

Comparative Analysis of Dynamic Routing Protocols

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Abstract - The main concepts of the dynamic routing protocols are discussed in this paper. Routing protocols are basically used to let the communication between the routers happen. The efficiency of the routing can be judged on the basis of metrics. This comparative study is carried out and explained.

INTRODUCTION

Dynamic routing protocols play an important role in today's networks. In the following paper, we describe the importance of each of these routing protocols, their usage, advantages and disadvantages. Firstly, let us understand what a routing protocol is. For example, if we want to transfer a box from room A to room B, the first thing we would calculate is the shortest path. Similarly, when the data is being transferred in the network layers, the path determination and switching are done using these protocols. The routing protocols are given in two forms,

- Static Routing
- Dynamic Routing

STATIC ROUTING:

When the IP addresses are set manually and the routes are entered from the keyboard, it is known as static routing. The entries are made into the routing table by the network administrator before the actual routing process begins. These entries can only be changed by the administrator, they cannot alter themselves. This requires additional configuration when the subnets are added in the internetwork. Since, they can't adapt to any changes made in the network, they are usually not preferred when the network is huge and the outcome is not predictable. They also do not send and routing information that can be heard by the hackers. They do not have CPU memory and link bandwidth.

DYNAMIC ROUTING:

On the other hand, dynamic routing is done using the routing protocols i.e., instead of giving each and every IP of the entry and exit of the router, the network administrator just has to write the protocol with the given syntax. In the real time, these are very practical and beneficial since they can identify, if notified, the changes brought into the network and find the shortest path. They can adjust to the changing network environments by reading the routing update messages. If the messages indicate any change in the network; they calculate the shortest path and send the message. The design goals of dynamic routing protocols are:

OPTIMALITY- the capability to choose the best path to route which depends on the metrics and metric weightings, used for calculations.

LOW OVERHEAD- simple and efficient overhead.

ROBUSTNESS- they should perform efficiently in the case of hardware failures or high load conditions.

FLEXIBILITY- they should quickly adapt to any new circumstances in the network environment

RAPID CONVERGENCE- agreement of the entire route to choose the most optimal path.

Components of dynamic routing protocols:

1. **Data Structures:** They are kept in RAM. Tables and Databases.
2. **Algorithm:** The steps in which the routing process occurs. Used for processing routing information and calculating the best path.
3. **Routing Protocol Messages:** Discovers the neighbors. Keep the accurate information of the exit and the entry points.

The dynamic routing protocols that are no longer used,

- a) RIP V1
- b) IGRP
- c) NLSP
- d) EGP- Exterior Gateway Protocol
- e) BGP- Border Gateway Protocol

The dynamic routing protocols in use and studied in this paper,

- a) RIP V2
- b) EIGRP
- c) OSPF

Dynamic routing protocol operation:

The common purpose and function of these protocols is to identify the remote networks and quickly adapt whenever there is a change in the network environment. The operations depend on the given protocol. The following are the general operations of a dynamic routing protocol,

- The router sends and receives the information on its interfaces.
- The router shares the routing messages with the other routers that are using the same routing protocol.

- The exchange of information among the routers is to find the remote networks.
- Whenever there is a change in the topology, the routing protocol is used to inform the routers about the changes.

ABBREVIATIONS AND COMMANDS:

RIP: Routing Information Protocol
IGP: Interior Gateway Protocols
IGRP: Interior Gateway Routing Protocols
NLSP: NetWare Link Services Protocol
EGP: Exterior Gateway Protocol
BGP: Border Gateway Protocol
EIGRP: Enhanced Interior Gateway Routing Protocol
OSPF: Open Shortest Path First

Commands:

```
Router>en (to enable the router)
Router# config t (to configure the terminal)
Router(config)# interface _____ (to enter the interface)
Router(config-if)#no shut (to save the added IP)
Router(config)#exit (to exit from that interface)
Router# show run (to look at all the commands given)
Router# show version (to show the versions in use)
Router# show ip route (to show the ip addresses)
```

DYNAMIC ROUTING PROTOCOLS

A. DRP AND CONVERGENCE:

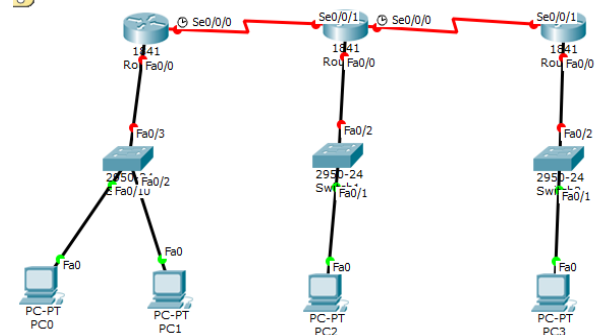
Convergence can be defined as a state where all the routers have the same topological information of the internetwork in which they are operating. In simpler words, the routers should have the accurate information about the neighbouring routers they are connected to. All the routers advertise the part of information they know and when all the routers have the consistent understanding of the network, it can be said that they are converged. However, for the traffic to flow, the routers need not be converged. Even if the routers are not converged the data flow will still occur but the path chosen may not be the optimal route. Any change in the network that affects the routing table, breaks the convergence temporarily until all the information is passed on to all the routers. Whenever there is a change in network topology, routing protocols are used to inform the routers about the changes and when all the routers have adapted to the new information, the convergence is reestablished. Hence, convergence is very important to calculate the best path. Convergence time can be defined as the time taken by the routers to converge. This is one of the main design goals and performance indicators of the routing protocols. RIP takes a lot of time to converge even if the network has only a few routers, it may take upto few minutes to converge. That's why OSPF and EIGRP are the most preferable routing protocols since they converge quickly.

B. DRP AND METRICS:

Metrics are a way to measure or compare. Routing protocols use metrics to determine which route is the best path. There are mostly n numbers of paths to reach one destination. Out of all those paths, to choose one optimal path, metrics are used. There are many factors that are considered when the

information is being sent to remote networks. For example, let's say there are two routes 1 and 2 from router A to router B. Both of them are the shortest paths but 1 costs slightly more than 2. So, the router would choose path 2. This happens when the protocol uses cost metric to determine the path. Each routing protocol uses different metrics to choose the path. RIP uses hop count and EIGRP uses a combination of bandwidth and delay. The available metrics are:

HOP COUNT- No. of routers the packet can traverse. The hop count represents the total number of routing devices a given piece of data (packet) passes through. For example, let's consider the network below to understand the concept of hop count. We have 3 devices each connected to a different router. Now, hop count can be defined as the number of hops taken to reach the destination. Most people interpret hop to be the number of links that are used in the data transfer. But, in real, it is the number of routers the data hops over to reach the destination. Let's say, message has to be passed from PC0 to PC2, the hop count =2. Similarly, from PC0 to PC3, the hop count is 3. However, from PC0 to PC1, the hop count=1 since there is only one router between them. Routing protocols that only reference hops as their metric do not always select the best path through a network. Just because a path to a destination contains fewer network hops than another does not make it best



BANDWIDTH- Path with highest bandwidth is chosen. Bandwidth is measured in terms of bits per second. The links that carry higher transfer rates are always preferred over lower capacity links. However, bandwidth alone is not enough to find the suitable path because let's say there is a high capacity link with greater delay and is highly loaded and a low capacity link with lower delay and lower traffic. What would be ideal is not easy to measure only with the bandwidth information.

DELAY-Time taken by the packet to traverse the path. Delay is the time taken by the packet to traverse the path. If delay is a measure, then the link with the lowest delay would be chosen as the best path. Each individual delay quantity would be an estimate based on the type of link to which the interface is connected. As said in the above example, if both bandwidth and delay are combined together, we can get an optimal path.

LOAD - Traffic utilization of the link. This metric reflects the amount of traffic utilizing the links along the path. The best path is the one with the lowest load. Unlike the hop count and Band width, load is not constant. So, it must be carefully checked before choosing the path.

RELIABILITY-Probability of link failure. Calculated from the interface error count. It is generally measured dynamically over a specific time frame, such as five seconds. Routers observe attached links, reporting problems, such as link failures, interface errors, lost datagram and so on. Links experiencing more problems would be considered less reliable than others, making them less desirable paths—the higher the reliability, the better the path. The network conditions are not stable so the reliability also changes.

COST-A value determined by the network administrator to indicate preference for a route. Network administrators set arbitrary metric values on links along the path end to end. These values are typically single integers with lower values indicating the best path. This is based on the efficiency of the link.

C. DRP AND TYPES:

- i. RIP
- ii. OSPF
- iii. EIGRP

RIP:

RIP is a standardized distance vector routing protocol designed for smaller networks. RIP prevents routing loops by implementing a limit on the number of hops allowed in a path from the source to a destination.

Characteristics of RIP:

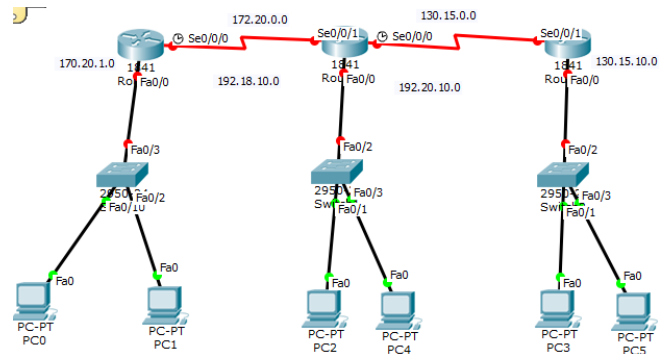
- RIP sends out periodic routing updates (every 30 seconds)
- Full routing table is sent out at every periodic updates.
- RIP uses a form of distance as it's metric.
- RIP routes have an administrative distance of 120.
- RIP has a maximum hop count of 15 hops.

RIP Versions:

It has two versions V1 and V2. V1 is the classful state, which means these protocols do not send subnet mask along with their updates. Whereas, V2 belongs to the classless state, which do send the subnet mask along with their updates. Let us consider the following diagram (a) for understanding the differences better.

Here, as you can see, the information from r1 to r3 goes as 172.20.0.0 without any subnet information and in diagram (b), the information from r1 to r3 is sent as 172.20.1.0/24.

We will discuss only about the V2 in this paper. The routing table most primarily consists of interfaces, ip addresses and metric values. RIP V2 uses multicast address 224.0.0.9. RIP is a interior gateway protocol(IGP), which means this can be used to exchange information between the gateways within an autonomous system.



RIP Configuration:

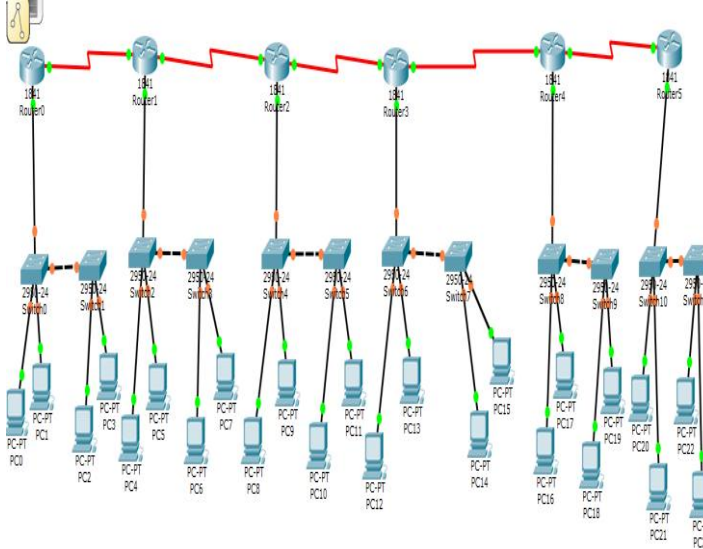
- All the configurations are done in cisco packet tracer 6.1.
- Initially, build a desired network with no more than 15 routers. Each of the router is connected to one or more switches which is further connected to devices.
- A router to router connection is made by serial cable (synchronized). A router to switch and a switch to device connections are made by straight copper cable.
- A switch to switch connection is made by the cross cable. Once all the devices are connected, the IP addresses and gateways are given. There are 2 methods of assigning the IPs, static and DHCP. Here, we have used static approach which means giving all the IP addresses manually. Whereas, in DHCP, if the range is given the IPs are set automatically. So, to set the IP, click on the device, go to desktop mode and click on IP configuration. You have to give the IP and the gateway of that particular device. Follow the same steps and configure all the devices. Once all the devices are configured move on to the routers. Click on the router and enter the CLI mode. Enter 'NO' and now we have to enable the router.
- *Router>en* (Syntax to enable the router) Once the router is enabled, you have entered the user execution mode. We've now entered the privilege mode and here you can run the commands such as show run, Show version ,etc., which are used for troubleshooting. Now, we have to configure the router and to do that, following syntax is used.
- *Router#config* terminal (syntax to configure the terminal) All the commands regarding the routing would be done in the configuration mode.
- To allocate the Ip addresses to the routers, we have to enter the interfaces of the each router. If the router is connected to a switch, its interface would be *fa0/0* or *fa0/1*
interface fa0/0 (Syntax)
- Here we have to enter the gateway of that particular switch; it should be in the same network as the devices connected to that switch.
ip add 170.10.0.3 255.255.0.0 (Syntax for adding a sample ip)

- The next command would be to save the ip and it is no shut. Once no shut is given, we have to exit from the interface and the exit command is exit.
- Now, to configure the routers, we have various serial ports available such as se0/0/0, se0/0/1, se0/1/0 and so on. Every entry point of the port is synchronized i.e., it has a clock rate allotted. A default clock rate of 64000 is used in the example.
`clock rate 64000` (syntax)
The other steps are the same as the `fa0/0`.

Configuration Example:

```
R1>enable
R1#config t
R1(config)#interface se0/0/0
R1(config-if)#ip ad 192.128.10.4 255.255.255.0
R1(config-if)#clock rate 64000
R1(config-if)#no shut
R1(config-if)#exit
R1(config)#
```

RIP Configuration Example:



Rip protocol was used to execute the following network. This network has 6 routers, each connected to one switch which is further connected to another switch. Each of these switches are connected to 2 devices. Each router is given one network and both the switches are connected to the router by the same gateway.

```
For router 1,
interface FastEthernet0/0
ip address 10.0.0.2 255.0.0.0
interface Serial0/0/0
ip address 70.0.0.2 255.0.0.0
clock rate 64000

interface Serial0/0/1
no ip address
clock rate 2000000
shutdown
```

The above three ports are configured using router the RIP routing is,

```
router rip
network 10.0.0.0
network 70.0.0.0
!
ip classless
ip route 0.0.0.0 0.0.0.0 70.0.0.3
```

The network ids are the Ids the router is directly connected through the exit point 70.0.0.3 .The syntax for RIP routing, When you've entered the configuration mode,

```
For router 1
R1#conf t
R1(config)#router rip
R1(config-router)#version 2
R1(config-router)#network 192.168.12.0
R1(config-router)#exit
```

```
For router 2,
interface FastEthernet0/0
ip address 20.0.0.2 255.0.0.0
duplex auto
speed auto
!
interface FastEthernet0/1
duplex auto
speed auto
shutdown
!
interface Serial0/0/0
ip address 130.0.0.2 255.255.0.0
clock rate 64000
```

```
RIP config
router rip
network 20.0.0.0
network 70.0.0.0
network 130.0.0.0
!
```

```
For router 3,
interface FastEthernet0/0
ip address 40.0.0.2 255.0.0.0
duplex auto
speed auto
!
interface FastEthernet0/1
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/0/0
ip address 160.0.0.2 255.255.0.0
clock rate 64000
!
interface Serial0/0/1
```

```
ip address 130.0.0.3 255.255.0.0
clock rate 2000000
```

```
RIP config,
router rip
network 40.0.0.0
network 130.0.0.0
network 160.0.0.0
!
```

It is similarly done for the other 3 routers.

OSPF:

Open shortest path first (OSPF) is a routing protocol which uses link state routing algorithm. It is mostly used for wide enterprise networks. It is an interior gateway protocol (IGP) for routing packets within a single routing domain, such as an autonomous system. It constructs topology based on the link state information from the routers. This topology is then presented as routing table to the internet layer. It supports both *Internet protocol version 4* (IPv4) and *Internet protocol version 6* (IPv6) and supports *classless inter-domain routing* (CIDR) addressing model.

An OSPF network can be divided into sub- domains called routing areas. These areas are the logical collection of OSPF networks, routers and links. Each area has different networks and there is only one area which creates communication between all attached areas. A router within that area maintains a topological database for the area to which it belongs. The router doesn't have detailed information about topology outside of its area, thereby reducing the size of database. It has complex network with multiple routers to balance load on multiple links to other subnets. It creates an adjacency database for exchanging routing updates with other routers. Two routers are neighbors if they are members of the same subnet and share the same area ID, subnet mask, timers and authentication. The OSPF neighbors exchange packets called hello packets.

Area types:

- Backbone area
- Stub area
- Not-so-stubby area
- totally stubby area
- Transit area

Router types:

- *Internal router (IR)*: An internal router has all its interfaces belonging to the same area.
- *Area border router (ABR)*: It connects one or more areas to the main backbone network.
- *Autonomous System boundary router (ASBR)*: It is connected by using more than one routing protocol and it exchanges routing information with routers autonomous systems.

Routing Metrics

OSPF uses path cost as its basic routing metric. Metrics are only directly comparable when of the same type. Following are the types of metrics:

1. Intra-area
2. Inter-area
3. External Type1
4. External Type2

OSPF Topology Configuration:

The area 0 routers is connected to four area 1 routers in which each area 1 router has two more routers connected to it. The commands for establishing the connections between routers and switch (typed in CLI):

```
>>enable
#configuration terminal
#interface fast Ethernet no.
#ip address ip address subnetmask
#no shutdown
```

The commands for establishing the connection between two routers(Typed in CLI):

```
>>>enable
#interface <serial port no.>
#ip address <ipaddress><subnetmask>
#clock rate 32000-64000
#exit
```

For routing the connections using OSPF the commands are

```
#config terminal
#router ospf<autonomous system>
#network <Network ID><Wildcard mask><area no.>
```

OSPF Configuration Example:

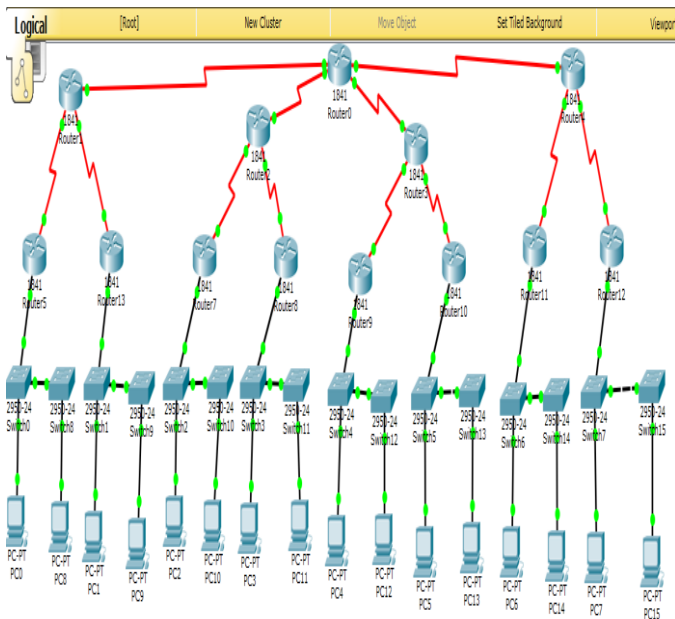
As shown in the diagram below, connect all the routers and the switches and the devices. The process remains the same as described above for RIP. Once all the switches and devices are connected to the routers, the routers would be connected to one another using the OSPF routing algorithm.

For router 0,

This is the medium through which all other routers would communicate. The configuration done is as follows,

```
interface FastEthernet0/0
no ip address
duplex auto
speed auto
shutdown
!
interface FastEthernet0/1
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/0/0
ip address 20.0.0.3 255.0.0.0
clock rate 64000
!
interface Serial0/0/1
ip address 40.0.0.3 255.0.0.0
clock rate 64000
!
```

```
interface Serial0/1/0
ip address 10.0.0.3 255.0.0.0
clock rate 64000
!
interface Serial0/1/1
ip address 30.0.0.3 255.0.0.0
clock rate 64000
!
interface Vlan1
no ip address
shutdown
!
router ospf 40
log-adjacency-changes
network 10.0.0.0 0.255.255.255 area 0
network 20.0.0.0 0.255.255.255 area 0
network 30.0.0.0 0.255.255.255 area 0
network 40.0.0.0 0.255.255.255 area 0
!
ip classless
```



For router 1,

```
interface FastEthernet0/0
no ip address
duplex auto
speed auto
shutdown
!
interface FastEthernet0/1
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/0/0
ip address 50.0.0.3 255.0.0.0
clock rate 64000
!
```

```
interface Serial0/0/1
no ip address
clock rate 2000000
shutdown
!
interface Serial0/1/0
ip address 60.0.0.3 255.0.0.0
clock rate 64000
!
interface Serial0/1/1
ip address 10.0.0.2 255.0.0.0
clock rate 2000000
!
interface Vlan1
no ip address
shutdown
!
```

For router 5,
interface FastEthernet0/0
ip address 130.0.0.2 255.255.0.0
duplex auto
speed auto
!

```
interface FastEthernet0/1
no ip address
duplex auto
speed auto
shutdown
!
```

```
interface Serial0/0/0
no ip address
clock rate 2000000
shutdown
!
```

```
interface Serial0/0/1
no ip address
clock rate 2000000
shutdown
!
```

```
interface Serial0/1/0
no ip address
clock rate 2000000
shutdown
!
```

```
interface Serial0/1/1
ip address 60.0.0.2 255.0.0.0
clock rate 2000000
!
```

```
interface Vlan1
no ip address
shutdown
!
```

```
router ospf 40
log-adjacency-changes
network 60.0.0.0 0.255.255.255 area 1
network 130.0.0.0 0.0.255.255 area 1
!
ip classless
!
```

In the same way, all the other routers are configured.

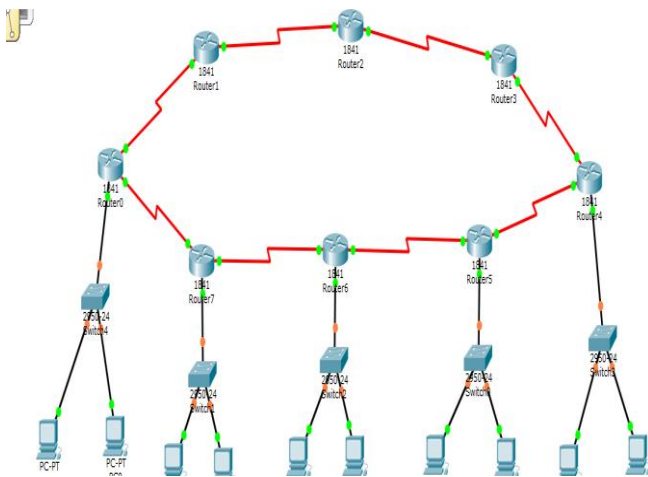
EIGRP

EIGRP is an advanced distance vector routing protocol which is used for automating routing decisions and configuration. It was designed by Cisco and used only on Cisco routers. It uses autonomous system to share routes of routers with other routers. It provides quick convergence times with minimal network traffic with very low usage of network resources during normal operations.

EIGRP uses Routing tables, Neighbor table and Topology table to store information. The neighbor table keeps a record of IP address that have direct connection with that particular router. The routers which are not connected or connected through another router are not recorded.

The topology table stores routes that it has learned from neighbor routing tables. It stores only those routes that are determined by EIGRP. It records the metrics of all EIGRP routes. There are two types of routes. One is active route which indicates that EIGRP is trying to get the best path and another is passive route which indicates that it has determined the path.

EIGRP is considered a hybrid protocol because it sends link state updates when link state is changed and also uses Distance vector protocol.



The configuration of the switches and devices are done as explained above in the RIP section. Once the switches and devices are configured, the routers are configured using the EIGRP algorithms. The configuration as follows,

```
For router 0,  
interface FastEthernet0/0  
ip address 9.0.0.1 255.0.0.0  
duplex auto  
speed auto  
!  
interface FastEthernet0/1  
no ip address  
duplex auto  
speed auto  
shutdown  
!  
interface Serial0/0/0  
ip address 96.0.0.2 255.0.0.0  
clock rate 64000  
!
```

```
interface Serial0/0/1  
ip address 97.0.0.1 255.0.0.0  
clock rate 2000000  
!  
interface Vlan1  
no ip address  
shutdown  
!  
router eigrp 1  
network 96.0.0.0  
network 97.0.0.0  
network 9.0.0.0  
auto-summary  
!  
ip classless  
!
```

```
For router 1,  
interface FastEthernet0/0  
no ip address  
duplex auto  
speed auto  
shutdown  
!  
interface FastEthernet0/1  
no ip address  
duplex auto  
speed auto  
shutdown  
!  
interface Serial0/0/0  
ip address 96.0.0.1 255.0.0.0  
clock rate 2000000  
!  
interface Serial0/0/1  
ip address 95.0.0.2 255.0.0.0  
clock rate 64000  
!  
interface Vlan1  
no ip address  
shutdown  
!  
router eigrp 1  
network 95.0.0.0  
network 96.0.0.0  
auto-summary  
!  
ip classless
```

```
For router 2,  
interface FastEthernet0/0  
no ip address  
duplex auto  
speed auto  
shutdown  
!  
interface FastEthernet0/1  
no ip address  
duplex auto  
speed auto
```

```
shutdown
!
interface Serial0/0/0
ip address 94.0.0.2 255.0.0.0
clock rate 2000000
!
interface Serial0/0/1
ip address 95.0.0.1 255.0.0.0
clock rate 2000000
!
interface Vlan1
no ip address
shutdown
!
router eigrp 1
network 94.0.0.0
network 95.0.0.0
auto-summary
!
ip classless
```

CONCLUSION

It can be concluded that when the number of routers is few, RIP could be used but it still cannot be said that it is an efficient method. Delay and load on combination give better results, to simplify, RIP is chosen on the basis of hop count but on the other hand when two to three metrics are considered on a whole, the protocol chosen would be the most efficient one. As per the results, OSPF has by far been the most preferred and the most used routing protocol.

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Comparison between RIP, EIGRP, OSPF

S.N o.	Routing Information Protocol (RIP)	Enhanced Interior Gateway Routing Protocol (EIGRP)	Open Shortest Path First (OSPF)
1	It is a distance vector routing protocol.	It uses advanced distance vector routing protocol.	It uses link state routing protocol.
2	Hop count 0-15 means that it supports maximum of 15 routers.	Hop count 0-255 means that it supports maximum of 255 routers.	There is no limit on hop count so it can support any number of routers.
3	It is used for small organizations.	It is used for medium and large organizations.	It is used for large enterprises.
4	RIPv1: does not support VLSM RIPv2: Supports VLSM	Supports VLSM.	Supports VLSM.
5	Administrative distance is 120.	Administrative distance is 100.	Administrative distance is 90.
6	It calculates the metric in terms of Hop count.	It calculates the metric in terms of bandwidth and delay.	It calculates the metric in terms of bandwidth
7	We can't create separate administrative boundary.	We can create separate administrative boundary using autonomous no.	We can create separate administrative boundary using area no. within the same area.
8	It is industry SRP	It is Cisco SRP	It is industry SRP