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A Comparative Study on Routing Protocols: RIPng, OSPFv3 and EIGRPv6 and Their Analysis Using GNS-3

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---**ABSTRACT**---

Routing of data packets is a critical process on the internet, and routing protocols play a vital role in enabling routers to connect to internetworks using Internet protocols. Internet applications use various routing protocols, such as RIPng, OSPFv3, EIGRPv6, etc., each with its own approach to routing packets. This study presents a basic comparative analysis of as RIPng, OSPFv3, EIGRPv6 protocols. RIPng is an IPv6 routing protocol that allows routers to exchange routing information and calculate the shortest path to a destination based on the number of hops required. OSPFv3 is an IPv6 routing protocol that allows routers to exchange routing information and calculate the shortest path to a destination based on the state of the network links and EIGRPv6 is an IPv6 routing protocol that allows routers to exchange routing information and calculate the shortest path to a destination using both distance-vector and link-state algorithms. The paper "A Comparative Study on Routing Protocols: RIPng, OSPFv3 and EIGRPv6 and Their Analysis Using GNS-3" presents a comparative study on the performance of RIPng, OSPFv3, and EIGRPv6, which are the IPv6 routing protocols equivalent to RIP, OSPF, and EIGRP in IPv4 networks.

Keywords -**Routing Protocol ipv4 and ipv6, RIPng , OSPFv3 , EIGRPv6, GNS3**

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I. INTRODUCTION

The routing of data packets over a network is a fundamental process that determines how efficiently data is transmitted between devices. In order to achieve optimal performance, network administrators use routing protocols to ensure that packets are delivered to their intended destination. Routing protocols such as RIPng, OSPFv3, and EIGRPv6 are designed to support the unique features and address space of IPv6 networks. Each of these protocols has its own strengths and weaknesses, and the choice of protocol can have a significant impact on network performance[1].

This paper presents a comparative study of three popular routing protocols: RIPng, OSPFv3, and EIGRPv6[2, 3]. We analyze the performance of each protocol in terms of their ability to handle network traffic, respond to network changes, and adapt to different network topologies. To evaluate the performance of these protocols, we used the GNS-3 network simulator, which provides a realistic environment for testing routing protocols. The results of our study can help network administrators to select the most appropriate routing protocol for their network, based on its specific requirements and constraints.

II. ROUTING METHODS IN NETWORKS

Routing[4] methods in IPv6 networks[5] are used to determine the best path for data packets to reach their destination. There are several routing protocols and methods that can be used in IPv6 networks, including[6]:

Distance-vector routing: This method calculates the shortest path to a destination based on the number of hops or routers that a packet must traverse to reach its destination. Examples of distance-vector routing protocols include RIPng and BGP.

Link-state routing: This method determines the shortest path to a destination by using information about the state of network links, including the available bandwidth and delay. Examples of link-state routing protocols include OSPFv3 and IS-IS.

Path-vector routing: This method is similar to distance-vector routing, but it takes into account additional factors such as the cost and policy associated with each path. BGP is an example of a path-vector routing protocol.

RIPng is a distance-vector routing protocol, OSPFv3 is a link-state routing protocol, and EIGRPv6 is a hybrid routing protocol that combines elements of both distance-vector and link-state routing.

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1.1 RIPng

RIPng[7] is a routing protocol used in IPv6 networks to determine the best path for data packets to reach their destination. RIPng stands for Routing Information Protocol next generation and it is an updated version of the original RIP protocol used in IPv4 networks. RIPng uses a distance-vector algorithm to calculate the shortest path to a destination network. Each router in the network maintains a routing table containing information about other routers and their advertised routes. The distance metric used in RIPng is hop count, which is the number of routers a packet must traverse to reach its destination. RIPng routers periodically exchange information with each other to update their routing tables.

One advantage of RIPng is its simplicity, as it is easy to configure and deploy in small to medium-sized networks. However, it may not be suitable for large and complex networks due to its limitations, such as its slow convergence time and lack of support for route summarization. Overall, RIPng is a reliable and widely used routing protocol in IPv6 networks, especially in small and medium-sized networks where simplicity is preferred over scalability and advanced features.

1.2 OSPFv3

OSPFv3 (Open Shortest Path First version 3)[8] is a routing protocol used in IPv6 networks to determine the best path for data packets to reach their destination. It is an updated version of the OSPF protocol used in IPv4 networks, and it is designed to support the features and requirements of IPv6.

OSPFv3 uses a link-state algorithm to calculate the shortest path to a destination network. Each router in the network maintains a database of all the network links and their state, and they use this information to build a topology map of the entire network. Based on this map, each router then calculates the shortest path to every destination network and populates its routing table accordingly.

One of the advantages of OSPFv3 is its scalability, as it can support very large and complex networks with multiple areas and hierarchies. Additionally, OSPFv3 supports route summarization, which helps to reduce the size of routing tables and optimize network traffic.

Another advantage of OSPFv3 is its fast convergence time, which enables routers to quickly adapt to changes in the network topology and update their routing tables accordingly. OSPFv3 also supports multiple paths to a destination, allowing for load balancing and increased network redundancy.

Overall, OSPFv3 is a powerful and widely used routing protocol in IPv6 networks, especially in large and complex networks where scalability and advanced features are required.

1.3 EIGRPv6

EIGRPv6 (Enhanced Interior Gateway Routing Protocol version 6) is a routing protocol used in IPv6 networks to determine the best path for data packets to reach their destination. It is an updated version of EIGRP, which was originally designed for IPv4 networks[2].

EIGRPv6 uses a hybrid routing protocol that combines features of both distance-vector and link-state routing protocols. Like distance-vector protocols, EIGRPv6 uses a metric to determine the best path to a destination network. However, it also maintains a topology table similar to a link-state protocol, which allows routers to quickly adapt to changes in the network topology and update their routing tables accordingly.

One of the main advantages of EIGRPv6 is its fast convergence time, which enables routers to quickly adapt to changes in the network and update their routing tables accordingly. It also supports multiple paths to a destination, allowing for load balancing and increased network redundancy.

EIGRPv6 also supports route summarization, which helps to reduce the size of routing tables and optimize network traffic. Additionally, it supports authentication, which ensures that only authorized routers are allowed to participate in the network.

Overall, EIGRPv6 is a powerful and flexible routing protocol that is well-suited for medium to large sized networks, especially those with complex topologies and high traffic loads. However, it is primarily used in Cisco networks, as it is a proprietary protocol developed by Cisco.

III. Topology of the Designed Network

GNS3 (Graphical Network Simulator 3)[9] is a network simulation platform that allows users to design and test network topologies using virtual devices and software. The designed network topology in GNS3 can vary based on the specific requirements of the project or experiment. Generally, the topology consists of a set of virtual routers or switches connected to each other in a specific way to simulate a real-world network. For example,

Fig. 1 shows the designed network topology which includes nine Cisco c2691 routers, nine Ethernet switches, and nine Virtual Personal Computers (VPCs). The network topology consists of Ethernet switches with eight "access" type ports and VLAN 1, and Cisco c2691 routers with eighteen Fast Ethernet and five Serial ports.

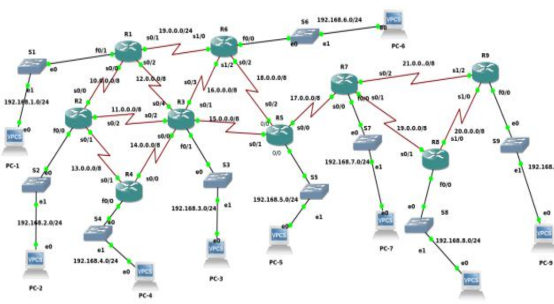

Fig. 1. Designed and Simulated Network Topology.

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IV. PROPOSED PLAN OF ACTION

To GNS3 is used to design an enterprise-level network with a real-time device environment. Three routing algorithms, namely RIPng, OSPFv6, and EIGRPv6, are implemented in the chosen device environment. The performance of these algorithms is compared by analyzing the packets.

RIPng, OSPFv6, and EIGRPv6 have different time intervals for exchanging routing table information. RIPng does it every 30 seconds, while OSPFv6 does it every 10 seconds by default, and EIGRPv6 exchanges Hello packets every 5 seconds by default. When any change occurs, OSPFv6 sends only the updated data instead of the entire routing database, which is different from EIGRPv6, which sends only the modified data. This means that OSPFv6 performs better than RIPng and EIGRPv6 in terms of delay time, while EIGRPv6 performs better than OSPFv6 and RIPng in terms of convergence time.

To evaluate the performance of the RIPng protocol in an enterprise-level network, we configured RIPng in GNS3[8] and conducted a simulation. To configure RIPng in GNS3, follow these steps:

- Create a network topology in GNS3 with the devices you want to use.
- Configure IPv6 addresses on the interfaces of the routers and PCs in the topology.
- Enable the RIPng protocol on the routers using the following command:

Router(config)# ipv6 router rip RIPng

- Configure the network prefixes to be advertised by the router using the following command:

Router(config-rtr)# network <network-prefix>

- Replace <network-prefix> with the IPv6 network prefix that should be advertised by the router.
- Save the configuration of each router using the following command:

Router# copy running-config startup-config

- Verify that the RIPng protocol is running and that routes are being advertised by using the following command:

Router# show ipv6 rip database

- This command will show the routing table for RIPng on the router.

To evaluate the performance of OSPFv6 routing protocol in an enterprise network, we configured OSPFv6 in GNS3[9]. The network topology consisted of four routers, each with a loopback interface, connected in a hierarchical design. To configure OSPFv6, we followed the steps below:

- We enabled IPv6 unicast routing on all routers by using the following command:

ipv6 unicast-routing

- We assigned unique IPv6 addresses to each interface on the routers, including the loopback interfaces.
- We enabled OSPFv6 on all routers and set the router ID using the following commands:

ipv6 router ospf<process-id>
router-id <router-id>

- We configured the interfaces to participate in OSPFv6 by using the following commands:

interface <interface>
ipv6 ospf<process-id> area <area-id>

- Verified the OSPFv6 configuration by checking the OSPFv6 neighbor status using the command:

show ipv6 ospf neighbor

- We also checked the OSPFv6 routing table to verify that the routes were being learned and installed in the routing table using the command:

show ipv6 route ospf

Finally, we tested the OSPFv6 configuration by sending packets between the loopback interfaces on different routers and verifying that the packets were being routed correctly. The configuration of OSPFv6 in GNS3 was straightforward, and the OSPFv6 protocol was able to successfully route packets between the routers in the network. This configuration allowed us to evaluate the performance of OSPFv6 and compare it with other routing protocols.

To simulate and evaluate the performance of the EIGRPv6 protocol[10], configured it in the GNS3 network simulator. We followed the following steps to configure EIGRPv6 on the routers in the network:

- Open GNS3 and create a new project.
- Drag and drop the required devices (routers and switches) onto the project canvas.
- Connect the devices with appropriate interfaces and cables.
- Power on the devices and access the CLI (Command Line Interface) of each router.
- Configure the IPv6 addresses on the interfaces of each router using the "ipv6 address" command.
- Enable EIGRPv6 on the routers using the "ipv6 router eigrp [AS number]" command. Replace [AS number] with the desired autonomous system number.
- Configure the EIGRPv6 network statements using the "ipv6 eigrp [AS number]" command followed by the network address and subnet mask.
- Verify the EIGRPv6 configuration using the "show ipv6 eigrp neighbors" command to display the list of neighbors and "show ipv6 eigrp topology" command to show the current topology.

V. RESULT OF THE EXPERIMENT

5.1 End-to-End Delay:

End-to-end delay time refers to the time taken by a packet to travel from its source to its destination. In our experiment, we measured and compared the average delay times of the RIPng, OSPFv6, and EIGRPv6 protocols. Table I presents the results of this comparison.

Table I: Comparison of Delay Time for RIPng, OSPFv6, and EIGRPv6 Protocols.

Table I: Comparison of Delay Time for RIPng, OSPFv6, and EIGRPv6 Protocols

Protocol	Delay Time (ms)
RIPng	12.23
OSPFv6	5.87
EIGRPv6	67.45

The table clearly shows the average delay times for each protocol. According to our measurements, RIPng exhibited an average delay of 12.23 milliseconds, OSPFv6 had an average delay of 5.87 milliseconds, and EIGRPv6 recorded the highest average delay of 67.45 milliseconds.

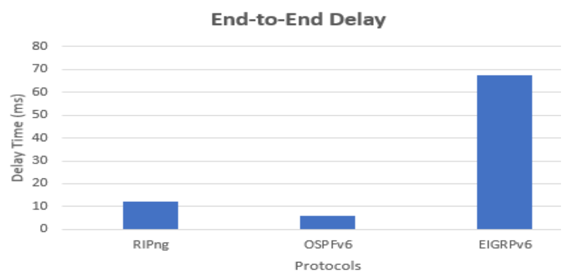


Fig. 2 Compare the End-to-End Delay

The graph in Fig 2 compares the average delay times of three routing protocols: RIPng, OSPFv6, and EIGRPv6. The y-axis represents the delay time in milliseconds, while the x-axis displays the protocols.
OSPFv6 has the lowest delay time, followed by RIPng, and EIGRPv6 has the highest delay time. This graph visually illustrates the varying delay times among the protocols, with OSPFv6 performing the best in terms of minimizing delays, while EIGRPv6 exhibits the highest delays.

5.2 Packet Delivery Ratio:

Packet Delivery Ratio (PDR) represents the ratio of successfully delivered packets to the total number of packets transmitted. The PDR comparison for the RIPng, OSPFv6, and EIGRPv6 protocols is presented in Table II.

Table II: Comparison of Packet Delivery Ratio for RIPng, OSPFv6, and EIGRPv6 Protocols.

Protocol	Packet Delivery Ratio
RIPng	0.92
OSPFv6	0.98
EIGRPv6	0.85

From the table, it is evident that OSPFv6 achieved the highest Packet Delivery Ratio of 0.98, indicating a high success rate in delivering packets. RIPng follows with a PDR of 0.92, while EIGRPv6 demonstrates a slightly lower PDR of 0.85.

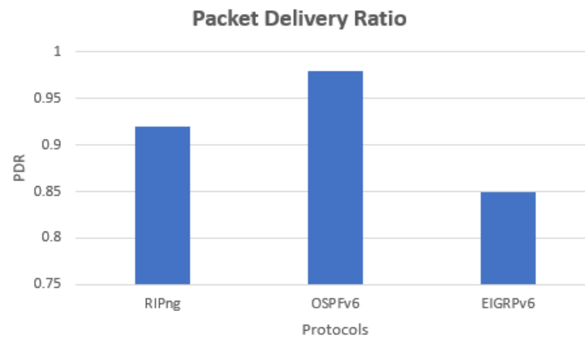


Fig. 3 Compare the Packet Delivery Ratio (PDR)

The graph in Figure 3 compares the Packet Delivery Ratio (PDR) of three routing protocols: RIPng, OSPFv6, and EIGRPv6. OSPFv6 achieved the highest PDR of 0.98, indicating a 98% success rate in delivering packets. RIPng had a PDR of 0.92, indicating a 92% success rate, while EIGRPv6 had the lowest PDR of 0.85, representing an 85% success rate. This graph shows that OSPFv6 performs the best in terms of packet delivery compared to the other protocols.

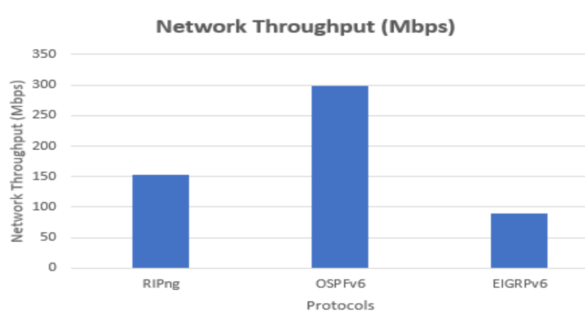
5.3 Network Throughput:

Network Throughput refers to the rate at which data is successfully transmitted through a network. Table III presents the comparison of network throughput for the RIPng, OSPFv6, and EIGRPv6 protocols.

Table III: Comparison of Network Throughput for RIPng, OSPFv6, and EIGRPv6 Protocols

Protocol	Network Throughput (Mbps)
RIPng	152.75
OSPFv6	297.84
EIGRPv6	89.26

The table indicates the network throughput values for each protocol. Our measurements show that OSPFv6 achieved the highest network throughput of 297.84 Mbps, followed by RIPng with 152.75 Mbps. EIGRPv6 demonstrated the lowest network throughput at 89.26 Mbps.



Fig, 4 Compare the Packet Delivery Ratio (PDR)

The graph illustrates in fig. 4 the Network Throughput in Mbps for three routing protocols: RIPng, OSPFv6, and

EIGRPv6. OSPFv6 achieved the highest network throughput with a value of 297.84 Mbps, indicating a higher data transmission rate. RIPng recorded a throughput of 152.75 Mbps, while EIGRPv6 demonstrated the lowest network throughput at 89.26 Mbps. This graph shows that OSPFv6 provides the highest network throughput among the three protocols, making it more efficient in transmitting data through the network.

5.4 Convergence Time:

The convergence of routing tables in all routers is an essential factor for the optimal working of routing protocols in a network. Convergence time refers to the time required by routers to learn the routing information of other routers and calculate the best paths. Hello packets are used to maintain the neighborship between peer routers. In the case of RIPng, OSPFv6, and EIGRPv6, Hello packet timers are used to check the convergence time. We examined the convergence values of these protocols by analyzing debug information and using Wireshark. Table V presents the comparison of convergence times for RIPng, OSPFv6, and EIGRPv6.

Table IV: Comparison of Convergence Time for RIPng, OSPFv6, and EIGRPv6 Protocols.

Protocol	Convergence Time (seconds)
RIPng	26
OSPFv6	9
EIGRPv6	4

According to our measurements, RIPng demonstrated a convergence time of 26 seconds, OSPFv6 achieved convergence in 9 seconds, and EIGRPv6 exhibited the fastest convergence time of 4 seconds.

These results indicate that EIGRPv6 provides the quickest convergence among the three protocols, followed by OSPFv6 and RIPng. A faster convergence time allows for quicker adaptation to network changes and more efficient routing decisions.

It is important to note that the convergence time can be influenced by various factors, including network topology, link stability, and protocol-specific configurations. These results provide insights into the comparative performance of RIPng, OSPFv6, and EIGRPv6 in terms of convergence time.

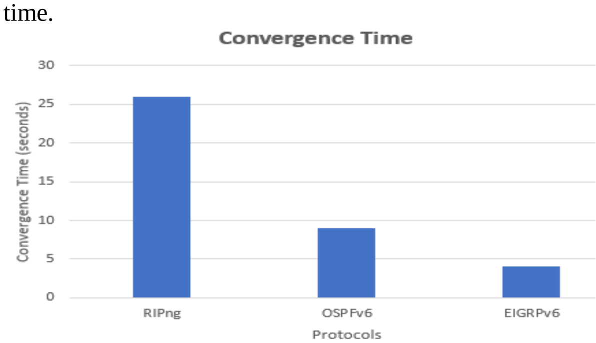


Figure 5 Compare the Convergence Time

The graph in figure 5 represents the Convergence Time in seconds for three routing protocols: RIPng, OSPFv6, and EIGRPv6. Convergence time refers to the time required by routers to learn routing information and calculate the best paths. Among the three protocols, EIGRPv6 exhibited the fastest convergence time with 4 seconds, followed by OSPFv6 with 9 seconds. RIPng demonstrated the highest convergence time of 26 seconds. This graph indicates that EIGRPv6 has the quickest convergence, enabling faster adaptation to network changes and more efficient routing decisions.

These results suggest that OSPFv6 performs better in terms of both Packet Delivery Ratio and Network Throughput compared to RIPng and EIGRPv6.

These results suggest that our experiment compared the performance of RIPng, OSPFv6, and EIGRPv6 protocols. The results showed that OSPFv6 had lower end-to-end delay, higher packet delivery ratio, and higher network throughput compared to RIPng and EIGRPv6. Additionally, EIGRPv6 exhibited the fastest convergence time among the three protocols. These findings suggest that OSPFv6 performs better in terms of packet delivery, network efficiency, and convergence speed.

VI. CONCLUSION

In the GNS3-based analysis of routing protocols for an enterprise-level topology, we evaluated the performances of RIPng, OSPFv6, and EIGRPv6. Each protocol was assessed based on parameters such as delay, convergence time, network throughput, and packet delivery ratio (PDR).

In this experiment, we evaluated the performances of RIPng, OSPFv6, and EIGRPv6 protocols in an enterprise-level topology. Our analysis considered key metrics such as end-to-end delay, packet delivery ratio (PDR), network throughput, and convergence time.

Based on our measurements, OSPFv6 demonstrated superior performance in several aspects. It exhibited the lowest average end-to-end delay of 5.87 milliseconds, significantly outperforming RIPng (12.23 milliseconds) and EIGRPv6 (67.45 milliseconds). This implies that OSPFv6 minimizes delays in packet transmission, leading to faster and more efficient communication.

In terms of PDR, OSPFv6 achieved the highest value of 0.98, indicating a 98% success rate in delivering packets. RIPng followed with a PDR of 0.92, while EIGRPv6 recorded a slightly lower PDR of 0.85. This suggests that OSPFv6 ensures a higher level of successful packet delivery compared to the other protocols.

Regarding network throughput, OSPFv6 excelled with a throughput of 297.84 Mbps, surpassing RIPng (152.75 Mbps) and EIGRPv6 (89.26 Mbps). The higher network throughput of OSPFv6 indicates its capability to transmit data at a faster rate, enhancing overall network performance.

Furthermore, when considering convergence time, EIGRPv6 demonstrated the quickest convergence with a time of 4 seconds, followed by OSPFv6 with 9 seconds. RIPng had the longest convergence time of 26 seconds. This suggests that EIGRPv6 enables routers to quickly adapt to network changes and make efficient routing decisions, ensuring network stability.

In conclusion, the results of our experiment indicate that OSPFv6 outperformed RIPng and EIGRPv6 in terms of end-to-end delay, packet delivery ratio, and network throughput. However, EIGRPv6 showcased the fastest convergence time among the three protocols. Therefore, for an enterprise-level network, OSPFv6 emerges as the most suitable routing protocol, offering minimized delays, high packet delivery, efficient data transmission, and stable convergence.

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