

OSPF Default Cost Variation for Type-1 and Type-2 External Links during Redistribution

Neeru Kumari
Ph.D. Scholar CSA
Baba Mastnath University
Asthal Bohar, Rohtak, Haryana

Alok Sharma, PhD
Associate Prof. CSA
Baba Mastnath University
Asthal Bohar, Rohtak, Haryana

ABSTRACT

With the increasing demand of internet to provide connectivity worldwide, the need for more service providers is also increasing. Border Gateway Protocol is the only routing protocol that provides connectivity over these service providers. Different service providers use BGP for exchanging these public routes. These large organizations are referred to as Autonomous System (AS) which are responsible for the overall internet connectivity worldwide. But within these AS the Open Shortest Path First (OSPF) serves as an interior gateway protocol. Because of its flexible and scalable feature, OSPF becomes the most commonly used routing protocol for internal management. OSPF can also be used with a multi-vendor environment i.e., using networking devices from more than one vendor like CISCO, Juniper, HP, etc. This study aims to discuss the OSPF default metric (cost) computation for different types of links used over the network so as to achieve a better path selection cost mechanism when OSPF is used with other routing protocols as well to manage any organization network.

General Terms

Interior Gateway Protocol (IGP), Exterior Gateway Protocol (EGP), Routing Protocol, Routed Protocol, Internet, Best-Path Selection, Source & Destination Address.

Keywords

OSPF, RIP, BGP, Bandwidth, Metric, Cost, IOS, Router, Type-1, Type-2, Routes, Redistribution, Hop-Count.

1. INTRODUCTION

In the field of computer networking nowadays internet plays an important role. The need for internet is increasing day by day. The two major routing protocols that are widely used over the internet are Border Gateway Protocol (BGP) and Open Shortest Path First (OSPF). The role of these routing protocol is to calculate the best path over the multiple links (paths) available in the network. These routing protocols works continuously to find the best path over the network, whereas, the actual data i.e., user traffic is carried by routed protocols like IPv4, IPv6, IPX, AppleTalk, etc. These routed protocols have different frame format but the goal remains the same. The goal is to carry the user traffic from one source towards destination and so on.

Border Gateway Protocol (BGP) is the primary choice over the public network like internet which provides great flexibility in terms of path selection, traffic shaping, policy manipulation, etc. BGP is mostly used by Internet Service Providers (ISP) and Service Providers (SP) acting as an Autonomous System (AS) to transmit public traffic over the internet. On the other hand, OSPF is used for its scalable and flexible design within the organization i.e., for maintenance

within the organization. Other advantage of OSPF is that it is an Industry Standard protocol which means multiple vendors like CISCO, Juniper, Huawei, Dell, etc. uses OSPF as the common routing protocol for inter-operability [1].

This research aims to achieve a better path selection cost mechanism in OSPF using the default cost metric for different types of links in the real time production environment.

2. CURRENT WORKING DESIGN

In any network the primary aim is to send the data from the source device acting as a sender towards the destination device (receiver). To form a network there are various components used like router, switch, firewall, server, access point, Wireless Lan Controller (WLC), etc. These devices can be hardware based as well as software based.

The various protocols are used along with these devices to function. Protocols like IPv4, IPv6, IPX, etc., which provide the framework how to carry the user traffic as called routed protocol. Whereas, the protocols like EIGRP, RIP, OSPF, BGP which aims to find the best path over the network as called as routing protocol. These routing protocols are broadly classified as

- Interior Gateway Protocol (IGP)
- Exterior Gateway Protocol (EGP)

The classification is based upon their working capability whether they are used within a single administrative domain called Autonomous System (AS) or can be used to work between two or more Autonomous Systems. Autonomous System (AS) is defined as a single big organization that can manage its own network and has its own unique AS number worldwide. Over the internet these organizations are assigned a different number for their identification. These AS works altogether to forward the traffic over a common network referred as internet [2][3].

Interior Gateway Protocol (IGP) are those set of protocols that work within a single AS only. These cannot be used to exchange the information between different AS. The well-known IGP are Routing Information Protocol (RIP), Enhanced Interior Gateway Routing Protocol (EIGRP), Open Shortest Path First (OSPF), Intermediate System to Intermediate System (IS-IS) etc. These routing protocol has the working scope within a single AS only.

Exterior Gateway Protocol (EGP) are those which can help in exchanging the information between different Autonomous Systems. These are widely used over the internet to exchange the public network information from one AS to another. Border Gateway Protocol (BGP) is the only protocol nowadays that comes under this category of EGP. BGP is the

protocol that runs the internet by exchanging the routes between different AS worldwide [4].

But within the AS the primary choice is the OSPF to manage the internal network. OSPF and RIP both are open standard that can be used by any vendor. In comparing to RIP the OSPF provides much more flexibility and scalability because of its hierarchal design. OSPF can also be used with multi-vendor environment and proves to be the best choice among all the IGP's.

For any routing protocol the goal remains the same, which is to calculate the best path available in the network. Different routing protocols have different algorithms that can analyze and choose the best path. Routing updates are exchanged between the routers which contains information such as Autonomous System (AS) number, Administrative Distance (AD), Metric values and interface information about that network [5].

Common Administrative Distance values that are used by CISCO devices are:

Table 1. Default AD Values on CISCO Devices

Source on CISCO Device	Value
Connected	000
Static	001
E-BGP	020
EIGRP	090
OSPF	110
RIP	120
I-BGP	200
Unreachable	255

Administrative Distance (AD) defines the reliability or the trust factor of the source. Smaller is the value, better is the trust on that source. Example, if the Connected AD=0 and the OSPF AD=110 are compared, which are advertising the same network information, the lower AD i.e., Connected routes will be given more preference than those learned via OSPF protocol.

Metric is another component used by routers to decide the best path if there are multiple paths suggested with the equal AD value i.e., from same source. It's a tie breaker when there is a conflict with AD values from two or more different paths. The path with the smaller or lower metric value is chosen as the best path. The path with the lowest cost (metric) is selected when there is conflict of AD value. Different routing protocols have different mechanism how to calculate the metric or cost for a given path.

RIP uses Hop-Count as the metric which defines routers as a Hop (jump) count. OSPF uses bandwidth on the interface or link to calculate the cost parameter. OSPF also uses different link types according to the design and calculates link cost according to them. When more than one routing protocol is used in the same network, then there is a need for mutual understanding of the rules of these routing protocol. This is done using the mechanism called redistribution i.e., sharing the information from one routing protocol to other. Information is exchanged with both ends hence refers to as mutual redistribution.

During redistribution the topology table build by each routing protocol is shared with other routing protocol. This exchange of topology tables helps to learn the other side of the network where a different routing protocol i.e., different set of rules are used to provide connectivity.

Topology tables are constructed by all routing protocols and are exchanged with their neighbors to learn about the network. Routers exchange the information that are stored inside these topology tables. From these topology tables, only the best routes are selected and are place inside the routing table. At last, the router uses this routing table for forwarding the traffic in the network [6].

OSPF and RIP both uses different mechanism during this phase of redistribution. RIP uses a term metric to define how many hops away the redistributed network is from the router on which the redistribution has been performed. Whereas, OSPF marks these new routes learned from RIP to be of TYPE-2 as External routes. OSPF defines a default metric cost of 20 for these external RIP routes. But the problem is that OSPF defines a fixed value of 20 on all of its routers inside OSPF domain. The routes are marked as External routes with fixed metric cost value 20 on all routers, irrespective of the topology and distance from the redistribution point [7].

3. EXPERIMENTAL ANALYSIS

3.1 Working Design Tools

In this research study the commonly used network topology has been taken. This topology consists networking devices like Routers, Switches, PC, Servers, etc. These are used to simulate a real time live environment which can derive the same result as real devices in a production or live deployment.

The tools like simulators and emulators that can mimic functionality of real devices are used. For this research work the GNS3 (Graphic Network Simulator v3) is used. GNS3 emulation tool works with real devices operating system to provide a better testing environment as close to real devices. GNS3 is widely used by engineers to test and simulate their actual network topology for testing and fault finding. These tools are widely used for debug and testing by major organizations over the globe.

The advantage of using the emulators-based tools over the simulators is that emulators tools does perform better and mimic almost the same real device.

3.2 Topology Description

For the topology 7 CISCO routers with 6 LAN are being used. Each router is connected with a switch that has a local LAN connected to it. The LANs are having one end device as a PC and one device as a Server.

Each Local Area Network (LAN) is using a subnet mask of 255.255.255.0 or /24 which means that a total of 254 different devices can be connected inside the LAN.

The left portion with 3 routers is configured to use Routing Information Protocol (RIP) and using LAN networks as 192.168.1.0/24, 192.168.2.0/24 and 192.168.3.0/24. The 3 routers on the right are configured to use Open Shortest Path First (OSPF) and using LAN networks as 192.168.4.0/24, 192.168.5.0/24 and 192.168.6.0/24. There is Router R7 acting as a mutual redistribution point i.e., doing topology exchange between RIP and OSPF routing protocol shown without any LAN.

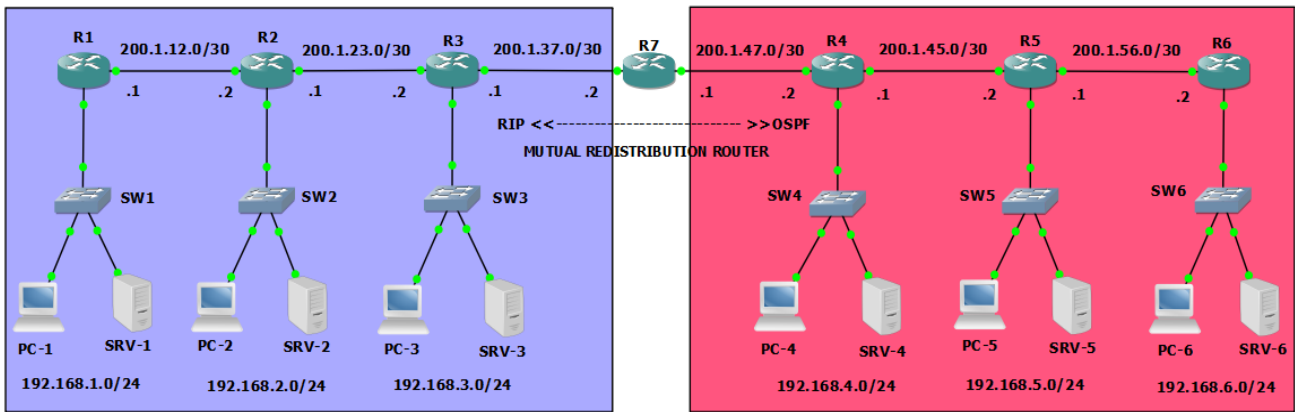


Fig 1: Topology with 6 Routers and 6 LAN along with 1 Redistribution Router as R7

3.3 Testing and Verification

For the current topology Routing Information Protocol (RIP) is used on routers R1, R2, R3 & R7. The configuration used on these routers are

For Router R1 the configuration for RIP protocol is

```
R1#show run | sec router
router rip
version 2
network 192.168.1.0
network 200.1.12.0
no auto-summary
```

Fig 2: Router R1 using RIP Routing Protocol

For Router R2 the configuration for RIP protocol is

```
R2#show run | sec router
router rip
version 2
network 192.168.2.0
network 200.1.12.0
network 200.1.23.0
no auto-summary
```

Fig 3: Router R2 using RIP Routing Protocol

For Router R3 the configuration for RIP protocol is

```
R3#sh run | sec router
router rip
version 2
network 192.168.3.0
network 200.1.23.0
network 200.1.37.0
no auto-summary
```

Fig 4: Router R3 using RIP Routing Protocol

For Router R7 the configuration for RIP protocol is

```
R7#sh run | sec router rip
router rip
version 2
redistribute ospf 7 metric 1
network 200.1.37.0
no auto-summary
```

Fig 5: Router R7 using RIP Routing Protocol

Router R7 is a mutual redistribution router which provides exchange of information between RIP and OSPF domain using redistribute mechanism.

Router R4, R5 & R6 are connected on the right side of R7 and are using OSPF. The configurations used on these routers are

For Router R7 the configuration for OSPF protocol is

```
R7#sh run | sec router ospf
router ospf 7
log-adjacency-changes
redistribute rip subnets
network 200.1.47.0 0.0.0.3 area 0
```

Fig 6: Router R7 using OSPF Routing Protocol

For Router R4 the configuration for OSPF protocol is

```
R4#sh run | sec router
router ospf 4
log-adjacency-changes
network 200.1.47.0 0.0.0.3 area 0
network 200.1.45.0 0.0.0.3 area 0
network 192.168.4.0 0.0.0.255 area 0
```

Fig 7: Router R4 using OSPF Routing Protocol

For Router R5 the configuration for OSPF protocol is

```
R5#sh run | sec router
router ospf 5
log-adjacency-changes
network 200.1.56.0 0.0.0.3 area 0
network 200.1.45.0 0.0.0.3 area 0
network 192.168.5.0 0.0.0.255 area 0
```

Fig 8: Router R5 using OSPF Routing Protocol

For Router R6 the configuration for OSPF protocol is

```
R6#sh run | sec router
router ospf 6
log-adjacency-changes
network 200.1.56.0 0.0.0.3 area 0
network 192.168.6.0 0.0.0.255 area 0
```

Fig 9: Router R6 using OSPF Routing Protocol

According to the default behavior of RIP and OSPF after the redistribution, the routing table are updated.

The Router R1 Routing Table (RT) using RIP protocol is

```
C    192.168.1.0/24 is directly connected
L    192.168.1.254/32 is directly connect
R    192.168.2.0/24 [120/1] via 200.1.12.2,
R    192.168.3.0/24 [120/2] via 200.1.12.2,
R    192.168.4.0/24 [120/3] via 200.1.12.2,
R    192.168.5.0/24 [120/3] via 200.1.12.2,
R    192.168.6.0/24 [120/3] via 200.1.12.2,
    200.1.12.0/24 is variably subnetted, 2
C    200.1.12.0/30 is directly connected,
L    200.1.12.1/32 is directly connected,
    200.1.23.0/30 is subnetted, 1 subnets
R    200.1.23.0/30 [120/1] via 200.1.12.2
    200.1.37.0/30 is subnetted, 1 subnets
R    200.1.37.0/30 [120/2] via 200.1.12.2
    200.1.45.0/30 is subnetted, 1 subnets
R    200.1.45.0/30 [120/3] via 200.1.12.2
    200.1.47.0/30 is subnetted, 1 subnets
R    200.1.47.0/30 [120/3] via 200.1.12.2
    200.1.56.0/30 is subnetted, 1 subnets
R    200.1.56.0/30 [120/3] via 200.1.12.2
```

Fig 10: Router R1 Routing Table using RIP protocol

Router R1 using Routing Information Protocol (RIP) has build the routing table with the learned routes having value [120/x]. The first parameter is the AD value as 120 and metric is the second parameter in output as 1 or 2 or 3 assigned with each RIP learned routes marked with [AD/Metric]. Metric in RIP means how many hops away is the network according to the current router on which the routing table is shown.

The Router R2 Routing Table (RT) using RIP protocol is

```
R    192.168.1.0/24 [120/1] via 200.1.12.1,
    192.168.2.0/24 is variably subnetted, 2
C    192.168.2.0/24 is directly connected
L    192.168.2.254/32 is directly connect
R    192.168.3.0/24 [120/1] via 200.1.23.2,
R    192.168.4.0/24 [120/2] via 200.1.23.2,
R    192.168.5.0/24 [120/2] via 200.1.23.2,
R    192.168.6.0/24 [120/2] via 200.1.23.2,
    200.1.12.0/24 is variably subnetted, 2
C    200.1.12.0/30 is directly connected,
L    200.1.12.2/32 is directly connected,
    200.1.23.0/24 is variably subnetted, 2
C    200.1.23.0/30 is directly connected,
L    200.1.23.1/32 is directly connected,
    200.1.37.0/30 is subnetted, 1 subnets
R    200.1.37.0/30 [120/1] via 200.1.23.2
    200.1.45.0/30 is subnetted, 1 subnets
R    200.1.45.0/30 [120/2] via 200.1.23.2
    200.1.47.0/30 is subnetted, 1 subnets
R    200.1.47.0/30 [120/2] via 200.1.23.2
    200.1.56.0/30 is subnetted, 1 subnets
R    200.1.56.0/30 [120/2] via 200.1.23.2
```

Fig 11: Router R2 Routing Table using RIP protocol

The Router R3 Routing Table (RT) using RIP protocol is

```
R    192.168.1.0/24 [120/2] via 200.1.23.1,
R    192.168.2.0/24 [120/1] via 200.1.23.1,
    192.168.3.0/24 is variably subnetted, 2
C    192.168.3.0/24 is directly connected
L    192.168.3.254/32 is directly connect
R    192.168.4.0/24 [120/1] via 200.1.37.2,
R    192.168.5.0/24 [120/1] via 200.1.37.2,
R    192.168.6.0/24 [120/1] via 200.1.37.2,
    200.1.12.0/30 is subnetted, 1 subnets
R    200.1.12.0/30 [120/1] via 200.1.23.1
    200.1.23.0/24 is variably subnetted, 2
C    200.1.23.0/30 is directly connected,
L    200.1.23.2/32 is directly connected,
    200.1.37.0/24 is variably subnetted, 2
C    200.1.37.0/30 is directly connected,
L    200.1.37.1/32 is directly connected,
    200.1.45.0/30 is subnetted, 1 subnets
R    200.1.45.0/30 [120/1] via 200.1.37.2
    200.1.47.0/30 is subnetted, 1 subnets
R    200.1.47.0/30 [120/1] via 200.1.37.2
    200.1.56.0/30 is subnetted, 1 subnets
R    200.1.56.0/30 [120/1] via 200.1.37.2
```

Fig 12: Router R3 Routing Table using RIP protocol

The Router R7 Routing Table (RT) using RIP protocol and OSPF protocol both as mutual redistributor router is

```
R    192.168.1.0/24 [120/3] via 200.1.37.1,
R    192.168.2.0/24 [120/2] via 200.1.37.1,
R    192.168.3.0/24 [120/1] via 200.1.37.1,
O    192.168.4.0/24 [110/2] via 200.1.47.2,
O    192.168.5.0/24 [110/3] via 200.1.47.2,
O    192.168.6.0/24 [110/4] via 200.1.47.2,
    200.1.12.0/30 is subnetted, 1 subnets
R    200.1.12.0/30 [120/2] via 200.1.37.1
    200.1.23.0/30 is subnetted, 1 subnets
R    200.1.23.0/30 [120/1] via 200.1.37.1
    200.1.37.0/24 is variably subnetted, 2
C    200.1.37.0/30 is directly connected,
L    200.1.37.2/32 is directly connected,
    200.1.45.0/30 is subnetted, 1 subnets
O    200.1.45.0/30 [110/2] via 200.1.47.2
    200.1.47.0/24 is variably subnetted, 2
C    200.1.47.0/30 is directly connected,
L    200.1.47.1/32 is directly connected,
    200.1.56.0/30 is subnetted, 1 subnets
O    200.1.56.0/30 [110/3] via 200.1.47.2
```

Fig 13: Router R7 Routing Table using RIP & OSPF both

The Router R7 has learned some routes through RIP that are marked with AD value 120. Whereas, the OSPF learned routes are marked with AD value 110. The value denoted as [AD/Metric] is for each routing protocol learned route. Both RIP and OSPF does calculate the metric values for their routes. Again, metric for RIP is hop-count and for OSPF is based upon bandwidth [8].

The Router R4 Routing Table (RT) using OSPF protocol is

```
O E2 192.168.1.0/24 [110/20] via 200.1.47.1,
O E2 192.168.2.0/24 [110/20] via 200.1.47.1,
O E2 192.168.3.0/24 [110/20] via 200.1.47.1,
O   192.168.4.0/24 is variably subnetted, 2
C   192.168.4.0/24 is directly connected,
L   192.168.4.254/32 is directly connecte
O   192.168.5.0/24 [110/2] via 200.1.45.2, 0
O   192.168.6.0/24 [110/3] via 200.1.45.2, 0
O   200.1.12.0/30 is subnetted, 1 subnets
O E2 200.1.12.0/30 [110/20] via 200.1.47.1
O   200.1.23.0/30 is subnetted, 1 subnets
O E2 200.1.23.0/30 [110/20] via 200.1.47.1
O   200.1.37.0/30 is subnetted, 1 subnets
O E2 200.1.37.0/30 [110/20] via 200.1.47.1
O   200.1.45.0/24 is variably subnetted, 2 s
C   200.1.45.0/30 is directly connected,
L   200.1.45.1/32 is directly connected,
O   200.1.47.0/24 is variably subnetted, 2 s
C   200.1.47.0/30 is directly connected,
L   200.1.47.2/32 is directly connected,
O   200.1.56.0/30 is subnetted, 1 subnets
O   200.1.56.0/30 [110/2] via 200.1.45.2,
```

Fig 14: Router R4 Routing Table using OSPF protocol

The Router R4 has assigned a default metric value of 20 for the routes that are learned via redistribution i.e., the RIP routes from R1, R2 and R3 are assigned with fixed metric value of 20 and are marked as OSPF E2 type routes in the routing table. Whereas, the OSPF learned routes from R5 like 192.168.5.0/24 are marked as O with the metric 2.

The Router R5 Routing Table (RT) using OSPF protocol is

```
O E2 192.168.1.0/24 [110/20] via 200.1.45.1,
O E2 192.168.2.0/24 [110/20] via 200.1.45.1,
O E2 192.168.3.0/24 [110/20] via 200.1.45.1,
O   192.168.4.0/24 [110/2] via 200.1.45.1, 0
O   192.168.5.0/24 is variably subnetted, 2
C   192.168.5.0/24 is directly connected,
L   192.168.5.254/32 is directly connecte
O   192.168.6.0/24 [110/2] via 200.1.56.2, 0
O   200.1.12.0/30 is subnetted, 1 subnets
O E2 200.1.12.0/30 [110/20] via 200.1.45.1
O   200.1.23.0/30 is subnetted, 1 subnets
O E2 200.1.23.0/30 [110/20] via 200.1.45.1
O   200.1.37.0/30 is subnetted, 1 subnets
O E2 200.1.37.0/30 [110/20] via 200.1.45.1
O   200.1.45.0/24 is variably subnetted, 2 s
C   200.1.45.0/30 is directly connected,
L   200.1.45.2/32 is directly connected,
O   200.1.47.0/30 is subnetted, 1 subnets
O   200.1.47.0/30 [110/2] via 200.1.45.1,
O   200.1.56.0/24 is variably subnetted, 2 s
C   200.1.56.0/30 is directly connected,
L   200.1.56.1/32 is directly connected,
```

Fig 15: Router R5 Routing Table using OSPF protocol

The Router R6 Routing Table (RT) using OSPF protocol is

```
O E2 192.168.1.0/24 [110/20] via 200.1.56.1,
O E2 192.168.2.0/24 [110/20] via 200.1.56.1,
O E2 192.168.3.0/24 [110/20] via 200.1.56.1,
O   192.168.4.0/24 [110/3] via 200.1.56.1, 0
O   192.168.5.0/24 [110/2] via 200.1.56.1, 0
O   192.168.6.0/24 is variably subnetted, 2
C   192.168.6.0/24 is directly connected,
L   192.168.6.254/32 is directly connecte
O   200.1.12.0/30 is subnetted, 1 subnets
O E2 200.1.12.0/30 [110/20] via 200.1.56.1
O   200.1.23.0/30 is subnetted, 1 subnets
O E2 200.1.23.0/30 [110/20] via 200.1.56.1
O   200.1.37.0/30 is subnetted, 1 subnets
O E2 200.1.37.0/30 [110/20] via 200.1.56.1
O   200.1.45.0/30 is subnetted, 1 subnets
O   200.1.45.0/30 [110/2] via 200.1.56.1,
O   200.1.47.0/30 is subnetted, 1 subnets
O   200.1.47.0/30 [110/3] via 200.1.56.1,
O   200.1.56.0/24 is variably subnetted, 2 s
C   200.1.56.0/30 is directly connected,
L   200.1.56.2/32 is directly connected,
```

Fig 16: Router R6 Routing Table using OSPF protocol

The Routers R4, R5 and R6 all are using OSPF default cost metric of 20 for external routes which are marked as O E2.

4. RESULT AND DISCUSSION

The problem here is the metric value should change on each router as the redistribution point which is R7 is getting far away. The metric shouldn't be the same, because same value means the redistribution point i.e., Router R7 is equidistant from all R4, R5 and R6.

But in actual router R7 routes like 200.1.47.0/30 are calculated with different metric values on each R4, R5 and R6. On router R4, it's directly connected therefore metric value 0, on router R5 these are marked with metric value of 1. On router R6 these routes are calculated with metric of 3. Therefore, the external routes learned from router R7 which are from RIP should be marked with some different values on R4, R5 and R6 and shouldn't use a single value of metric 20.

The OSPF uses link bandwidth for the calculation of metric referred as "Cost". The cost formula is reference bandwidth divided by interface or link bandwidth.

The default reference bandwidth of 100 Mbps is used for OSPF cost calculation.

For example, if a Fast Ethernet interface (100Mbps) is taken, the OSPF path cost value is 100 Mbps / 100 Mbps = 1,

Whereas, for Giga Ethernet interface (1000Mbps) the cost value is 100 Mbps / 1000 Mbps = 0.1 ~ 1 (rounded to 1)

Important points to note related to Cost are:

- Cost is a positive integer value i.e., Cost > 0
- Any decimal value will be rounded back in nearest positive (+) integer.
- Any value below 1 would be considered as 1.

The route that has lowest Cumulative Cost value between the source and the destination will be selected for routing table.

Cumulative Cost => Sum of all outgoing interface cost in path.

Only outgoing interface cost is considered and OSPF doesn't add the cost of incoming interface during Cumulative Cost calculation.

If multiple routes exist, OSPF Shortest Path First (SPF) algorithm compares the Cumulative Costs. Route which has the lowest Cumulative Cost will be chosen for RT i.e.,

Best route for Routing Table (RT) => Route which has the lowest Cumulative Cost value.

But the OSPF has other mechanism to deal with this type of Cost variation during redistribution. These External routes referred as OSPF Type-2 (O E2) if not defined uses Cost value of 20. If during the redistribution, these External routes are marked with Type-1 (O E1) routes then the default Cost computation value changes.

For using OSPF Type-1 routes, the configuration needs to be changed as on redistribution point i.e., Router R7 only as

```
R7#sh run | sec router ospf
router ospf 7
log-adjacency-changes
redistribute rip metric-type 1 subnets
network 200.1.47.0 0.0.0.3 area 0
```

Fig 17: Router R7 using updated OSPF TYPE-1 routes

The impact would be seen on the Routers like R4, R5 and R6 which are now using new metric values as shown.

The Routing Table (RT) on Router R4 with new metric as

```
O E1 192.168.1.0/24 [110/21] via 200.1.47.1,
O E1 192.168.2.0/24 [110/21] via 200.1.47.1,
O E1 192.168.3.0/24 [110/21] via 200.1.47.1,
    192.168.4.0/24 is variably subnetted, 2
C    192.168.4.0/24 is directly connected,
L    192.168.4.254/32 is directly connecte
O    192.168.5.0/24 [110/2] via 200.1.45.2, 0
O    192.168.6.0/24 [110/3] via 200.1.45.2, 0
    200.1.12.0/30 is subnetted, 1 subnets
O E1 200.1.12.0/30 [110/21] via 200.1.47.1
    200.1.23.0/30 is subnetted, 1 subnets
O E1 200.1.23.0/30 [110/21] via 200.1.47.1
    200.1.37.0/30 is subnetted, 1 subnets
O E1 200.1.37.0/30 [110/21] via 200.1.47.1
    200.1.45.0/24 is variably subnetted, 2 s
C    200.1.45.0/30 is directly connected,
L    200.1.45.1/32 is directly connected,
    200.1.47.0/24 is variably subnetted, 2 s
C    200.1.47.0/30 is directly connected,
L    200.1.47.2/32 is directly connected,
    200.1.56.0/30 is subnetted, 1 subnets
O    200.1.56.0/30 [110/2] via 200.1.45.2,
```

Fig 18: Router R4 using updated OSPF TYPE-1 routes

The redistributed external routes are now marked with O E1 and using updated metric values on each router. The metric

value calculate on Router R4 is External Default (20) + the link Cost as 100 Mbps / 1000 Mbps = 0.1 ~ 1 i.e. {20+1} = 21

The Routing Table (RT) on Router R5 with new metric as

```
O E1 192.168.1.0/24 [110/22] via 200.1.45.1,
O E1 192.168.2.0/24 [110/22] via 200.1.45.1,
O E1 192.168.3.0/24 [110/22] via 200.1.45.1,
O    192.168.4.0/24 [110/2] via 200.1.45.1, 0
    192.168.5.0/24 is variably subnetted, 2
C    192.168.5.0/24 is directly connected,
L    192.168.5.254/32 is directly connecte
O    192.168.6.0/24 [110/2] via 200.1.56.2, 0
    200.1.12.0/30 is subnetted, 1 subnets
O E1 200.1.12.0/30 [110/22] via 200.1.45.1
    200.1.23.0/30 is subnetted, 1 subnets
O E1 200.1.23.0/30 [110/22] via 200.1.45.1
    200.1.37.0/30 is subnetted, 1 subnets
O E1 200.1.37.0/30 [110/22] via 200.1.45.1
    200.1.45.0/24 is variably subnetted, 2 s
C    200.1.45.0/30 is directly connected,
L    200.1.45.2/32 is directly connected,
    200.1.47.0/30 is subnetted, 1 subnets
O    200.1.47.0/30 [110/2] via 200.1.45.1,
    200.1.56.0/24 is variably subnetted, 2 s
C    200.1.56.0/30 is directly connected,
L    200.1.56.1/32 is directly connected,
```

Fig 19: Router R5 using updated OSPF TYPE-1 routes

The Routing Table (RT) on Router R6 with new metric as

```
O E1 192.168.1.0/24 [110/23] via 200.1.56.1,
O E1 192.168.2.0/24 [110/23] via 200.1.56.1,
O E1 192.168.3.0/24 [110/23] via 200.1.56.1,
O    192.168.4.0/24 [110/3] via 200.1.56.1, 0
O    192.168.5.0/24 [110/2] via 200.1.56.1, 0
    192.168.6.0/24 is variably subnetted, 2
C    192.168.6.0/24 is directly connected,
L    192.168.6.254/32 is directly connecte
    200.1.12.0/30 is subnetted, 1 subnets
O E1 200.1.12.0/30 [110/23] via 200.1.56.1
    200.1.23.0/30 is subnetted, 1 subnets
O E1 200.1.23.0/30 [110/23] via 200.1.56.1
    200.1.37.0/30 is subnetted, 1 subnets
O E1 200.1.37.0/30 [110/23] via 200.1.56.1
    200.1.45.0/30 is subnetted, 1 subnets
O    200.1.45.0/30 [110/2] via 200.1.56.1,
    200.1.47.0/30 is subnetted, 1 subnets
O    200.1.47.0/30 [110/3] via 200.1.56.1,
    200.1.56.0/24 is variably subnetted, 2 s
C    200.1.56.0/30 is directly connected,
L    200.1.56.2/32 is directly connected,
```

Fig 20: Router R6 using updated OSPF TYPE-1 routes

Therefore, the metric value is updated for the external routes marked with OSPF Type-1 using the new mechanism. The external routes are marked with O E2 throughout the OSPF domain and the metric increments as the calculating OSPF router moves away from the redistribution point Router R7.

5. CONCLUSION AND FUTURE SCOPE

The above experimental study concludes that the OSPF default metric calculation for external routes needs to be change and a better metric calculation is required whenever two or more routing protocols are used with OSPF via redistribution method.

Therefore, whenever OSPF is deployed in real production environment the cost (metric) used for default OSPF external types routes like OSPF Type-2 is fixed and not correct. The routes must be modified to be of External Type-1 (O E1) so that a better metric value is calculated then the default fixed metric cost of 20.

The change in metric for each router results in an updated metric calculation process and provides a better view about the topology used in the network.

Future scope could be done for providing an enhanced and better metric calculation using multiple parameters during the redistribution where there is a need for using more than one routing protocol.

Further study can be conducted towards finding new parameters required for cost calculation or changing the existing OSPF Shortest Path First algorithm with some modifications resulting in better selection and enhanced cost computation for OSPF links in the network.

6. ACKNOWLEDGMENTS

Our thanks to Deepak Malik (C.C.I.E. 51724) CISCO network expert for providing the correct set of tools and a simplified approach for completing this research work.

7. REFERENCES

- [1] Deepak Malik, Pritam Kumar and Shikha Pandit, "Optimising OSPF Database by Intra-Area Summarization, IJCA Vol 97, No. 23, July 2014.
- [2] Anuj Gupta and Neha Grang, "Compare OSPF Routing Protocol with other Interior Gateway Routing Protocols in IJEBEA 13-147; 2013.
- [3] A. Shikh, E. Baccelli, G. Choudhary, H. Hosseini, K. Trivedi, M. Goyal and M. Soperi, "Improving Convergence Speed and Scability in OSPF at IEEE communications surveys & tutorials.
- [4] M.I. Alsaydia dan O. M. Alsaydia, "Analysis and Performance Evaluation of OSPF & RIP using QualNet, at International Jou. Of Computer Science and Information Technologies, vol 4, no. 3, pp. 125-132, 2016.
- [5] Aparjit Utpat, Chandan N Bhagwat and Y. Navaneeth Krishnan, "Performance with other Interior Gateway Routing Protocols in IJEBEA 13-147; 2013.
- [6] OSPF Network Design Solutions, OSPF design covered in the CISCO press book, (ISBN 1-57870-046-9).
- [7] Albert Greenberg, Aman Shikh, Chris Isett, Mattew Roughan and Joel Gottlieb, "A case study of OSPF Behaviour in a Large Enterprise Network".
- [8] A. Verma and N. Bhardwaj, "A Review on Routing Information Protocol (RIP) and Open Shortest Path First (OSPF) Routing Protocol", International J. Future General Comm. Network, vol 9, no. 4 pp. 161-170, 2016.