbps = 10.
- For example, in the case of GigaEthernet, it is 100 Mbps / 100 Mbps = 1.
- For example, in the case of serial, it is 100 Mbps / 1.54 Mbps = 64.

At start: how to build routing tables

1. Neighbor discovery
2. Database exchange
3. Dijkstra’s algorithm
4. Build routing table

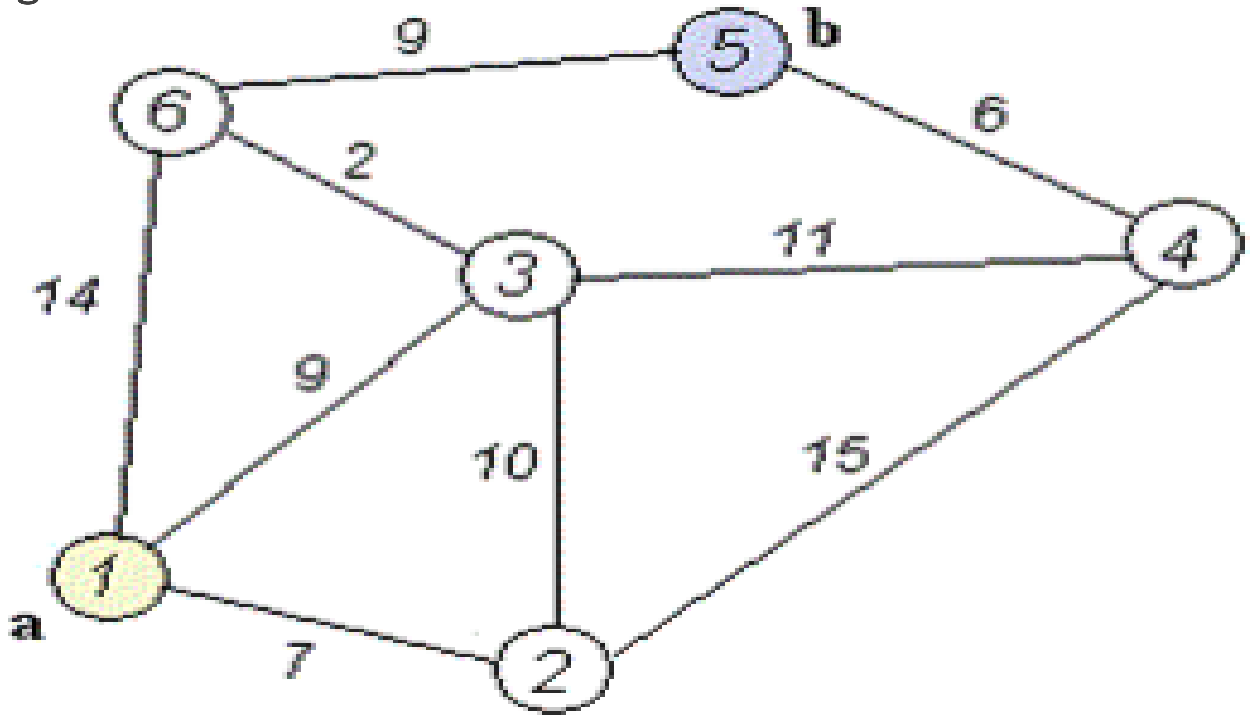
OSPF


Received
LSAs
Link State
Database
Dijkstra's
Algorithm
IP Routing
Table
LSAs are flooded
to other interfaces

Dijkstra Algorithm

Also called shortest path

For a given source vertex (node) in the graph, the algorithm can be used to find shortest path from a single starting vertex to a single destination vertex.



AT Convergence

The router will send LSA refresh each 30 min

Send hello each interval (every 10 sec) as keep alive

OSPF Packet Types

Hello: neighbor discovery, build neighbor adjacencies and maintain them.

DBD: This packet is used to check if the LSDB between 2 routers is the same. The DBD is a **summary of the LSDB**.

LSR: Requests specific link-state records from an OSPF neighbor.

LSU: Sends specific link-state records that were requested. This packet is like an envelope with multiple LSAs in it.

LSAck: OSPF is a reliable protocol so we have a packet to acknowledge the others

Hello msg

Hello Packets are used to:

Discover OSPF neighbors and establish neighbor adjacencies.

Advertise parameters on which two routers must agree to become neighbors.

Elect the Designated Router (DR) and Backup Designated Router (BDR) on multi-access networks like Ethernet and Frame Relay.

OSPF Hello packets are transmitted to multicast address 224.0.0.5 in IPv4

- Network IP and submask
- Priority
- Hello interval
- Dead interval
- Area id
- RID of DR
- RID of BD

Process and Wild card

Process is used as an identifier of the local OSPF process; different OSPF process IDs would be used on the same router if multiple independent OSPF processes were being run on the same device.

The process-id value represents a number between 1 and 65,535 and is selected by the network administrator.

A wildcard mask is a mask of bits that indicates which parts of an IP address are available for examination.

Cisco Packet Tracer

Switch

Switch Basic Commands (1/2)

Command	Purpose
1-Configure Terminal Example: Switch> enable Switch# configure terminal (or config t) Switch(config)#	Enters global configuration mode, when using the console port.
2-Hostname Name Example: Switch (config)# hostname S1 S1(config)#	Specifies the name for the switch.
3-Interface Type Number Example: Switch(config)# **interface vlan 1** Switch(config-if)#	Enters the configuration mode for Vlan interface on the Switch. **Must be in enabled configuration Mode**

Switch Basic Commands (2/2)

Command	Purpose
4-IP Address IP-Address Mask Example: Switch(config-if)# ip address 192.168.12.1 255.255.255.0 Switch (config-if)#	Sets the IP address and subnet mask for the specified vlan interface.
5-No shutdown Example: Switch(config-if)# no shutdown Switch(config-if)#	Enables the vlan interface, changing its state from administratively down to administratively up **Wait 2 seconds after that command**
6-Exit Example: Switch(config-if)# exit Switch(config)#	Exits configuration mode for vlan interface and returns to global configuration mode

Verifying Your Configuration

Switch# show running-config

Switch# show ip interface brief

Save Switch Configuration

Exit from configuration mode

S1#write memory (or wr)

- This command write your configuration in memory

S1# copy running-config startup-config

- This command will take your current configuration and save it to the startup configuration file

Router

Router Basic Commands (1/2)

Command	Purpose
1-Configure Terminal Example: Router> enable Router# configure terminal (or config t) Router(config)#	Enters global configuration mode, when using the console port.
2-Hostname Name Example: Router(config)# hostname MyRouter MyRouter(config)#	Specifies the name for the router.
3-Interface Type Number Example: Router(config)# interface fastethernet 4 (or int f0/4) Router(config-if)#	Enters the configuration mode for a Fast Ethernet WAN interface on the router. **Must be in enabled configuration Mode**

Router Basic Commands (2/2)

Command	Purpose
4-IP Address IP-Address Mask Example: Router(config-if)# ip address 192.168.12.1 255.255.255.0 Router(config-if)#	Sets the IP address and subnet mask for the specified Fast Ethernet interface.
5-No shutdown Example: Router(config-if)# no shutdown Router(config-if)#	Enables the Ethernet interface, changing its state from administratively down to administratively up **Wait 2 seconds after that command**
6-Exit Example: Router(config-if)# exit Router(config)#	Exits configuration mode for the Fast Ethernet interface and returns to global configuration mode

Configuration Example

R1

```
*Mar  1 00:00:04.539: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/1, changed state to down
*Mar  1 00:00:04.539: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/2, changed state to down
*Mar  1 00:00:04.543: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet1/0, changed state to down
*Mar  1 00:00:04.543: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/0, changed state to down
*Mar  1 00:00:04.547: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/1, changed state to down
*Mar  1 00:00:04.551: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/2, changed state to down
*Mar  1 00:00:04.551: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/3, changed state to down
R1#
R1#enable
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int f0/0
R1(config-if)#ip address 192.168.12.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#exit
R1(config)#exit
```

Save Router Configuration

Exit from configuration mode

R1#write memory (or wr)

- This command write your configuration in memory

R1# copy running-config startup-config

- This command will take your current configuration and save it to the startup configuration file

```
R1(config-if)#exit
R1(config)#exit
R1#wr
*Mar  1 00:01:44.095: %SYS-5-CONFIG_I: Configured from console by console
R1#copy runnin
R1#copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
[OK]
R1#
```

Verifying Your Configuration

Router# show ip route

Router# show ip interface brief

R1

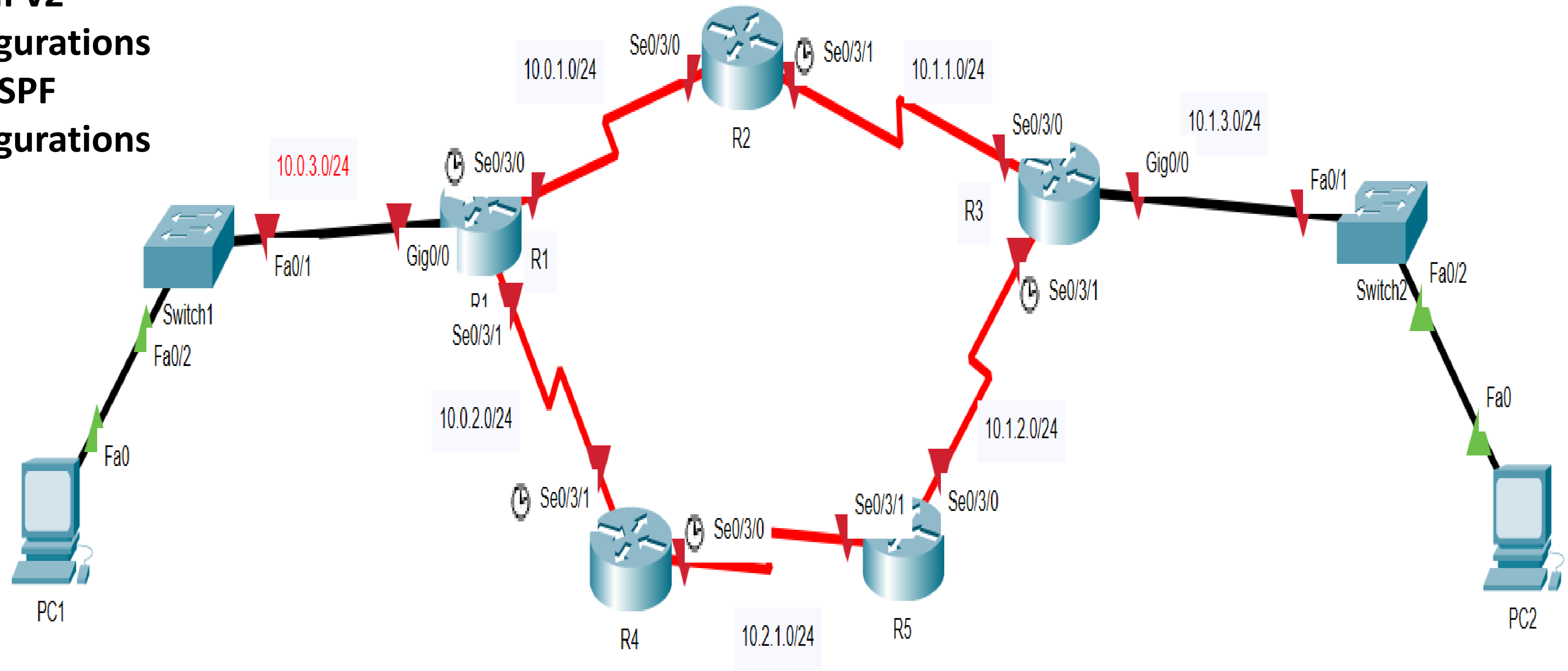
```
R1(config-if)#ip address 192.168.12.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#exit
R1(config)#exit
R1#wr
*Mar  1 00:01:44.095: %SYS-5-CONFIG_I: Configured from console by console
R1#copy runnin
R1#copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
[OK]
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 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       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
R1#
```

Lab6- NETWORK LAYER

Lab Experiment

Lab Topology

Objectives
Part 1: Configure RIPv2
Part 2: Verify Configurations
Part 3: Configure OSPF
Part 4: Verify Configurations



Lap configuration

create the preceding topology and configure the devices as per the values mentioned in the following table. **First of all, configure the IP addresses on each device ,**
On switches ; only configure their hostname.

Device	interfaces	IP Address	Device	Interface	IP address
R1	Se0/3/0 Se0/3/1 Gig0/0	10.0.1.1/24 10.0.2.1/24 10.0.3.1/24	R4	Se0/3/0 Se0/3/1	10.2.1.1/24 10.0.2.2/24
R2	Se0/3/0 Se0/3/1	10.0.1.2/24 10.1.1.2/24	R5	Se0/3/0 Se0/3/1	10.1.2.2/24 10.2.1.2/24
R3	Se0/3/1 Se0/3/0 Gig0/0	10.1.2.1/24 10.1.1.1/24 10.1.3.1/24	PC1	E0	10.0.3.2/24
			PC2	e0	10.1.3.2/24

PART 1 RIP

Configure RIPv2 on each router

Once you have configured the appropriate IP addresses on each device, perform the following steps to configure RIP routing. The default version of RIP is RIPv1.

But we will configure RIPv2 routing.

Install RIP on all routers.

```
R(config)#router rip
R(config-router)#version 2
R(config-router)#network 10.0.0.0      % The 'network' command should reference a classful network. No subnet mask is specified
R(config-router)#no auto-summary
R(config-router)#exit
```

Save your configuration

R#wr

PART 2 RIP : Verify Configurations

Verifying routing tables

Once you have configured RIP routing protocol on each router,

wait for a few seconds (let complete the convergence process),

and then execute the show ip route command on any router to show the routing information.

Router(config)#do show ip route

Verifying RIP Configuration

To verify and test the RIP configuration, perform the following steps:

1. To verify which routing protocol is configured, use the **show ip protocols** command.

```
Router#show ip protocols
```

2. To view the RIP messages being sent and received, use the **debug ip rip** command.

```
Router#debug ip rip
```

3. To stop the debugging process, use the **undebug all** command.

```
Router#undebug all
```

RIP LAB Questions

- **Q1. . On every router , verify which routing protocol is configured, Verify your answer , Take screenshots**
- **Q2. On every router , Verify all networks are in the router’s routing table. Verify your answer , Take screenshots**
- **Q3. Can R2 ping any other interface of R4? Verify your answer , Take screenshot**
- **Q4. Can PC2 now ping PC1? Verify your answer , Take screenshot**

PART 3 :OSPF

Configure OSPFv2 Routing

Hint: Be sure to disable RIP protocol from all routers configuration, by using the command (no router rip

Part 1: Step 1: Configure OSPF on All Routers

Use the following requirements to configure OSPF routing on all five routers:

– Process ID 1
– Router ID for each router: R1 = 1.1.1.1; R2 = 2.2.2.2; R3 = 3.3.3.3, R4 = 4.4.4.4; R5 = 5.5.5.5
– Network address for each interface

Install OSPF on all routers.

- **R(config)# router ospf <process--_id>**
- **R(config-router)# router-id <IP A.B.C.D>**
- **R(config-router)# network <IP A.B.C.D> <wildcard bits> area <area_--id>**
- **R(config-router)#exit**

Save your configuration

R#wr

PART 4 OSPF : Verify Configurations

Verifying routing tables

Once you have configured OSPF routing protocol on each router,

wait for a few seconds (let complete the convergence process),

and then execute the show ip route command on any router to show the routing information.

Router(config)#do show ip route

Verification Commands

- To show the OSPF database router: show ip ospf database router x.x.x.x
  - Where x.x.x.x is the router ID
- Help ospf ip: show ip ospf ?
- Show the routing information base: show ip ospf
- Show the details of the OSPF: show ip ospf <*proc-id*>
- Show the router neighbor: show ip ospf neighbor (DR-BDR-DROTHER)

OSPF LAB Questions

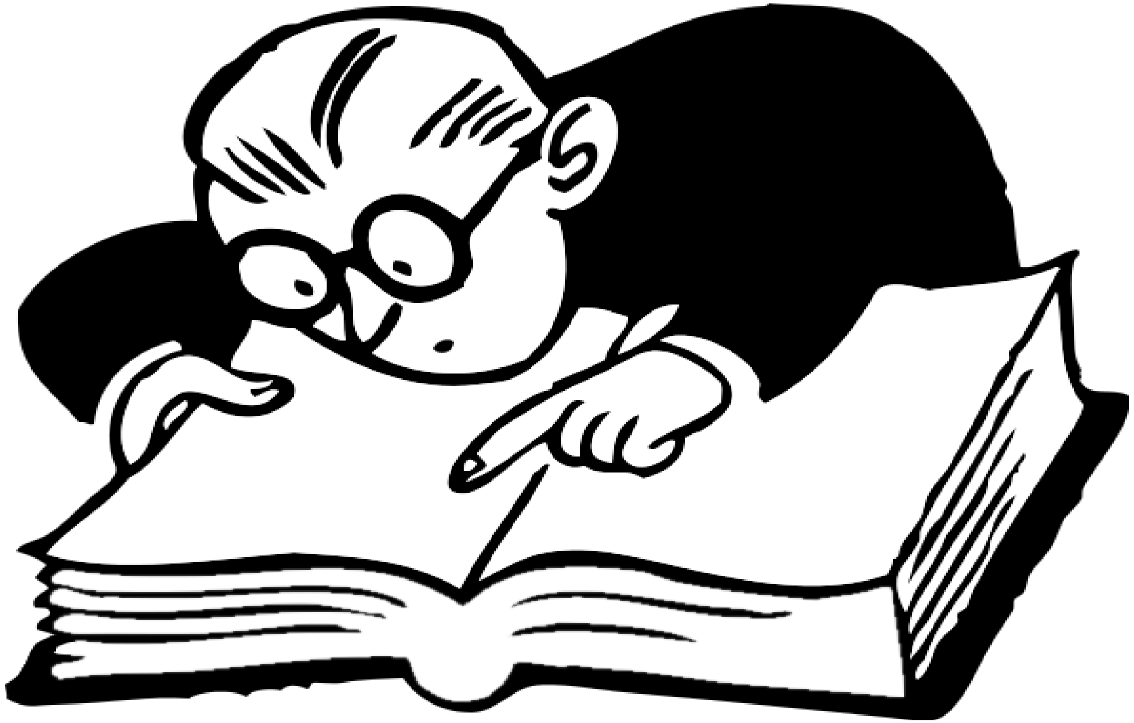
- ❑ **Q5. On every router , verify which routing protocol is configured, Verify your answer , Take screenshots**
- ❑ **Q6. On every router , Verify all networks are in the router's routing table. Verify your answer , Take screenshots**
- ❑ **Q7. Can PC2 now ping PC1? Verify your answer , Take screenshot**
- ❑ **Q8. Use the following commands to gather information about your OSPFv2 implementation. In all routers**
  - **show ip ospf database**
  - **show ip ospf neighbor**

  Verify your answer , Take screenshots

Answer the following questions :

- ❑ **Q9. Which router(s) are backbone routers?**
- ❑ **Q10. Which routers are generating Type 1 LSAs?**
- ❑ **Q11. Which routers are generating Type 2 LSAs?**

Task



- ❑ Post your **pdf-format** explanation report on the Google classroom **after lab due** **Sunday (26th April)**
- ❑ All answers should be contained in **one explanation report**. DO NOT create a separate answer report for each question
- ❑ Don't forget to provide your project as appendices for **full credit.**


Questions

Thank you.....!