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Research paper

Corroboration of RIPng, EIGRPv6 and OSPFv3 Routing Protocols in IPv6 Environment through Simulation and Actual Operation

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Abstract

The IPv4 address exhaustion is incipient and apparent with the growing computer network system technologies. The computing world is moving to the adoption of the next generation Internet Protocol, IPv6. Such transition poses immense and significant considerations; specifically, in building networks and in the identification of suitable routing protocols for computer integration with high degree of adaptability. As routing plays a significant and major component in network's performance, performance reference evaluation of RIPng, EIGRPv6 and OSPFv3 in IPv6 setting is undertaken and studied. This paper focused on testing the performance consistency of the RIPng, EIGRPv6 and OSPFv3 routing protocols in simulation and actual operations in IPv6 environment. A packet tracer was used during simulation and corroborated to real time situation. Performances in both simulation and actual operation yielded similar results, with high consideration on setting parameters consistently. The mock-up process had been authenticated by the actual set-up. It is therefore recommended that simulation should be considered in studying the behavior of the system before building it as results are reliable in general. . Integration of simulation for networking configurations is not only cost-effective but also creativity and learning-supportive. Moreover, network administrators can engage into network services through abstraction of higher-level functionality that is changing, economic and adjustable which is ideal for the dynamic nature of today's applications.

Keywords: *RIPng; EIGRPv6; OSPFv3; IPv6; Cisco Packet Tracer; HyperTerminal Emulator; Network Topology*

1. Introduction

The scarcity of free address pools and the large-scale demand for IPv4 address space is imminent. Networks that require more address allocations from their respective registries are limited [1]. The high demand of the internet calls for an adoption and migration of the next generation Internet protocol, IPv6, which though inceptive is accelerating. With the transition from IPv4 to IPv6, internet protocol addressing systems are needed to deal and support its gradation. Routing protocols are therefore highly considered in IPv6 network.

Routing IPv6 interchange is not sustained by existing IPv4 routing protocols [2]. Therefore, studies on the advancement of IPv6 dynamic routing protocols are essential as dependability and scalability are significant in many networks. Moreover, dynamic routing protocols' ability to voluntarily regulate to network topological changes like failed components and rerouting traffic through alternative paths compared to static routing protocols poses a significant advantage. The choice of the routing protocol becomes a very crucial factor to successfully distribute data to define success of the network overtime.

Several works have been done with dynamic routing protocols consistent with IPv6's recent growth and changing utilization. In [3] the authors have explored RIP and OSPF in IPv6 network. Authors in [4] have contrasted and discussed OSPF and EIGRP routing protocols with both IPv4 and IPv6 environments. Reference [5], illustrated the performance analysis of various routing protocols like RIP, OSPF, IGRP and EIGRP with the parameters such as packets dropping, interchange received, end to end delay and jitter in voice. Related works from authors [6] – [12] have also contributed in unravelling the characteristics of configurations of these protocols. Performances of these protocols have also been observed through actual scenario and simulations. Certain studies were conducted to investigate packet tracer tools for computer networks as cited with authors in [13].

With the direction, adoption and transition to IPv6, relative studies on the three dynamic routing protocols' performances have been undertaken by other researchers but studies on performance corroboration of simulation to real-time situation is limited. This has prompted the researcher to bridge this gap of knowledge with the purpose of finding out whether theoretical analysis will have consistent and similar results in the simulation and actual operation, specifically in IPv6 networks. The study aims to validate and corroborate the simulated performances in IPv6 environment of these three dynamic routing protocols; namely, Routing Information Protocol Next Generation (RIPng), Enhanced Interior Getaway Routing Protocol for IPv6 (EIGRPv6) and Open Shortest Path First Version 3 (OSPFv3) using packet tracer to actual set-up utilizing HyperTerminal Emulator. The comparative set-up becomes the basis for evaluation whether performance consistency and regularity are observed by both simulation and actual operation. Data collected from the configuration will be maximized to address time, effort and cost concerns in creating and designing networks. Once simulation can be substantiated by the actual operation, this can provide practical feedback before designing real world systems and consequently allow explorations that merit alternative designs without actually building them. Problems, considerations and constraints especially in the migration to IPv6 can be studied at several different levels of abstraction to counteract the complexity of the overall new environment.

2. Materials and Methods

These were the proceedings during the study.

2.1 IPv6 Address Assignment

Table 1 & 2 shows IPv6 addresses of the devices used in Gigabit Ethernet and Serial Ports.

Table 1: Device Configuration in Gigabit Ethernet Ports

Device	Gigabit Ethernet 0/0	Gigabit Ethernet 0/1
Router 1	ABCD:7F:246:2::1/64	ABCD:7F:246:3::1/64
Router 2	NA	ABCD:7F:246:1::1/64
Router 3	NA	ABCD:7F:246:4::1/64

Table 2: Device Configuration in Serial Ports

Device	Serial 0/0/0	Serial 0/0/1
Router 1	NA	ABCD:7F:246:6::2/64
Router 2	ABCD:7F:246:5::1/64	ABCD:7F:246:6::1/64
Router 3	NA	ABCD:7F:246:5::2/64

Table 3 shows IPv6 addresses and default gateways of the devices.

Table 3: Device Configuration

Device	IP Address	Default Gateway
PC 1	ABCD:7F:246:2::2/64	ABCD:7F:246:2::1/64
PC 2	ABCD:7F:246:1::2/64	ABCD:7F:246:1::1/64
PC 3	ABCD:7F:246:4::2/64	ABCD:7F:246:4::1/64
PC 4	ABCD:7F:246:3::2/64	ABCD:7F:246:3::1/64

2.2 Network Simulation

A Packet Tracer software was employed during the simulation to evaluate the performance of RIPng, EIGRPv6 and OSPFv3 in IPv6 environment.

Logical Topology: A logical topology design was built.
Figure 1 shows the simulation set-up using Cisco Packet Tracer.

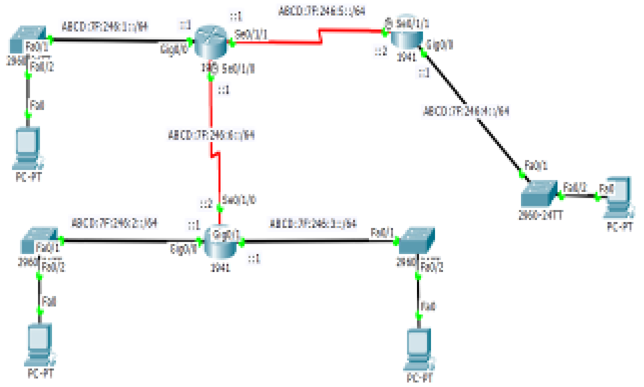

Figure 1: Topology Diagram

Table 4: Device Specification

Quantity	Device Name	Model
3	Router	Cisco 1941
4	Switch	Cisco 2960
4	Desktop	PC-PT

Device Configuration: Carrying out of router configuration in simulation.

Figure 2 implements command configuration of hostname and IPv6 address on R1 using Packet Tracer.

```
Router(config)#hostname R1
R1(config)#int se0/1/0
R1(config-if)#ipv6 add abcd:7f:246:6::2/64
R1(config-if)#no shut
```

Figure 2: Hostname and IP Address Assignment

Figure 3, 4 & 5 show the execution of commands using three Routing Protocols.

```
R1(config)#ipv6 unicast
R1(config)#ipv6 unicast-routing
R1(config)#ipv6 router rip DIT
R1(config-rtr)#int se0/1/0
R1(config-if)#ipv6 rip DIT en
```

Figure 3: RIPng Configuration

```
R2(config)#ipv6 unicast
R2(config)#ipv6 unicast-routing
R2(config)#ipv6 router eigrp 7
R2(config-rtr)#eigrp router-id 2.2.2.2
R2(config-rtr)#no shut
R2(config-rtr)#int se0/1/0
R2(config-if)#ipv6 eigrp 7
```

Figure 4: EIGRPv6 Configuration

```
R3(config)#ipv6 unicast
R3(config)#ipv6 unicast-routing
R3(config)#ipv6 router ospf 7
%OSPFv3-4-NORTRID: OSPFv3 process 7 could not
pick a router-id,please configure manually
R3(config-rtr)#router-id 3.3.3.3
R3(config-rtr)#int se0/1/1
R3(config-if)#ipv6 ospf 7 area 1
```

Figure 5: OSPFv3 Configuration

2.3 Network Actual Operation

A HyperTerminal software was utilized to evaluate the performance of RIPng, EIGRPv6 and OSPFv3 in IPv6 environment.

Physical Topology: A physical topology was devised and constructed.
Figure 6 displays the actual set-up of network devices in the laboratory.

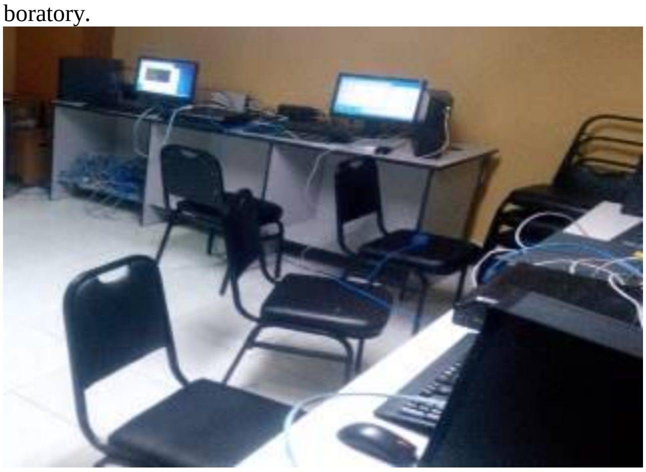

Figure 6: Topology Set-up

Table 5: Device Specification

Quantity	Device Name	Model
3	Router	Cisco 1900
4	Switch	Cisco Catalyst 2960
4	Desktop	Dell

Device Configuration: Carrying out of router configuration in actual operation.

Figure 7 implements command configuration of hostname and IPv6 address on R1 using HyperTerminal.

```
Router(config)#hostname R1
R1(config)#int se0/0/1
R1(config-if)#ipv6 add abcd:7f:246:6::2/64
R1(config-if)#clock rate 64000
R1(config-if)#no shut
```

Figure 7: Hostname and IP Address Assignment

Figure 8, 9 & 10 show the execution of commands using the three Routing Protocols.

```
R1(config)#ipv6 unicast
R1(config)#ipv6 unicast-routing
R1(config)#ipv6 router rip DIT
R1(config-rtr)#int se0/0/1
R1(config-if)#ipv6 rip DIT en
```

Figure 8: RIPng Configuration

```
R2(config)#ipv6 unicast
R2(config)#ipv6 unicast-routing
R2(config)#ipv6 router eigrp 7
R2(config-rtr)#eigrp router-id 2.2.2.2
R2(config-rtr)#no shut
R2(config-rtr)#int se0/0/1
R2(config-if)#ipv6 eigrp 7
```

Figure 9: EIGRPv6 Configuration

```
R3(config)#ipv6 unicast
R3(config)#ipv6 unicast-routing
R3(config)#ipv6 router ospf 7
R3(config-rtr)#
*Sep  2 12:53:21.107: %OSPFv3-4-NORTRID:
router-id, please configure manually
R3(config-rtr)#router-id 3.3.3.3
R3(config-rtr)#int se0/0/1
R3(config-if)#ipv6 ospf 7 area 1
```

Figure 10: OSPFv3 Configuration

3. Results and Discussion

The evaluation of the three routing protocols in simulation and actual operation in IPv6 environment resulted in the findings discussed below.

3.1 Ping Command

The reachability hosts for both simulated and actual procedures consistently yielded matching results as shown in Figures 11 and 12.

```
R3#ping abcd:7f:246:3::2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to
abcd:7f:246:3::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5)  round-trip
min/avg/max = 3/8/12 ms
```

Figure 11: Ping in Simulation

```
R3#ping abcd:7f:246:3::2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to ABCD:7F:246:3::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5) round-trip min/avg/max = 52/55/56 ms
```

Figure 12: Ping in Actual Operation

3.2 IP Route Command

The IPv6 routing table displays summary information about all routes for the specified protocol. Figure 13 and 14 show the highlighted information in blue which implies the administrative distance; red in hop counts; and green in directly connected networks. Similar data results have been manifested in RIPng for both simulated and actual operations.

```
C   ABCD:7F:246:1::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   ABCD:7F:246:1::1/128 [0/0]
     via GigabitEthernet0/0, receive
R   ABCD:7F:246:2::/64 [120/2]
     via FE80::240:BFF:FEBD:7774, Serial0/1/0
R   ABCD:7F:246:3::/64 [120/2]
     via FE80::240:BFF:FEBD:7774, Serial0/1/0
R   ABCD:7F:246:4::/64 [120/2]
     via FE80::20D:BDFF:FE63:B849, Serial0/1/1
C   ABCD:7F:246:5::/64 [0/0]
     via Serial0/1/1, directly connected
L   ABCD:7F:246:5::1/128 [0/0]
     via Serial0/1/1, receive
```

Figure 13: RIPng Routing Table in Simulation

```
C   ABCD:7F:246:1::/64 [0/0]
     via GigabitEthernet0/1, directly connected
L   ABCD:7F:246:1::1/128 [0/0]
     via GigabitEthernet0/1, receive
R   ABCD:7F:246:2::/64 [120/2]
     via FE80::262:ECFF:FEA3:36E0, Serial0/0/1
R   ABCD:7F:246:3::/64 [120/2]
     via FE80::262:ECFF:FEA3:36E0, Serial0/0/1
R   ABCD:7F:246:4::/64 [120/2]
     via FE80::278:88FF:FEB4:BA60, Serial0/0/0
C   ABCD:7F:246:5::/64 [0/0]
     via Serial0/0/0, directly connected
L   ABCD:7F:246:5::1/128 [0/0]
     via Serial0/0/0, receive
```

Figure 14: RIPng Routing Table in Actual Operation

Results in IPv6 network for both simulation and actual operation in EIGRPv6 are the same in directly connected networks and administrative distance as shown in the green and blue highlighted data respectively; however, the highlighted information in red shows the differences in metric data.

```
C   ABCD:7F:246:1::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   ABCD:7F:246:1::1/128 [0/0]
     via GigabitEthernet0/0, receive
D   ABCD:7F:246:2::/64 [90/2172416]
     via FE80::240:BFF:FEBD:7774, Serial0/1/0
D   ABCD:7F:246:3::/64 [90/2172416]
     via FE80::240:BFF:FEBD:7774, Serial0/1/0
D   ABCD:7F:246:4::/64 [90/2172416]
     via FE80::20D:BDFF:FE63:B849, Serial0/1/1
C   ABCD:7F:246:5::/64 [0/0]
     via Serial0/1/1, directly connected
L   ABCD:7F:246:5::1/128 [0/0]
     via Serial0/1/1, receive
```

Figure 15: EIGRPv6 Routing Table in Simulation

```
C   ABCD:7F:246:1::/64 [0/0]
     via GigabitEthernet0/1, directly connected
L   ABCD:7F:246:1::1/128 [0/0]
     via GigabitEthernet0/1, receive
D   ABCD:7F:246:2::/64 [90/20514560]
     via FE80::262:ECFF:FEA3:36E0, Serial0/0/1
D   ABCD:7F:246:3::/64 [90/20514560]
     via FE80::262:ECFF:FEA3:36E0, Serial0/0/1
D   ABCD:7F:246:4::/64 [90/20514560]
     via FE80::278:88FF:FEB4:BA60, Serial0/0/0
C   ABCD:7F:246:5::/64 [0/0]
     via Serial0/0/0, directly connected
L   ABCD:7F:246:5::1/128 [0/0]
     via Serial0/0/0, receive
```

Figure 16: EIGRPv6 Routing Table in Actual Operation

IPv6 network results for both simulation and actual operation in OSPFv3 are the same in directly connected networks and administrative distance as shown in the highlighted information in green and blue respectively. But, cost data highlighted in red are different.

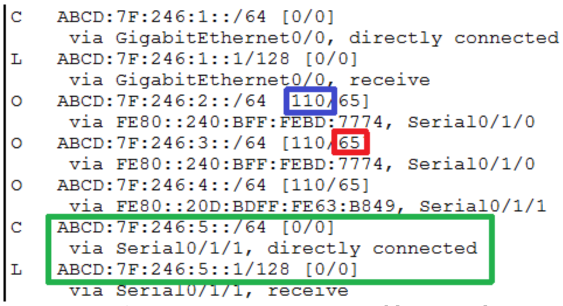

Figure 17: OSPFv3 Routing Table in Simulation

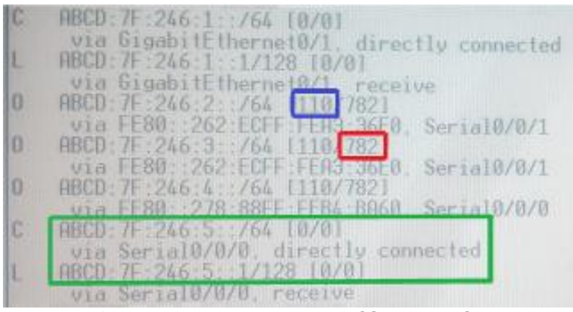

Figure 18: OSPFv3 Routing Table in Actual Operation

From the data gathered in IPv6 environment, the basis for set metric of RIPng is hop count. Being static in nature had resulted to comparable data in both simulation and actual operation with high consideration of establishing similar topology for findings to be consistent. On the other hand, EIGRPv6 yielded a different result as bandwidth during simulation had not been set. Results would be the same if bandwidth is set for both simulation and actual operation. This can be justified by using the simplified formula:

EIGRP Metric = 256 * (Bandwidth + Delay).
Originally, formula had been set with:
EIGRP Metric = 256*((K1*Bandwidth) + (K2*Bandwidth)/(256-Load) + K3*Delay)*(K5/(Reliability + K4)))
By default, the values of K1 and K3 are set to 1, and K2, K4 and K5 are set to 0. Hence the above equation is deduced to the simplified formula mentioned above. Below are figures 19 and 20 to validate the k values.

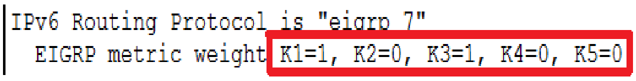

Figure 19: K values for EIGRPv6 in a simulated environment

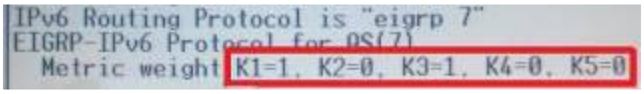

Figure 20: K values for EIGRPv6 in a real environment

Furthermore, OSPFv3 yields different result in cost because bandwidth was not set during simulation. If it has been set, it could have yielded same results for both simulation and actual operation. This can be computed using the formula:
OSPF Cost = Reference Bandwidth / Interface Bandwidth.

4. Conclusion

The results on the corroboration of RIPng, EIGRPv6 and OSPFv3 routing protocols in IPv6 environment through simulation and actual operation have been similar, taking into consideration that set parameters especially on bandwidth in EIGRPv6 and OSPFv3 should be consistently established. The bandwidth is emphasized for both aforementioned routing protocols because it is the basis for their metric computations and determinations. RIPng's computation, on the other hand, is not influenced since its metric determination is done through hop counts, making bandwidth ineffectual.

The outcome from the proceedings has answered the author's inquiry on the consistency of the routing protocols in study from its actual operations to simulation in IPv6 network. This has prompted the proponent to conclude that results in simulation are generally accurate and reliable with that of real time scenario. Unanticipated phenomenon and "what-ifs" analysis can also be integrated and easily performed in mock up models. Simulation is time, effort and cost efficient.

It is, therefore, recommended that further studies shall be undertaken to investigate and experiment different topologies, not limiting testing to few devices especially as we are faced with the inevitable migration to IPv6 environment. Simulations should also be taken into account for further thorough investigations so as potential designs will be aptly evaluated before fabricating the network themselves. By mimicking the behavior of the designs, the simulator will be able to provide the information pertaining to the correctness and efficiency of alternate designs. The integration of simulation for networking configurations can provide an abstraction of higher-level functionality that shall enhance exploration and easy navigability by being economic and adjustable.

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