

A Comparative Evaluation of Classless Routing Protocols (EIGRP) and Classful Routing Protocols (RIP)

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Abstract- The Classful routing protocol does not carry the subnet mask information in its routing table. RIP version 1 (Routing Information Protocol) is a Classful routing protocol, this was the Internet's first widely used routing protocol in networks. RIP is useful for local and medium size networks. The RIP is known as a distance-vector routing protocol, which works in the hop count as a routing metric, The RIP allowed 15 no's maximum hops counts. The 16th hop count is considered as infinite distance viewing such distance as unreachable and undesirable route in it routing process. The RIP operates the limited size of the networks.

The Classless routing protocol can carry the subnet mask information, Enhanced Interior Gateway Routing Protocol (EIGRP) is an advanced distance-vector routing protocol, Classful routing protocol designed by Cisco Systems. EIGRP is an enhanced version of old routing protocol, as IGRP (Interior Gateway Routing Protocol). EIGRP supports VLSM and CIDR allowing network designers to maximize address space. EIGRP is based on distance vector and link-state algorithms. This paper consist of advantages of classless (EIGRP) routing protocol over Classful routing Protocol (RIP). This includes the various trouble resolving techniques and traffic handling techniques during communication in simple as well in bulky networks. [1]

Key Words: - Routing protocols, Classful (RIP), Classless (EIGRP)

I. INTRODUCTION

Classful Routing: The Classful routing Protocol does not send subnet mask info at what time a route update is send out. All devices in the system has to make use of the similar subnet mask. It's not allows Variable Length Subnet Masking. [2]

For example: RIP V1 & IGRP are the Classful routing protocols

Routing Information Protocol (RIP):

RIP is a Classful protocol, means that it doesn't carry subnet mask info in its routing table. RIP is not able to support Variable Length Subnet Masking (VLSM) and discontinuous networks. It is a Distance-Vector protocol.

RIP version 1

The originally RIP specified in RFC 1058 [5] Uses Classful routing. The periodic routing updates do not carry subnet information, lacking support for variable length subnet masks (VLSM). This limitation makes it impossible to have different-sized subnets inside of the same network class. So the all subnets in a network class must have the same size. RIP V1 doesn't support for router authentication, making RIP vulnerable to various attacks. [6]

1. RIP uses the Bellman-Ford Algorithm to calculate its routes.
2. RIP uses the Bellman Ford Algorithm to calculate the network.
3. The all router sends a list of distance-vectors each of its neighbors periodically in the network.
4. The metric should be a positive integer. The metric measures the cost to get to the destination. In RIP, the cost describes number of hops.
5. RIP allowed 15 hops counts.
6. RIPv1 is specified in RFC 1058
7. RIPv2 is specified in RFC 2453[5]

The Message format for RIP

RIP message format is shown in below. (Fig: 1) all messages contains command entry and a version number and can contain entries for up to 25 routes. Each route entry includes an address family ID (identifier), the IP address accessible by the route, and the hop count for the route. [7]

Command	Version	Reserved
Address Family ID		Reserved
IP Address		
Reserved		
Reserved		
Metric		

Fig: 1 (Message format for RIP)

Command will always be set to either one, signifying a Request message, or two, signifying a Response message.

There are some other commands, but they are all either obsolete or reserved for private use.

Version will be set to one for RIPv1.

Address Family Identifier is set to two for IP. The only exception to this is a request for a router's full route table.

IP Address is the address of the destination of the route. This entry might be a major network address, a subnet, or a host route.

Metric is a hop count between 1 and 16.

RIP Timers

RIP uses several timers to control its operation.

There are 4 different timers that are used in RIP (Fig 2)

- Update Timer
- Invalid Timer
- Hold down Timer
- Flush Timer

Update Timer: Time between each update = 30s (Default)
Invalid Timer: "Margin of the error" for update = 180s (Default)
Hold-down Timer: Route declare unusable = 180s (Default)
Flush Timer: Remove route =240s (Default)

Fig 2: (RIP Timer)

The characteristics of a Classful routing protocols are given below:

- In Classful routing, each IP address requires its own entry in the routing table. [3]
- Summarization occurs at the network boundary.
- Foreign networks exchanged the routes are summarized to the NIC number network boundary.
- Inside the same network (NIC number), subnet routes are exchanged by routers, without the mask.
- The consumption of address space may be inefficient.
- The VLSM is not possible within the Classful networks.

Classless Routing: The Classless routing protocols were designed to overcome the constraints listed above. The Classless routing sends subnet mask information within the routing updates. Classless routing protocols allows Variable Length Subnet Masking (VLSM). For example: RIP V2, EIGRP, OSPF, IS-IS and BGP.

RIP version 2

The RIP version 2 (RIP v2) was developed in 1993[6] and last standardized in 1998. [6] RIP v2 can carry the subnet

information, and supporting Classless Inter-Domain Routing (CIDR). RIP v2 also support 15 hop counts to maintain the backward compatibility.

RIP v2 multicasts the routing table to avoid unnecessary load on hosts that do not participate in routing. RIPv2 multicasts the entire routing table to all neighboring routers, as opposed to RIPv1 which uses broadcast. In RIP v2 allowed unicast addressing for special applications.

RIPv2 is Internet Standard STD56 (which is RFC 2453).

The route tags were also added in RIP v2. Route tag functionality allows for routes to be distinguished from internal routes to external redistributed routes from EGP (Exterior Gateway Protocol) protocols. [6]

RIPng

RIP next generation (RIPng), defined in RFC 2080. This is an extension of RIPv2. RIPng is supporting of IPv6 (Internet Protocol version 6), the next generation Internet Protocol.

The main differences between RIPv2 and RIPng are:

- RIPng is supporting IPv6 protocol.
- While RIPv2 supports RIPv1 supporting IPv4
- RIPv2 supports RIPv1 updates authentication
- RIPng does not updates authentication. IPv6 supposed to use IPsec for authentication.
- RIPv2 allows attaching arbitrary tags to routes.
- RIPng does not allows attaching arbitrary tags to routes.
- RIPv2 encodes the next-hop into each route entries.
- RIPng requires specific encoding of the next hop for a set of route entries.

The characteristics of a classless routing protocol are listed here:

- In Classless routing network the router interfaces within the same network can have different – different subnet masks (VLSM).
- Classless Inter Domain Routing (CIDR) is supported by classless routing protocols like: BGP-4 and RIP v2.
- Some routes can be summarized within the major NIC number. This is done manually. [4]

The differences between classless and Classful are important within the routing protocols.

Enhanced Interior Gateway Routing Protocol

Enhanced Interior Gateway Routing (EIGRP), referred to an advanced Distance Vector (DV) protocol, EIGRP offers radical improvements over Interior Gateway Routing Protocol (IGRP). DV protocols such as RIP and IGRP exchange periodic routing updates with their neighbors, saving the best distance or metric and the next hop for each destination. EIGRP is different in that it saves not only the best route but all routes, allowing convergence to be much faster. The EIGRP updates are sent only upon a network topology change, updates are not periodic. [8]

The EIGRP is having fast convergence feature due to the Diffusing Update Algorithm (DUAL). [8] The IP header of an EIGRP packet specifies protocol number 88, and the maximum length of the packet will be the IP Maximum Transmission Unit (MTU) of the interface on which it is transmitted usually 1500 octets. [8]

EIGRP Reliable Transport Protocol

EIGRP is having five types of packets, further categorized as reliable packets and unreliable packets.

The reliable EIGRP packets are as follows [8]:

Update— This packet is having EIGRP routing updates sent to an EIGRP neighbor.

Query— When the route is not available the queries are sent to neighbors and the router needs to ask the status of the route for fast convergence.

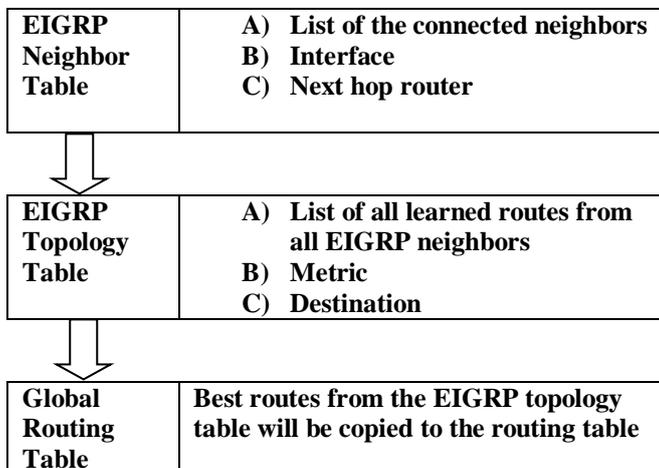
Reply— Reply packets is having the status of the route being queried for.

The unreliable EIGRP packets are as follows:

Hello— EIGRP neighbor relationships across a link is used Hello packets.

Acknowledgment— Acknowledgment packets ensure reliable delivery of EIGRP packets.

The EIGRP Table



The EIGRP Metrics

The EIGRP can utilize 5 separate metrics to determine the best route/ path to a destination:

- Bandwidth (K1)** – The slowest link in the route, measured in kilobits
- Load (K2)** – Cumulative load of all outgoing interfaces in the path, given as a fraction of 255
- Delay of the Line (K3)** – Cumulative delay of all outgoing interfaces in the path in tens of microseconds
- Reliability (K4)** – Average reliability of all outgoing interfaces in the path, given as a fraction of 255
- MTU (K5)** – The smallest Maximum Transmission Unit in the path. The Metric never use the MTU for calculation.

EIGRP used only Bandwidth and Delay of the Line. This is equal to IGRP, except that EIGRP provides a more granular metric by multiplying the bandwidth and delay by 256. Bandwidth and delay are determined by the interfaces that lead to the destination network. [11]

The full formula for determining the EIGRP metric is:
 $[1000000/\text{bandwidth} + \text{delay}] * 256$

Bandwidth value represents the link with the lowest bandwidth in the path, in kilobits. **Delay** is the total delay of all outgoing interfaces in the path.

As mentioned above, every metric is symbolized with a “K” and then a number. For configuring EIGRP metrics only Bandwidth and Delay are considered. Thus, using on/off logic:

$K1=1, K2=0, K3=1, K4=0, K5=0$

If all metrics set to “on,” then full formula for determining the EIGRP metric will be:

$[K1*\text{bandwidth}*256 + (K2*\text{bandwidth}) / (256 - \text{load}) + K3*\text{delay}*256] * [K5 / (\text{reliability} + K4)]$

Remember, the “K” value is either set to on (“1”) or off (“0”).

The Packet Header for EIGRP

EIGRP, IP header packet specifies IP protocol number 88 within it, and the maximum length of the packet will be the IP Maximum Transmission Unit (MTU) of the interface on which it is transmitted, most of the time 1500 octets. (Fig: 3)
 The IP header is the various Type/Length/Value (TLV) triplets. These TLVs will not only carry the route records but also give the fields for managing of the DUAL process, multicast sequencing, and IOS software versions from the router. [12]

Version (0-8)	Opcode (8-16)	Checksum (24-32)
Flags (32)		
Sequence Number (32)		

Autonomous System Number (32)	
Type (16)	Length (16)
Values (32)	
Other TLV (Type/Length/Value) Triplets ...	

Fig: 3 (EIGRP Packet Header)

The EIGRP header contains the following fields: [13]

Field	Description
Version	The current EIGRP version is 2.
Opcode	Identifies the types of EIGRP packet.
Checksum	The checksum of the entire EIGRP packet , excluding the IP header.
Flags	The flag indicates either an init for new neighbor relationship or the conditional receive for EIGRP RTP (Reliable Transport Protocol). EIGRP contain only two flags now.
Sequence and Acknowledgement	Identified the SEQ number used by RTP. ACK used by EIGRP RTP for reliable message exchange.
Autonomous System Number	Identifies the autonomous system of an EIGRP packet.
Type / Length / Value (TLV)	TLVs are- a 16-bit Type field, a 16-bit Length field, and a vary number of fields depends on the type of TLV.

II. SIMULATION OF RIP v1 AND EIGRP

RIPv1 Configuration:

For the simulation part, we will use Cisco Packet Tracer 5.3.3.0019. We will use two Routers-2811, serial ports for connection, Pcs and IP addresses.

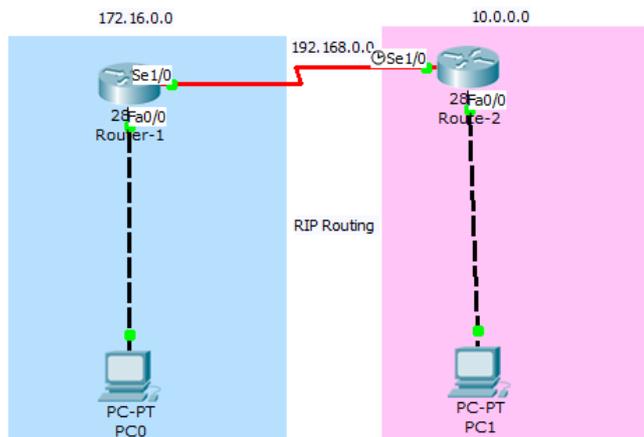


Fig: 4 Simulation

Step1: Assign the IP address for PC0 as: 172.16.0.2 255.255.0.0 with Gateway 172.16.0.1

Step2: Assign the IP address for PC0 as: 10.0.0.2 255.0.0.0 with Gateway 10.0.0.1

Step3: For Router-1

```

Router>en
Router#conf t
Enter configuration commands, one per line. End with
CNTL/Z.
Router(config)#hostname Router-1
Router-1(config)#enable secret cisco
Router-1(config)#line vty 0 4
Router-1(config-line)#password cisco
Router-1(config-line)#login
Router-1(config-line)#exit
Router-1(config)#^Z
Router-1#
%SYS-5-CONFIG_I: Configured from console by console
Router-1#wr me
Building configuration...
[OK]
Router-1#

Router-1#conf t
Enter configuration commands, one per line. End with
CNTL/Z.
Router-1(config)#interface fastEthernet 0/0
Router-1(config-if)#ip address 172.16.0.1 255.255.0.0
Router-1(config-if)#no shutdown
%LINK-5-CHANGED: Interface FastEthernet0/0, changed
state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/0, changed state to up
Router-1(config-if)#ex
Router-1(config)#interface serial 1/0
Router-1(config-if)#ip address 192.168.0.1 255.255.255.0
Router-1(config-if)#encapsulation ppp
Router-1(config-if)#no sh
%LINK-5-CHANGED: Interface Serial1/0, changed state to
down
Router-1(config-if)#
Router-1#
%SYS-5-CONFIG_I: Configured from console by console

Router-1#conf t
Enter configuration commands, one per line. End with
CNTL/Z.
Router-1(config)#router rip
Router-1(config-router)#network 172.16.0.0
Router-1(config-router)#network 192.168.0.0
Router-1(config-router)#end
Router-1#
%SYS-5-CONFIG_I: Configured from console by console
Router-1#show ip protocols
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 21 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Outgoing update filter list for all interfaces is not set
    
```

Incoming update filter list for all interfaces is not set
 Redistributing: rip

Default version control: send version 1, receive any version

Interface Send Recv Triggered RIP Key-chain
 FastEthernet0/0 1 2 1

Automatic network summarization is in effect

Maximum path: 4

Routing for Networks:

172.16.0.0

192.168.0.0

Passive Interface(s):

Routing Information Sources:

Gateway Distance Last Update

Distance: (default is 120)

**Configuration for Router-2- approx same as Router-1
 Just change the IP addresses and connected networks.**

Router-1#**sh ip route**

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, via - 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

R 10.0.0.0/8 [120/1] via 192.168.0.2, 00:00:13, Serial1/0

C 172.16.0.0/16 is directly connected, FastEthernet0/0

192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.0.0/24 is directly connected, Serial1/0

C 192.168.0.2/32 is directly connected, Serial1/0

Packet Tracer PC Command Line 1.0

PC>**ping 10.0.0.2**

Pinging 10.0.0.2 with 32 bytes of data:

Reply from 10.0.0.2: bytes=32 time=17ms TTL=126

Reply from 10.0.0.2: bytes=32 time=20ms TTL=126

Reply from 10.0.0.2: bytes=32 time=18ms TTL=126

Reply from 10.0.0.2: bytes=32 time=17ms TTL=126

Ping statistics for 10.0.0.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 17ms, Maximum = 20ms, Average = 18ms

Packet Tracer PC Command Line 1.0

PC>**ping 172.16.0.2**

Pinging 172.16.0.2 with 32 bytes of data:

Reply from 172.16.0.2: bytes=32 time=18ms TTL=126

Reply from 172.16.0.2: bytes=32 time=18ms TTL=126

Reply from 172.16.0.2: bytes=32 time=20ms TTL=126

Reply from 172.16.0.2: bytes=32 time=30ms TTL=126

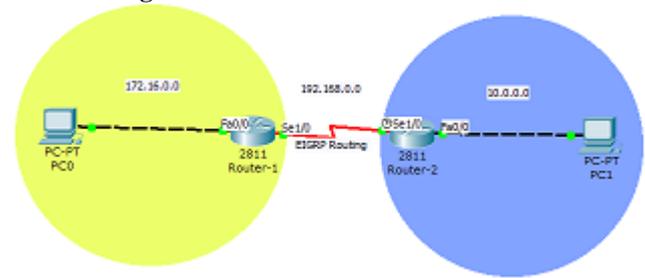
Ping statistics for 172.16.0.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 18ms, Maximum = 30ms, Average = 21ms

EIGRP Configuration:



Router>**en**

Router#**conf t**

Enter configuration commands, one per line. End with
 CNTL/Z.

Router(config)#**hostname Router-1**

Router-1(config)#**enable secret cisco**

Router-1(config)#**line vty 0 4**

Router-1(config-line)#**password cisco**

Router-1(config-line)#**login**

Router-1(config-line)#**exit**

Router-1(config)#**^Z**

Router-1#

%SYS-5-CONFIG_I: Configured from console by console

Router-1#**wr me**

Building configuration...

[OK]

Router-1#

Router-1#**conf t**

Enter configuration commands, one per line. End with
 CNTL/Z.

Router-1(config)#**interface fastEthernet 0/0**

Router-1(config-if)#**ip address 172.16.0.1 255.255.0.0**

Router-1(config-if)#**no shutdown**

%LINK-5-CHANGED: Interface FastEthernet0/0, changed
 state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface
 FastEthernet0/0, changed state to up

Router-1(config-if)#**ex**

Router-1(config)#**interface serial 1/0**

Router-1(config-if)#**ip address 192.168.0.1 255.255.255.0**

Router-1(config-if)#**encapsulation ppp**

Router-1(config-if)#**no sh**

%LINK-5-CHANGED: Interface Serial1/0, changed state to
 down

Router-1(config-if)#

Router-1#

%SYS-5-CONFIG_I: Configured from console by console

Router-1#**conf t**

Enter configuration commands, one per line. End with
 CNTL/Z.

Router-1(config)#**router EIGRP 10**

Router-1(config-router)#**network 172.16.0.0**

Router-1(config-router)#**network 192.168.0.0**

Router-1(config-router)#**end**

Router-1#

%SYS-5-CONFIG_I: Configured from console by console

Router-1#**sh ip route**

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, 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

D 10.0.0.0/8 [90/20514560] via 192.168.0.2, 00:08:08, Serial1/0
C 172.16.0.0/16 is directly connected, FastEthernet0/0
192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.0.0/24 is directly connected, Serial1/0
C 192.168.0.2/32 is directly connected, Serial1/0

**Configuration for Router-2- approx same as Router-1
Just change the IP addresses and connected networks.**

Packet Tracer PC Command Line 1.0
PC>ping 10.0.0.2
Pinging 10.0.0.2 with 32 bytes of data:
Reply from 10.0.0.2: bytes=32 time=17ms TTL=126
Reply from 10.0.0.2: bytes=32 time=20ms TTL=126
Reply from 10.0.0.2: bytes=32 time=18ms TTL=126
Reply from 10.0.0.2: bytes=32 time=17ms TTL=126

Ping statistics for 10.0.0.2:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 17ms, Maximum = 20ms, Average = 18ms

Packet Tracer PC Command Line 1.0
PC>ping 172.16.0.2
Pinging 172.16.0.2 with 32 bytes of data:
Reply from 172.16.0.2: bytes=32 time=18ms TTL=126
Reply from 172.16.0.2: bytes=32 time=18ms TTL=126
Reply from 172.16.0.2: bytes=32 time=20ms TTL=126
Reply from 172.16.0.2: bytes=32 time=30ms TTL=126

Ping statistics for 172.16.0.2:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 18ms, Maximum = 30ms, Average = 21ms

III. CLASSFUL ROUTING PROTOCOL VS. CLASSLESS ROUTING PROTOCOL: [14]

Classful Routing Protocol	Classless Routing Protocol:
Classful routing protocol do not carry the Subnet mask in the update.	Classless routing protocol carry Subnet Mask in the update.
Router interfaces inside the same network can't have different subnets.	Router interfaces inside the same network can have different subnets.
The utilization of addresses	The utilization of addresses

space might be insufficient.	space is more efficient.
Implements triggered updates.	Uses DUAL for loop prevention.
Do not support VLSM.	Supports VLSM.
Allow only automatic summarization of routes.	Allow manual summarization of routes.
Protocol working on Classful Routing – RIP version 1, IGRP	Protocol working on Classless routing – RIP version 2, RIPng, EIGRP, OSPF, IS-IS and BGP-4
Used in small, flat networks.	Used in large networks

IV. CONCLUSION

The routing protocol is showing how routers communicate with each other, disseminating information that enables them to select routes between any two computers on a computer network. [15] The routing protocol also specifies how routers in a network share information with each other and report changes. The routing protocol enables a network to make dynamic adjustments to its conditions, so routing decisions do not have to be predetermined and static [16].

The Classful protocol doesn't carry subnet mask information in its routing table, RIP v1 is a Classful protocol, means that it doesn't carry subnet mask info in its routing table. RIP v1 is not able to support Variable Length Subnet Masking (VLSM) and discontinuous networks. EIGRP is a Classless routing protocol it's supporting VLSM and uses the notions of successor and feasible successor and the query process to achieve fast convergence. EIGRP also carries the subnet mask information when sending out routing update. This enables EIGRP to support discontinuous networks which makes EIGRP a scalable routing protocol capable of fitting network requirements.

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