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OSPF Metric Convergence & Variation Analysis During Redistribution with Routing Information Protocol

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Abstract

Open Shortest Path First networking protocol falls under the category of Interior gateway routing protocols and is multi-vendor supported. The task of OSPF like any other routing protocol is to calculate the best path between source IP address and destination IP address within the organisation computer network. There are various other routing protocols like Routing Information Protocol, Border Gateway Protocol, Intermediate System - Intermediate System (IS-IS), Enhanced Interior Gateway Routing Protocol, etc. which are used in computer network. Routing protocols have different algorithms through which they compute the best path selection criteria. OSPF because of its flexible design is often used with other routing protocol over the large network. This research focuses on the working of OSPF metric value variation and convergence for best path selection using network simulation tool like Cisco Packet Tracer tool for getting similar outcome just like a real networking device like router working in a real production environment. This research would use multiple combinations of OSPF metric calculation for routes learned from other routing protocols like Routing Information Protocol (RIP). Being able to correctly identify metric values obtain by testing with OSPF and other routing protocols and analysis them for best path selection.

Keywords: *Best-Path; Hop-Count; IP; Metric; OSPF; RIP.*

1. Introduction

Computer network consists of collection of multiple small networks and devices working together as a single unit to share resources. Resources can be anything depending upon user requirements like printer, internet, files, etc. To build a computer network the routing protocols and routed protocols are used together as a single unit. Routed protocols provide the framework how to carry data over the network. Internet Protocol (IP) version 4 or IPv6, IPX are examples of routed protocol as they provide the framework how to carry the user data in the network. This framework is predefined using these set of rules called routed protocol. On the other hand, routing protocols like OSPF, EIGRP, BGP, RIP have the task to determine where to carry the user data. These protocols have different algorithms through which each routing protocol calculate the best path selection towards the destination IP address throughout the network. The path selection criteria are different for each routing protocol as the parameters selected for calculation are different. [1-2] The primary aim is to find the best path through which the user data can be carried within the large network using multiple parameters used by routing protocols. Open Shortest Path First (OSPF) is the most commonly used Interior Gateway Protocol (IGP) to manage any organization whether the organization is small or large. OSPF is used widely inside large network to calculate the best path for sending user traffic. Because of its Industry Standard feature OSPF & RIP are used with multi-vendor environment where other protocols like EIGRP are not welcome. [3] This research aims to achieve a better selection of OSPF metric values which are required during redistribution i.e. when club with other routing protocol like RIP which has a totally different mechanism for Best Path Selection.

2. Current Working Method

The aim of any computer network is resource sharing

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for which the multiple networking devices works together. Networking devices like router, switch, firewall, access-points, etc. are used in both hardware and software deployment. The various protocols are used with these devices like routing and routed protocols. The routing protocols works to find the best path over the computer network by using some pre-defined algorithms for metric calculation. OSPF belongs to the category of Interior Gateway Protocol (IGP) in which other protocols like Routing Information Protocol (RIP), Enhanced Interior Gateway Routing Protocol (EIGRP), IS-IS etc., also falls. [4] Within a large network the primary choice is the OSPF to manage the network and find the best path for user traffic. RIP is also a good choice but not widely used like OSPF. OSPF also provides much more flexible and scalable design as compared to any other routing protocol. Because of its multi-vendor support OSPF becomes the best routing protocol to work within a large-scale computer network environment. For any routing protocol the primary aim is the same i.e. to calculate the best path available in the user network. Different routing protocols have different algorithms that can find a different best path over the same computer network. The routing updates are exchanged between the routers which contains information such as Administrative Distance (AD), metric values and interface information like Bandwidth, Delay, Reliability, etc. [5] Administrative Distance (AD) defines the reliability of the source used for calculating the best path in the network. Smaller the value, more trusted is the source i.e. better selection as compared to other higher value source. For example, the AD value of OSPF is less (110) as compared to RIP (120) i.e. OSPF is better and more trusted than RIP protocol in CISCO based network. Metric is next parameter used by networking devices (routers) to decide which path is better if there are multiple paths with the same AD value. The path with lower metric value is chosen as the better path i.e. the path with lowest metric value is selected when there is tie of similar AD values for multiple paths. Some common Administrative Distance values that are used in networking devices particularly in CISCO vendor are OSPF uses bandwidth of the interface to calculate the metric (cost) parameter. Refer Table 1.

Table 1 Different AD Values on CISCO Devices

DEVICE SOURCE INFO	AD VALUE
Directly Connected	0
Static Route	1
External BGP	20
EIGRP (Internal)	90
OSPF	110
RIP	120
Internal BGP	200
Unreachable	255

Whereas RIP uses hops for calculation of metric on the network path. When more than one routing protocol is used then there is a need for redistribution i.e. mutual understanding of the rules of different routing protocol. This is done using the sharing of information from one routing protocol to another. Information is exchanged with both ends hence refers to as mutual redistribution. Topology tables are constructed by all routing protocols and are exchanged with their neighbors to learn information about the network. Networking devices (routers) exchange the information that are stored inside these tables for better understanding the design of the network. [6] From these topology tables the best routes are placed in routing table for final lookup during the forwarding phase. During redistribution the Topology Table (TT) build by each routing protocol is exchanged with other routing protocol. This sharing of topology table helps the devices to learn about the network design at another end. OSPF and RIP both uses different algorithm (mechanism) during the redistribution phase. OSPF uses

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parameters like bandwidth to calculate the metric or cost for the path used while RIP uses parameters like hop-count i.e. how many hops away is the redistributed router for calculation of path metric. [7]

3. Description of Tools and Topology Used

In this research the official CISCO simulator tool i.e. CISCO Packet Tracer is used to simulate the network. This is available from CISCO and gives correct output during testing. The testing design topology consists of 5 CISCO routers with 4 CISCO switches simulating a large network (Figure 1).

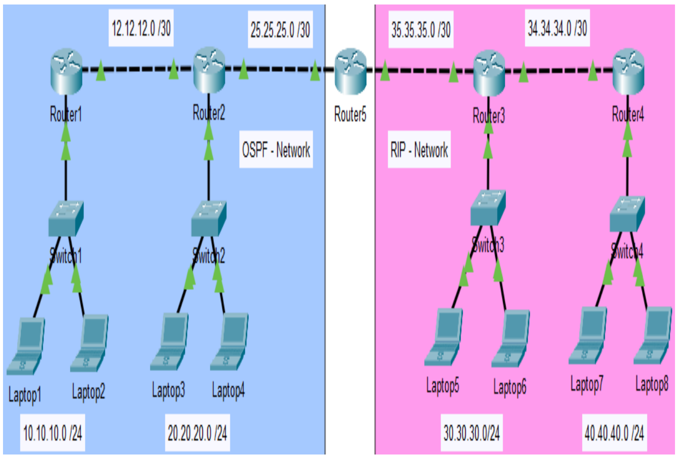

Figure 1 **OSPF-RIP Network Topology with R5 as Redistribution Point**

Each router is connected to a different network. There are networks like 10.10.10.0/24, 20.20.20.0/24, 30.30.30.0/24 & 40.40.40.0/24 simulating 4 user LANs. Each subnet can add total 254 users because of subnet mask used as 255.255.255.0 or /24. The OSPF network is shown on the left-hand side and the RIP network is shown are on the right side. The router 5 is acting like a common router for both OSPF and RIP thus referred as a mutual redistribution point for exchanging. This router is responsible for exchanging the topology information between OSPF and RIP [8].

4. Testing and Verification

For LAB setup, Open Shortest Path First (OSPF) is configured on R1, R2 & R5 whereas, Routing Information Protocol (RIP) is configured on R3, R4 & R5. Router R5 is acting like a common redistribution point for exchanging OSPF and RIP routing protocol. Therefore, partial information of OSPF and RIP is done according to the topology. For Router R1, R2 & R5 the configuration for OSPF protocols are shown in Figure 2 to 4 [9].

```
R1#show run | sec router ospf
router ospf 1
 log-adjacency-changes
 network 10.10.10.0 0.0.0.255 area 0
 network 12.12.12.0 0.0.0.3 area 0
```

Figure 2 **Router R1 OSPF Configuration**

```
R2#show run | sec router ospf
router ospf 2
 log-adjacency-changes
 network 12.12.12.0 0.0.0.3 area 0
 network 20.20.20.0 0.0.0.255 area 0
 network 25.25.25.0 0.0.0.3 area 0
```

Figure 3 **Router R2 OSPF Configuration**

```
R5#show run | sec router ospf
router ospf 5
 log-adjacency-changes
 network 25.25.25.0 0.0.0.3 area 0
```

Figure 4 **Router R5 OSPF Configuration**

For Router R3, R4 & R5 the configuration for RIP protocol are shown in Figure 5 to 7.

```
R5#show run | sec router rip
router rip
 network 35.0.0.0
```

Figure 5 **Router R5 RIP Configuration**

```
R3#show run | sec router rip
router rip
 network 30.0.0.0
 network 34.0.0.0
 network 35.0.0.0
```

Figure 6 **Router R3 RIP Configuration**

```
R4#show run | sec router rip
router rip
 network 34.0.0.0
 network 40.0.0.0
```

Figure 7 **Router R4 RIP Configuration**

Based upon the current configuration the Routing Table of R1, R2, R3, R4 & R5 are shown in Figure 8 to 12.

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```
L - local, C - connected, S - static, R - RIP, M - mobile, B -
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
* - candidate default, U - per-user static route, o - ODR
P - periodic downloaded static route
```

Figure 8 All Routers Routing Table Codes

```
     10.0.0.0/8 is variably subnetted, 2 subn
C       10.10.10.0/24 is directly connected,
L       10.10.10.254/32 is directly connected
     12.0.0.0/8 is variably subnetted, 2 subn
C       12.12.12.0/30 is directly connected,
L       12.12.12.1/32 is directly connected,
     20.0.0.0/24 is subnetted, 1 subnets
O       20.20.20.0/24 [110/2] via 12.12.12.2,
     25.0.0.0/30 is subnetted, 1 subnets
O       25.25.25.0/30 [110/2] via 12.12.12.2,
```

Figure 9 R1 RT Before Redistribution

```
     10.0.0.0/24 is subnetted, 1 subnets
O       10.10.10.0/24 [110/2] via 12.12.12.1,
     12.0.0.0/8 is variably subnetted, 2 subn
C       12.12.12.0/30 is directly connected,
L       12.12.12.2/32 is directly connected,
     20.0.0.0/8 is variably subnetted, 2 subn
C       20.20.20.0/24 is directly connected,
L       20.20.20.254/32 is directly connected
     25.0.0.0/8 is variably subnetted, 2 subn
C       25.25.25.0/30 is directly connected,
L       25.25.25.1/32 is directly connected,
```

Figure 10 R2 RT Before Redistribution

```
     30.0.0.0/8 is variably subnetted,
C       30.30.30.0/24 is directly conne
L       30.30.30.254/32 is directly con
     34.0.0.0/8 is variably subnetted,
C       34.34.34.0/30 is directly conne
L       34.34.34.1/32 is directly conne
     35.0.0.0/8 is variably subnetted,
C       35.35.35.0/30 is directly conne
L       35.35.35.1/32 is directly conne
R    40.0.0.0/8 [120/1] via 34.34.34.2,
```

Figure 11 R3 RT Before Redistribution

```
R    30.0.0.0/8 [120/1] via 34.34.34.1,
     34.0.0.0/8 is variably subnetted,
C       34.34.34.0/30 is directly conne
L       34.34.34.2/32 is directly conne
R    35.0.0.0/8 [120/1] via 34.34.34.1,
     40.0.0.0/8 is variably subnetted,
C       40.40.40.0/24 is directly conne
L       40.40.40.254/32 is directly con
```

Figure 12 R4 RT Before Redistribution

Based upon the current configuration the Routing Table of R5 having both information about OSPF and RIP routes R5 Routing Table (RT) before redistribution is shown in Figure 13.

```
     10.0.0.0/24 is subnetted, 1 subnets
O       10.10.10.0/24 [110/3] via 25.25.25.1,
     12.0.0.0/30 is subnetted, 1 subnets
O       12.12.12.0/30 [110/2] via 25.25.25.1,
     20.0.0.0/24 is subnetted, 1 subnets
O       20.20.20.0/24 [110/2] via 25.25.25.1,
     25.0.0.0/8 is variably subnetted, 2 subn
C       25.25.25.0/30 is directly connected,
L       25.25.25.2/32 is directly connected,
R    30.0.0.0/8 [120/1] via 35.35.35.1, 00:00
R    34.0.0.0/8 [120/1] via 35.35.35.1, 00:00
     35.0.0.0/8 is variably subnetted, 2 subn
C       35.35.35.0/30 is directly connected,
L       35.35.35.2/32 is directly connected,
R    40.0.0.0/8 [120/2] via 35.35.35.1, 00:00
```

Figure 13 R5 RT Before Redistribution

As R5 has information about both Routing Protocols but it will maintain separate Topology Tables for each protocol i.e. Topology Tables (TT) are separated and not shared with each other [10]. Therefore, mutual redistribution is required. After Mutual Redistribution the output on R5 is shown in Figure 14 & 15.

```
R5#show run | sec router ospf
router ospf 5
 log-adjacency-changes
 redistribute rip subnets
 network 25.25.25.0 0.0.0.3 area 0
```

Figure 14 R5 OSPF Configuration After Redistribution

```
R5#show run | sec router rip
router rip
 redistribute ospf 5 metric 1
 network 35.0.0.0
```

Figure 15 R1 RIP Configuration After Redistribution

After the mutual redistribution the information is shared in both routing protocols as the Topology Tables are shared with each other. But partial or incomplete information is shared not complete as rules are different. R1 Routing Table (RT) after default redistribution are shown in Figure 16 to 19.

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```
     10.0.0.0/8 is variably subnetted, 2 subn
C       10.10.10.0/24 is directly connected,
L       10.10.10.254/32 is directly connected
     12.0.0.0/8 is variably subnetted, 2 subn
C       12.12.12.0/30 is directly connected,
L       12.12.12.1/32 is directly connected,
     20.0.0.0/24 is subnetted, 1 subnets
O       20.20.20.0/24 [110/2] via 12.12.12.2,
     25.0.0.0/30 is subnetted, 1 subnets
O       25.25.25.0/30 [110/2] via 12.12.12.2,
O E2 30.0.0.0/8 [110/20] via 12.12.12.2, 00:0
O E2 34.0.0.0/8 [110/20] via 12.12.12.2, 00:0
     35.0.0.0/30 is subnetted, 1 subnets
O E2    35.35.35.0/30 [110/20] via 12.12.12.2
O E2 40.0.0.0/8 [110/20] via 12.12.12.2, 00:0
```

Figure 16 **R1 RT After Default Redistribution**

```
     10.0.0.0/24 is subnetted, 1 subnets
O       10.10.10.0/24 [110/2] via 12.12.12.1,
     12.0.0.0/8 is variably subnetted, 2 subne
C       12.12.12.0/30 is directly connected, G
L       12.12.12.2/32 is directly connected, G
     20.0.0.0/8 is variably subnetted, 2 subne
C       20.20.20.0/24 is directly connected, G
L       20.20.20.254/32 is directly connected,
     25.0.0.0/8 is variably subnetted, 2 subne
C       25.25.25.0/30 is directly connected, G
L       25.25.25.1/32 is directly connected, G
O E2 30.0.0.0/8 [110/20] via 25.25.25.2, 00:07
O E2 34.0.0.0/8 [110/20] via 25.25.25.2, 00:07
     35.0.0.0/30 is subnetted, 1 subnets
O E2    35.35.35.0/30 [110/20] via 25.25.25.2,
O E2 40.0.0.0/8 [110/20] via 25.25.25.2, 00:07
```

Figure 17 **R2 RT After Default Redistribution**

```
R    10.0.0.0/8 [120/1] via 35.35.35.2, 00:00:26,
R    12.0.0.0/8 [120/1] via 35.35.35.2, 00:00:26,
R    20.0.0.0/8 [120/1] via 35.35.35.2, 00:00:26,
R    25.0.0.0/8 [120/1] via 35.35.35.2, 00:00:26,
     30.0.0.0/8 is variably subnetted, 2 subnets,
C       30.30.30.0/24 is directly connected, Giga
L       30.30.30.254/32 is directly connected, Gi
     34.0.0.0/8 is variably subnetted, 2 subnets,
C       34.34.34.0/30 is directly connected, Giga
L       34.34.34.1/32 is directly connected, Giga
     35.0.0.0/8 is variably subnetted, 2 subnets,
C       35.35.35.0/30 is directly connected, Giga
L       35.35.35.1/32 is directly connected, Giga
R    40.0.0.0/8 [120/1] via 34.34.34.2, 00:00:30,
```

Figure 18 **R3 RT After Default Redistribution**

```
R    10.0.0.0/8 [120/2] via 34.34.34.1,
R    12.0.0.0/8 [120/2] via 34.34.34.1,
R    20.0.0.0/8 [120/2] via 34.34.34.1,
R    25.0.0.0/8 [120/2] via 34.34.34.1,
R    30.0.0.0/8 [120/1] via 34.34.34.1,
     34.0.0.0/8 is variably subnetted,
C       34.34.34.0/30 is directly conne
L       34.34.34.2/32 is directly conne
R    35.0.0.0/8 [120/1] via 34.34.34.1,
     40.0.0.0/8 is variably subnetted,
C       40.40.40.0/24 is directly conne
L       40.40.40.254/32 is directly con
```

Figure 19 **R4 RT After Default Redistribution**

5. Results and Discussion

5.1.Results

The problem in given scenario is that the routers on the left side of R5 i.e. R1 and R2 which are inside OSPF domain are not getting complete information about the RIP network which is available on right side of R5. Whereas, the routers on the right side of R5 i.e. R3 and R4 are not able to fetch the information about the OSPF network which is present on the left side of R5. This results in partial or incomplete information and requires the need for mutual redistribution.

5.2.Discussion

For the OSPF network all the routers in the domain i.e. R1, R2 & R5 shares the information and build up the topology table as per the rules of OSPF. The OSPF uses link bandwidth for the calculation of metric referred as “Cost”. The cost formula is reference bandwidth divided by the interface (link) bandwidth. The reference bandwidth of 100 Mbps is used for OSPF cost calculation. For example, the OSPF path cost value is 1 (100 Mbps/100 Mbps) for a Link with bandwidth of 100 Mbps. But for 1000 Mbps link bandwidth the cost calculated will be 0.1 (100 Mbps/ 1000 Mbps) but rounded off to 1. Default behavior of OSPF is to choose metric type 2 routes which are not good in real time production environment where there can be multiple redistribution points and cost is not updated on each hop. The OSPF type 2 metric is default should be updated with type1 so as to have a better updated cost value to be used in the network. Before updating OSPF “metric-type 1” in R5. It is shown in Figure 20.

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```
R5#show run | sec router ospf
router ospf 5
 log-adjacency-changes
 redistribute rip subnets
 network 25.25.25.0 0.0.0.3 area 0
```

Figure 20 R5 OSPF Before Complete Redistribution

After updating OSPF "metric-type 1" in R5 is shown in Figure 21.

```
R5#show run | sec router ospf
router ospf 5
 log-adjacency-changes
 redistribute rip metric-type 1 subnets
 network 25.25.25.0 0.0.0.3 area 0
```

Figure 21 R5 OSPF After Complete Redistribution

During the mutual redistribution process OSPF shares it Topology Table (TT) which was constructed using the bandwidth parameter with RIP. On the other hand, RIP also shares its Topology table (TT) but used Hops i.e. jumps count for metric calculation. R1 Routing Table (RT) after complete "metric-type 1" redistribution is shown in Figure 22.

```
     10.0.0.0/8 is variably subnetted, 2 subne
C       10.10.10.0/24 is directly connected, G
L       10.10.10.254/32 is directly connected,
     12.0.0.0/8 is variably subnetted, 2 subne
C       12.12.12.0/30 is directly connected, G
L       12.12.12.1/32 is directly connected, G
     20.0.0.0/24 is subnetted, 1 subnets
O       20.20.20.0/24 [110/2] via 12.12.12.2,
     25.0.0.0/30 is subnetted, 1 subnets
O       25.25.25.0/30 [110/2] via 12.12.12.2,
O E1 30.0.0.0/8 [110/22] via 12.12.12.2, 00:00
O E1 34.0.0.0/8 [110/22] via 12.12.12.2, 00:00
     35.0.0.0/30 is subnetted, 1 subnets
O E1    35.35.35.0/30 [110/22] via 12.12.12.2,
O E1 40.0.0.0/8 [110/22] via 12.12.12.2, 00:00
```

Figure 22 R1 RT After Complete Redistribution

R2 Routing Table (RT) after complete "metric-type 1" redistribution is shown in Figure 23.

```
     10.0.0.0/24 is subnetted, 1 subnets
O       10.10.10.0/24 [110/2] via 12.12.12.1,
     12.0.0.0/8 is variably subnetted, 2 subne
C       12.12.12.0/30 is directly connected, G
L       12.12.12.2/32 is directly connected, G
     20.0.0.0/8 is variably subnetted, 2 subne
C       20.20.20.0/24 is directly connected, G
L       20.20.20.254/32 is directly connected,
     25.0.0.0/8 is variably subnetted, 2 subne
C       25.25.25.0/30 is directly connected, G
L       25.25.25.1/32 is directly connected, G
O E1 30.0.0.0/8 [110/21] via 25.25.25.2, 00:00
O E1 34.0.0.0/8 [110/21] via 25.25.25.2, 00:00
     35.0.0.0/30 is subnetted, 1 subnets
O E1    35.35.35.0/30 [110/21] via 25.25.25.2,
O E1 40.0.0.0/8 [110/21] via 25.25.25.2, 00:00
```

Figure 23 R2 RT After Complete Redistribution

During the mutual redistribution process OSPF shares it Topology Table (TT) which was constructed using the bandwidth parameter with RIP. On the other hand, RIP also shares its Topology table (TT) but used Hops i.e. jumps count for metric calculation. This metric calculation is used by RIP thus translated into rules which the OSPF can understand. Thus, RIP network information is learnt by OSPF and OSPF network information is passed on to RIP based network. The result would be OSPF routers like R1 & R2 which are present on the left side of R5 will get updated information about the network that is present in RIP domain. Along with that, the RIP router like R3 & R4 will be updated with the network information available in OSPF network without any problem. Both protocols will calculate their desired metric for these newly updated routes learned via redistribution. Therefore, the various types of variation are required to transform the different routing protocols information into each other. In case of OSPF the redistribution is done along with change in the metric type 1 including subnets as default type is just type 2 without including any classless network i.e. classful network only. Modification is necessary to have a clear information about the network routes which were available on the other end.

Conclusion

The above experimental study concludes that the OSPF default metric calculation needs to be modified whenever there are multiple routing protocols are used with OSPF. The modification needed for having clear visibility of complete network where OSPF is not available. During the mutual redistribution process OSPF shares it Topology Table (TT) which was constructed using the bandwidth parameter with RIP process. On the other hand, RIP also shares its Topology table (TT). RIP uses parameter like jumps called hop-count on the link for metric calculation. Future scope could be done for finding better results by further tuning of OSPF metric calculation parameters and testing them with other routing protocols like Enhanced Interior Gateway Routing Protocol (EIGRP), Border Gateway Protocol (BGP), etc. Further study can be conducted for OSPF protocol how to change the metric (cost) computation by combining multiple link parameters like delay, MTU, etc. for further enhancement as other routing protocols. OSPF algorithm can be optimized to work better for better path selection.

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