

OPTIMISATION OF ROUTING PROTOCOLS: A COMPARATIVE ANALYSIS OF RIP AND OSPF IN SIMULATED NETWORKS.

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Abstract

The research is carried out that the group of computers combine together for exchanging the data packets over a network channel, where these channels use different protocol methods. These protocols consist of rules and standards that govern how the data should pass. Data movement from one channel to another is facilitated by a router that keeps track of network paths for packet forwarding in a routing table, highlighting the importance of well-defined communication protocols. The best and most scalable communication protocol is the key to secure and effective communications. This research paper presents a simulated comparative analysis of dynamic routing with an emphasis on Routing Information Protocol (RIP) and Open Shortest Path First (OSPF) which are part of Distance Vector Routing Protocol and Link state Routing Protocol respectively. The experiment of both protocols in Networking Simulator Software CISCO PACKET TRACER and GNS3 Graphical Network Simulator-3 and stated the time coverage, hop count and observed that OSPF is much faster as compared to RIP. Comparisons of both show clear differences where OSPF depends on bandwidth and RIP depends on hop counts.

Keywords: Interior Gateway Protocol (IGP), Exterior Gateway Protocol (EGP), Distance Vector Protocol, Link State Protocol, Routing Information Protocol (RIP), Open Shortest Path First Protocol (OSPF).

1. Introduction:

Several computers and other related devices connect together through wired or wireless communication channels to form a network that facilitates communication and collaboration

among users for data exchange (Jagtap et al., 2025)). Modern communication networks rely immensely on routing and without it, the data cannot move beyond the subnet from where it originated (Baba-Ali et al., 2014). Routing protocols must be implemented to facilitate efficient data transmission over a network. These protocols define the rules that routers use to interact and share information. There are two approaches to forward packets: static routing and dynamic routing. In static routing, network administrators manually define the routes that router use to forward the data packets, whereas in dynamic routing routers automatically learn and update the routes using routing protocols such as Routing Information Protocol, Open Shortest Path First, Interior Gateway Routing Protocol, Enhanced Interior Gateway Routing Protocol, and others (Sirika & Mahajan, n.d.)). A routing protocol serves to describe how routers communicate and find the optimal path between two nodes, which helps the router to understand the network's architecture (Sirika & Mahajan, n.d.)

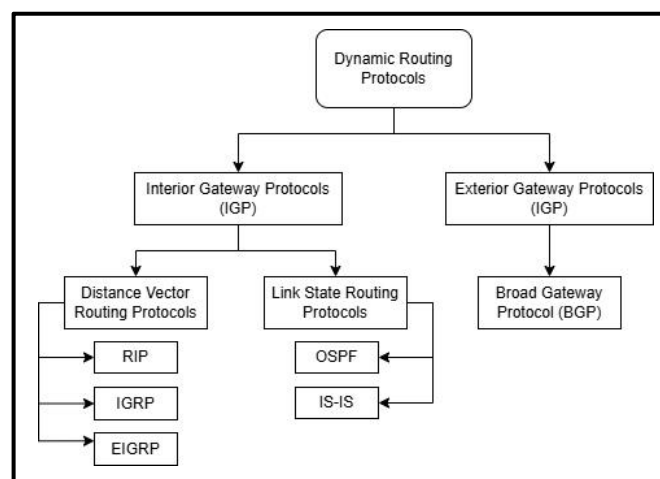


Figure 1: Classification of Dynamic Routing Protocols

This study discusses the dynamic routing protocols with the aim of examining their functionality and evaluating their effectiveness, along with a simulation-based analysis to evaluate their performance. *Figure 1* depicts the categorization of dynamic routing protocols based on where they operate inside a network. Interior Gateway routing protocols are typically employed on autonomous networks which have only one control and are implemented over distance vector and link state (Wachid et al., 2020) In contrast, Exterior Gateway routing protocols allow different autonomous systems to exchange routing information such as communication between Internet Service Providers (ISPs) (Chaudhary et al., 2013) An EGP protocol helps learn routes from its nearby neighbours and the devices linked with them but it lacks information about all routes across the Internet (Sendra et al., 2011) An EGP determines

whether a network can be reached between two autonomous systems, IGP is used to determine the path within an autonomous system.

1.2 Grouping of Dynamic Routing Protocols:

Dynamic Routing Protocols, specifically Interior Gateway Protocols (IGPs) are typically divided into two main categories:

1.2.1 IGP: A routing protocol that enables routers within the same Autonomous System (AS) to exchange routing information is known as an Interior Gateway Protocol (IGP). It can enable routers within a company / network to automatically select the most efficient forwarding path for data packets.

1.2.1.1 Distance Vector Protocol:

Dynamic Routing Protocols, particularly Interior Gateway Protocols (IGPs), are commonly classified into **distance-vector** and **link-state routing** protocols. The distance indicates the remoteness of a destination network from the source router (Smith, 1997). The vector specifies the direction to the destination which is usually stated by next hop router or the exit interface used to forward the packet. These protocols work by gathering routing information from nearby routers and revising their routing table accordingly. The router adds the gathered data to its matrix values to determine the optimal path. Changes in network topology are informed through periodic routing table updates and not instantly (Chiesa et al., 2021). As a result, distance vector protocols usually have slower convergence times compared to other routing techniques (Sirika & Mahajan, n.d.)

1.2.1.1.1 RIP:

The Routing Information Protocol (RIP) is one of the earliest dynamic routing protocols utilized within an Autonomous System (AS) that runs as an Interior Gateway Protocol (IGP) and relies on distance-vector routing algorithm (Nasir & Tariq, n.d.)

1.2.1.1.2 IGRP:

IGRP (Interior Gateway Routing Protocol) is a distance-vector routing protocol developed by Cisco Systems to be used for routing within a single Autonomous System (AS). It selects the best route according to various factors such as bandwidth, delay, load and dependability, and automatically exchanges routing information among routers.

1.2.1.1.3 EGRP:

Enhanced Interior Gateway Routing technology or EIGRP (Enhanced Interior Gateway Routing technology) is the advanced distance-vector (hybrid) routing technology developed by Cisco Systems. It is based on parameters such as bandwidth and delay (and possibly load and dependability) which it automatically exchanges routing information among members of a single Autonomous System (AS) to determine the best path. EIGRP provides for fast convergence, unequal-cost load balancing and effective network change adaptation.

1.2.1.2 Link State Protocol:

These protocols put together a complete and in-depth interpretation of topology by gathering information from all routers. Each router creates an indistinguishable network map and independently evaluates the shortest path to every destination (Ben Andrew, 2022). Link state routing protocol send updates only when a change takes place in a network allowing for faster convergence. The updates are sent in the form of Link State Advertisements (LSAs) that holds specific data about changes in networks (Sirika & Mahajan, n.d.)

1.2.1.2.1 OSPF:

OSPF functions inside the TCP/IP architecture and autonomously acquires routes from adjacent routers using Link State Advertisements (LSAs). It employs Dijkstra's SPF method to ascertain the optimal route (Tadimety, 2015) Each router sustains a Link State Database (LSDB) and independently computes the shortest path tree.

It employ cost as a routing metric, assigning a cost value to every router interface and estimating the entire path cost. The optimum route is chosen based on the lowest cumulative cost.

1.2.1.2.2 IS-IS:

The International Organization for Standardization (ISO) created the link-state routing protocol known as S-IS. It was later expanded to enable IP networks after first being created for the OSI (Open Systems Interconnection) networking model. IS-IS also builds a complete map of the network and computes the optimal path using the Dijkstra's shortest path first (SPF) algorithm, like OSPF. IS-IS is often used in large enterprise networks as well as Internet service providers

(ISPs) because of its convergence speed, stability and good scalability.

1.2.2 EGP:

This is known as "routing protocol" and is the Exterior Gateway Protocol (EGP) which is used to share routing information between different Autonomous Systems (ASes). It makes it possible for networks run by various companies, such Internet service providers (ISPs), to communicate with one another.

1.2.2.1 BGP:

The Internet's standard routing protocol is called BGP. It makes communication easier between many organizations, such as cloud providers, Internet service providers (ISPs) and large organizations, where each has its own Autonomous System (AS).

BGP is designed for inter-domain routing (routing between ASes) as opposed to the intra-domain routing (routing within ASes) processes such as IGPs as RIP (Routing Information Protocol), OSPF (Open shortest path first) or EIGRP. It is running a BGP (Border Gateway Protocol) application that uses such parameters as the AS (Autonomous System) path, Local Preference, and MED (Multi-Exit Discriminator) to select the optimal route after exchanging routing data with neighboring BGP routers, called BGP peers.

2. Review of Literature:

The existing literature emphasizes the significance of dynamic routing protocols in achieving efficient, reliable, and scalable network communication. Numerous studies have examined the performance of Interior Gateway Protocols (IGPs), particularly the Routing Information Protocol (RIP) and Open Shortest Path First (OSPF), by evaluating their convergence time, routing efficiency, scalability, and adaptability under different network conditions (Jagtap et al., 2025)

The theoretical foundations of distance-vector and link-state routing protocols are established in the Routing Information Protocol specification (RFC 1058) and are further discussed in networking literature. These studies explain the routing mechanisms, path selection algorithms, routing metrics, and convergence characteristics that form the basis for evaluating the performance of dynamic routing protocols.

Survey-based research has further classified dynamic routing protocols according to their

routing mechanisms and discussed their suitability for enterprise, real-time, and large-scale network environments (Sirika & Mahajan, n.d.); (Chaudhary et al., 2013) In addition, experimental studies have compared the performance of various routing protocols with respect to convergence time, packet delivery, routing overhead, and network scalability (Sendra et al., 2011) The findings reported in these studies generally indicate that RIP provides a simple routing mechanism based on hop count and periodic routing updates, whereas OSPF employs a link-state approach that enables faster convergence, improved scalability, and more efficient route computation in complex network environments.

Building upon these contributions, the present study performs a comparative analysis of RIP and OSPF using simulation-based experimentation in Cisco Packet Tracer and GNS3 (Graphical Network Simulator-3). The objective is to evaluate the performance of both routing protocols under identical network conditions using metrics such as convergence time, routing efficiency, and scalability. This approach extends previous research by providing practical validation of the theoretical characteristics of RIP and OSPF within a controlled enterprise network environment.

4. Protocols considered in the Study:

The effectiveness of a relevant and scientifically sound comparative analysis is greatly dependent on the routing protocols selected. The two most widely used types of Interior Gateway Protocols (IGPs)—distance-vector and link-state routing protocols—are the only ones studied: Routing Information Protocol (RIP) and Open Shortest Path First (OSPF). By comparing one sample protocol from each group, it is possible to compare fundamentally different routing philosophies in a controlled experimental setting.

The primary purpose of this study is not to compare all the existing routing protocols, but to look at the impact of the design of the routing algorithm on the performance of the network. The various features of RIP and OSPF, such as route discovery techniques, routing metrics, convergence behavior, routing update strategies, scalability and resources required are very different. Although OSPF uses Dijkstra's Shortest Path First (SPF) algorithm, it keeps a synchronized Link State Database (LSDB) and only sends incremental Link State Advertisements (LSAs) when there are topology changes, while RIP only sends full routing tables periodically. The study's scope deliberately omitted other routing techniques. Because Enhanced Interior Gateway Routing Protocol (EIGRP) was initially created as a Cisco

proprietary protocol and its performance is intimately linked to Cisco-specific implementations, it was not taken into consideration. Because Intermediate System-to-Intermediate System (IS-IS) is mostly used in carrier-grade networks and large-scale service provider backbones, whose operational characteristics differ significantly from the enterprise network topology examined in this study, it was left out. Because it is an Exterior Gateway Protocol (EGP) designed for routing between independent systems rather than within a single organizational network, Border Gateway Protocol (BGP) was also left out. As a result, incorporating these techniques would lower the validity of a targeted comparison and add factors beyond the study's stated goals. Therefore, restricting the study to RIP and OSPF guarantees an impartial, controlled, and methodologically consistent assessment of two essentially distinct routing paradigms while maintaining the experimental scope in line with the research goals. In enterprise network systems, this method enables a thorough evaluation of routing performance in terms of convergence time, packet delivery, routing overhead, throughput, latency, and scalability.

4.1 RIP:

The Routing Information Protocol (RIP) is one of the earliest dynamic routing protocols utilized within an Autonomous System (AS) that runs as an Interior Gateway Protocol (IGP) and relies on distance-vector routing algorithm (Nasir & Tariq, n.d.) RIP gained widespread adoption in small to moderate size networks owing to its simplicity and minimal complexity. In RIP, route selection is merely based on hop count, which represents the figure of intermediary routers that connect source and the destination, where each forwarding router contributes one to the metric value ((Deep Medhi & Karthik Ramasamy, n.d.) When choosing the best route, the one with the fewest hop is chosen and any route that surpasses the maximum permitted hop count of 15 becomes inaccessible. Although this method makes route calculation simpler, it ignores other important network performance factors including bandwidth, delay, and reliability.

The Routing Information Protocol (RIP) administers a routing table containing essential information about all accessible networks ((Dr. Dinakaran S et al., 2026) Each record within the table comprises the IP address of intended location, hop count, route status indicator indicating changes, the gateway address, and a number of timers that ensure validity and route stability. RIP routers communicate routing information on a regular basis to guarantee that all routers in AS have consistent and current routing tables (Black, 2000). Routing updates are normally delivered every 30 comprising the router's whole routing table and are directed via

UDP (User Datagram Protocol) on port 520. This regular information transmission allows routers to remain alert to changes in network topology.

A router upon receiving request from an adjacent router updates the hop count by adding one. Should the new route has fewer hops than the prior entry, the routing table is amended to include the sender's IP address as the subsequent hop. The updated information is then forwarded to adjacent routers (Black, 2000). Along with periodic updates, RIP also allows for provoked updates, which are sent instantly in response to change in route metrics. This provides faster adaptability to changes in network.

4.2 OSPF:

OSPF functions inside the TCP/IP architecture and autonomously acquires routes from adjacent routers using Link State Advertisements (LSAs). It employs Dijkstra's SPF(**Shortest Path First**) method to ascertain the optimal route ((Tadimety, 2015) Each router sustains a Link State Database (LSDB) and independently computes the shortest path tree.

It employ cost as a routing metric, assigning a cost value to every router interface and estimating the entire path cost. The optimum route is chosen based on the lowest cumulative cost. Low cost links are ideal for forwarding traffic. In contrast to RIP, that just considers the hop count, OSPF considers bandwidth, reliability, delay, and connection availability (Black, 2000). Furthermore, OSPF allows load balancing across several paths having equal costs, which enables traffic to be dispersed rapidly and efficiently among available routes.

In OSPF each router keeps an LSDB that holds data about all interfaces, routers, link states, and related costs. These LSDBs are kept synchronized by exchanging LSAs (Tadimety, 2015) When the network changes, OSPF promptly sends new LSAs to every router and each router modifies its routing table in accordance with findings of recalculating its shortest path tree using Dijkstra's algorithm. This results in guaranteed rapid convergence.

OSPF creates and preserves relationships with neighbours using the Hello protocol, with a default Hello timer of 10 seconds and a neighbour is deemed down if the Dead interval passes without any Hello packet which is usually 40 seconds but can occasionally be 120 seconds (Cakaj, 2012).

5. Methodology:

RIP and OSPF are the primary focus of this research, which employs an experimental network topology to assess their functionality and behaviour under controlled and measurable network

conditions.

5.1 Topologies:

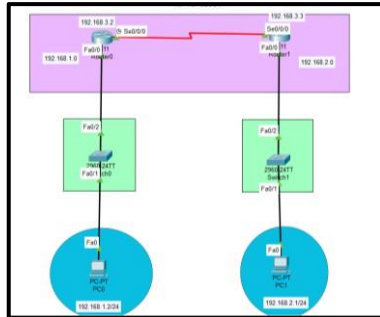


Figure 2: RIP topology in Cisco

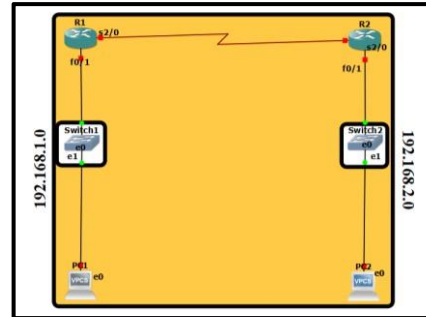


Figure 3: Rip Topology in GNS

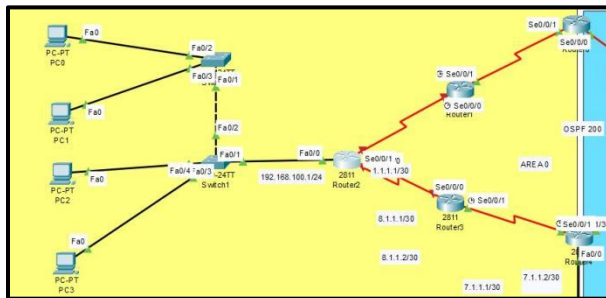


Figure 4: OSPF topology in GNS3

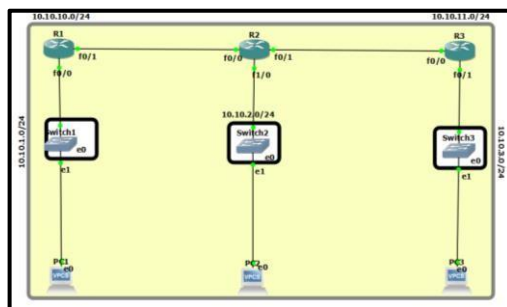


Figure 5: OSPF topology in Cisco

The topology in above *Figures* consist routers, switches, end devices serial links connecting the routers in addition to the assignment of multiple subnets to distinct network segments.

5.2 Network Configuration and Setup:

Table 1: Configurations of RIP Topology

Device	Interface	IP Address	Network
PC1	Fa0	192.168.1.2	192.168.1.0/24
R1	Fa0/0	192.168.1.1	192.168.1.0/24
R1	Serial0/0/0	192.168.3.2	192.168.3.0/24
R2	Serial0/0/0	192.168.3.3	192.168.3.0/24
R2	Fa0/0	192.168.2.1	192.168.2.0/24
PC2	Fa0	192.168.2.2	192.168.2.0/24

Table 2: RIP Configurations Commands

Interface	Command
FastEthernet	shutdown
Serial	ip address 192.168.3.2 255.255.255.0
Serial	clock rate 2000000

Table 1 and Table 2 present the configuration of the RIP topology. Table 1 shows the devices, interfaces, IP addresses, and networks, while Table 2 lists the commands used to configure interfaces and enable proper routing.

5.3 Observations and Comparisons:

Table 3: Comparative Experimental Performance Analysis of RIP and OSPF in Cisco Packet Tracer and GNS3

Protocol	Cisco Packet Tracer	GNS3
	Test 1: ICMP Connectivity Test (Ping Test): Command: ping 192.168.2.2	
	Packets Sent: 4, Received: 4 → Packet Loss: 0%, Individual Packet Delay: 9 ms, 11 ms, 4 ms, 6 ms.	Packets Sent: 5, Received: 5 → Packet Loss: 0%, Individual Packet Delay: 61.030 ms, 61.454 ms, 62.165 ms, 60.345 ms, 61.947 ms.

RIP	Test 2: Delay Measurement Test	
	Minimum Delay: 4 ms, Average Delay: 7 ms, Maximum Delay: 11 ms.	Minimum Delay: 60.345 ms, Average Delay: ~61 ms, Maximum Delay: 62.165 ms.
	Test 3: Performance Metrics Evaluation	
	Success Rate: 100%	Success Rate: 100%
	Test 4: Routing Table Verification Test Command: <i>show ip route</i>	
	Routes marked with R , indicating RIP-learned routes. Hop Count: 1, Administrative Distance: 120, Next-hop: 192.168.3.3.	Routing table confirmed RIP routes correctly installed.
	Test 5: Routing Protocol Verification Test Command: <i>show ip protocols</i>	
	RIP observed active with periodic updates (30 seconds).	RIP active and exchanging updates.
	Test 6: Convergence Test (Link Failure Scenario)	
	Before Failure: Network operational (0% loss, 3–5 ms delay). During Failure: No connectivity, 100% packet loss. After Recovery: Network restored successfully (0% loss).	Before Failure: Network operational (~61 ms delay). During Failure: No connectivity, 100% packet loss. After Recovery: Network restored (~61 ms delay maintained).
	Final Observation	
	RIP demonstrates effective performance in Cisco with low delay and low adaptation as a result of	RIP functions correctly but shows significantly higher delay in GNS3 compared to Cisco.

	periodic updates.	
OSPF	Test 1: ICMP Connectivity Test (Ping Test):	
	Command: <i>ping 192.168.100.5</i> Packets Sent: 4, Received: 4 → Packet Loss: 0%, Individual Packet Delay: <1 ms, <1 ms, <1 ms, 22 ms, TTL: 128.	Command: <i>ping 10.10.2.1</i> Packets Sent: 5, Received: 5 → Packet Loss: 0%, Individual Packet Delay: 45.765 ms, 45.676 ms, 45.629 ms, 46.953 ms, 45.728 ms, TTL: 254.
	Test 2: Delay Measurement Test	
	Minimum Delay: 0 ms, Average Delay: 5 ms, Maximum Delay: 22 ms.	Minimum Delay: 45.629 ms, Average Delay: 45.95 ms, Maximum Delay: 46.953 ms.
	Test 3: Performance Metrics Evaluation	
	Success Rate: 100%	Success Rate: 100%
	Test 4: Routing Table Verification Test Command: <i>show ip route</i>	
	Routes marked with O , indicating OSPF-learned routes based on cost.	OSPF routes correctly learned and maintained in routing table.
	Test 5: Routing Protocol Verification Test Command: <i>show ip protocols</i>	
	OSPF observed active with LSA-based updates.	OSPF actively exchanging LSAs and maintaining topology.
	Test 6: Convergence Test (Link Failure Scenario)	

	Before Failure: Network operational. During Failure: No connectivity, 100% packet loss. After Recovery: Rapid recovery due to SPF recalculation.	Before Failure: Network operational. During Failure: No connectivity, 100% packet loss. After Recovery: Fast convergence and route restoration.
	Final Observation	
	OSPF provides lower delay and faster convergence than RIP in Cisco.	OSPF maintains better performance than RIP and lower delay even in GNS3.

Table 3 outlines the overall experimental results that were obtained by implementing RIP and OSPF on the environment of Cisco Packet Tracer and GNS3 (Graphical Network Simulator-3). It includes the output of various tests, such as **Internet Control Message Protocol (ICMP)** connection, delay test, routing table test, protocol test and convergence test. The results show that both protocols are effective in setting up communication with no loss of packets in under standard conditions. There is a considerable delay difference, especially within the GNS3 environment, where RIP experiences a higher delay compared to OSPF. The convergence test shows that OSPF restores network communication faster after a breakdown of a link, but that RIP takes a similar extended period due to its periodic update cycle.

Table 4: Comparative Analysis of RIP and OSPF Based on Observed Performance Characteristics

Basis of Comparison	RIP	OSPF
Routing Decision Basis	Path selection based on hop count, observed as value = 1 in routing table.	Path selection based on cost (bandwidth-related metric), resulting in more optimized routes.

Delay Behaviour Across Environments	Shows significant increase in delay in GNS3 compared to Cisco	Shows increase in delay in GNS3, but remains consistently lower than RIP in both environments.
Delay Stability	Higher fluctuation in delay values across packets, especially noticeable in GNS3 results.	More stable and consistent delay values across packets in both environments.
Routing Update Mechanism	Uses periodic updates, leading to slower response to topology changes.	Uses event-driven updates (LSAs), enabling faster adaptation to changes.
Convergence Behaviour	Slower convergence observed after link recovery due to dependence on update intervals.	Faster convergence observed due to immediate route recalculation using SPF algorithm.
Response to Network Changes	Takes more time to update routing information after topology change.	Quickly updates routing information and restores communication efficiently.
Scalability Indication (from behaviour)	Performance degradation (higher delay) indicates less suitability for larger or complex environments.	Better delay handling and faster convergence indicate higher suitability for complex networks.
Efficiency in Different Environments	Performance is highly affected by simulation environment, especially in GNS3.	Performance is more consistent across environments, with better efficiency than RIP.
Overall Performance Trend	Reliable but less efficient due to higher delay and slower adaptation.	More efficient, faster, and stable, providing better overall performance.

Table 4 provides a brief comparison between RIP and OSPF in terms of their behavior as observed in the experiments. It can be noted from the findings that RIP depends on updates and

hops, thus making it take longer times before it reacts to any changes. However, OSPF is based on costs, where updates occur dynamically. Therefore, OSPF performs better than RIP, with convergence occurring faster. Additionally, delay remains stable in OSPF. Consequently, it is apparent that OSPF is more economical and ideal for performance-oriented networks.

6. Results and Discussion:

The comparative analysis of the practical operation of the protocols was made through their examination via two popular tools designed for network simulation – Cisco Packet Tracer and GNS3(Graphical Network Simulator-3. In the course of the experiment, it was necessary to investigate the work of protocols during ordinary functioning and in the case of failures in one of the links, with special attention paid to such parameters as packet delivery delay, reliability, and convergence.

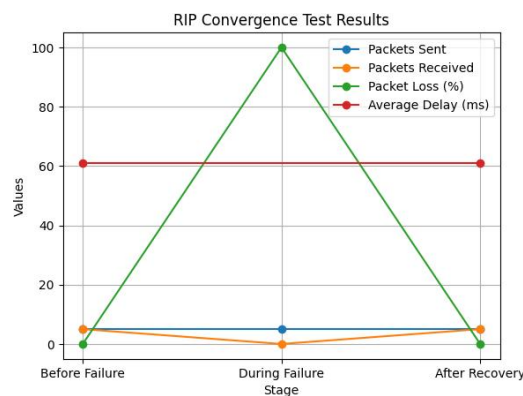


Figure 6: RIP Convergence Efficacy During Link Failure and Restoration

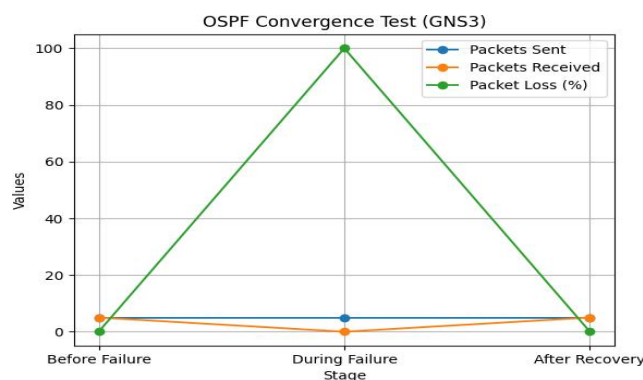


Figure 7: OSPF Convergence Performance During Link Failure and Restoration in GNS3 Environment

Firstly, it should be noted that the principles of working of the two protocols under discussion are different, which leads to various performance results of their operation. The main feature of RIP protocol is that it uses hop count as a routing measure and determines routes only based on the number of hops between two devices. Conversely, OSPF creates a graph of network structure and determines the optimal path according to the Dijkstra algorithm.

To measure the performance parameters of RIP and OSPF in comparison, it is necessary to conduct ICMP ping test between two devices situated in different segments of the network. The time of packet transmission is regarded as the main parameter for estimating delay. Both Cisco Packet Tracer and GNS3 (Graphical Network Simulator-3) were used in the experiments for achieving reliable results.

7. Conclusion:

From the experimental results, there are clear performance differences observed between the two routing protocols being considered. While it is true that both RIP and OSPF exhibited effective connections with no packet loss on a regular basis, the experiments show that OSPF offers better routing efficiency. This can be seen in terms of reducing delays since OSPF uses link state technology that allows routers to have a clear picture of the network topology and calculate optimal routes using shortest path first.

It is fair to say that OSPF is more efficient in time when compared to RIP. Further, the experiments have shown that ENSP has a faster average response time compared to GNS3 (Graphical Network Simulator-3) implying better performance for ENSP. The OSPF routing protocol can be used to monitor computer network in real time by looking at data packets being sent as well as their sending times (cost reduction in transmitting). It is worth noting that OSPF has maximum throughput and minimizes queue delays.

References:

Andrew, B. (2022). *Delay-Tolerant Link-State Routing* (Undergraduate dissertation). University of Cambridge.

Baba-Ali, A., Tabassum, M., & Mathew, K. (2014). Performance Analysis of Interior Gateway Routing Protocols across Different AS. *Journal of Computer Science &*

- Computational Mathematics*, 4(4), 59–65. <https://doi.org/10.20967/jcscm.2014.04.011>
- Black, U. D. (2000). IP routing protocols: RIP, OSPF, BGP, PNNI, and Cisco routing protocols. Prentice Hall Professional.
- Cakaj, M. (2012). *Implementing OSPF for ISP Faculty of Computer Sciences and Engineering Implementing OSPF for ISP Bachelor Thesis Milot Cakaj October / 2012*.
- Chaudhary, S., Bibhu, V., Arora, A., Singh, B., Aastha,], & Agarwal, J. (2013). Study of Dynamic Routing Protocols. *International Journal of Computer Science and Mobile Applications*, 2, 101–108. <https://www.ijcsma.com/articles/study-of-dynamic-routing-protocols.pdf>
- Chiesa, M., Kamisi, A., Rak, J., & Member, S. (2021). *A Survey of Fast-Recovery Mechanisms in Packet-Switched Networks*. 23(2), 1253–1301. <https://doi.org/10.1109/COMST.2021.3063980>
- Dinakaran, S., Ashok Raj, R., Saravanan, P., & Felcy Judith, F. (2026). *Design and analysis of secure IP networking using RIP, NAT, and VPN*. *International Journal of Science and Technology (IJST)*, 3(1), 72–83. <https://doi.org/10.70558/IJST.2026.v3.i1.241185>
- FortiOSTM Handbook - Networking*. (n.d.). <https://fortinetweb.s3.amazonaws.com/docs.fortinet.com/v2/attachments/cf390652-1a11-11e9-9685-f8bc1258b856/Networking-Handbook-5.6.3.pdf>
- agtap, A., Jaykar, O., Kalyane, P., & Dhumse, H. (2025). *Performance evaluation of RIP and OSPF routing protocol*. *International Journal for Multidisciplinary Research*, 7(2), 1–8. <https://doi.org/10.36948/ijfmr.2025.v07i02.42290>
- Majid, N. W. A., & Fuada, S. (2020). Rip Vs. Ospf Routing Protocols: Which One Is the Best for a Real-Time Computer Network? *Simetris: Jurnal Teknik Mesin, Elektro Dan Ilmu Komputer*, 11(1), 249–256. <https://doi.org/10.24176/simet.v11i1.3796>
- Medhi, D., & Ramasamy, K. (2017). Network routing: algorithms, protocols, and architectures. Morgan kaufmann.
- Nasir, A., & Tariq, U. (n.d.). *A Comparative Study of Routing Protocols Including RIP , OSPF and BGP*. 2(1), 47–56.

- Sendra, S., Fernández, P. A., Quilez, M. A., & Lloret, J. (2011). Study and Performance of Interior Gateway IP routing Protocols. *Network Protocols and Algorithms*, 2(4), 88–117. <https://doi.org/10.5296/npa.v2i4.547>
- Sirika, S., & Mahajan, S. (2018). Survey on Dynamic Routing Protocols. *International Journal of Engineering Research & Technology (IJERT)*, 5(01), 10–14.
- Sirika, S., & Mahajine, S. (2016). Performance Evaluation of Dynamic Routing Protocols for Real time application. *International Journal of Engineering Trends and Technology*, 32(7), 328–337. <https://doi.org/10.14445/22315381/ijett-v32p263>
- Tadimety, P. R. (2015). OSPF: a network routing protocol (pp. 13-17). Berkeley: Apress.