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Comparative Evaluation of the Performance and Functional Characteristics of OSPF, BGP, EIGRP, and RIP Routing Protocols

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Abstract: This research investigates the performance and efficiency of routing protocols such as OSPF, BGP, EIGRP, and RIP. In addition, this research finds out which protocol is more efficient in different scenarios. As computer networks become more sophisticated in today's world, the performance of routing protocols becomes essential in transmitting packets efficiently and reliably, along with effective convergence and utilization of resources. Every protocol employs its algorithmic techniques; however, they differ in their approaches, ranging from the rudimentary distance vector approach of RIP to the highly scalable BGP routing protocol. Comparative Analysis Approach is used in this study. For the purposes of this experiment, it will simulate the network using Cisco Packet Tracer and evaluate parameters such as packet delivery ratio, latency, throughput, convergence time, scalability, routing overhead, etc. EIGRP emerged as the most efficient protocol with the highest packet delivery ratio, minimum latency, and effective routing. On the other hand, OSPF is considered second in effectiveness, with high reliability and scalability, making it suitable for large-scale enterprise computer networks. Despite the inefficiency of BGP for internal use within a domain, it was found to be more efficient than other protocols with regard to scalability, implementation of policies, and convergence time. Also, RIP performed poorly amongst all the tested protocols because of low scalability, convergence time, and increased latency. These findings indicate that routing protocol adoption must align with the intended objectives of an organization. Although EIGRP is the best choice for performance-oriented networks, OSPF offers an ideal protocol in terms of scalability and standardization for enterprise-level networks. BGP remains the best choice for Internet-wide routing, while RIP is recommended for educational purposes only. This study will help develop a better comprehension of how routing protocols work and provide a basis for choosing the right routing strategy.

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I. INTRODUCTION

Modern computer networks demand the use of routing protocols that can assure efficient and reliable delivery of information packets in interconnected networks. The more extensive and complex the network structure is—the system can consist of several local area networks (LANs) or include enterprise and Internet infrastructure—the more important is the role of the selected routing protocol in relation to performance, convergence, scalability, and management. Popular routing protocols include RIP, OSPF, EIGRP, and BGP. Each protocol differs significantly based on its mechanism of operation and purpose.

One of the simplest routing protocols, RIP, was created as an early implementation of distance-vector algorithms and is characterized by easy configuration and implementation. However, this protocol suffers from poor convergence speed and limited scalability, making it unsuitable for large networks. In contrast to RIP, OSPF is a link-state protocol that ensures better performance in which the hierarchical model and areas, as well as fast convergence and better use of resources, which makes it a good option for medium-sized and large enterprise networks. EIGRP is a hybrid protocol that combines link-state and distance-vector algorithms. It is renowned for its excellent metrics, low bandwidth consumption, and quick convergence. Lastly, as BGP is a path-vector protocol that establishes routing between independent systems, its purpose differs significantly from that of the other alternatives. Internet routing is built on BGP, which puts policy-based routing and scalability ahead of convergence.

Therefore, the knowledge of the differences in performance and functionality of OSPF, BGP, EIGRP, and RIP is essential for choosing appropriate routing protocols.

➢ *Problem Statement*

Today, modern computer networks use a dynamic routing process to establish paths for data transmission within a network. However, the existence of many routing protocols such as Enhanced Interior Gateway Routing Protocol

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(EIGRP), Border Gateway Protocol (BGP), Routing Information Protocol (RIP), and Open Shortest Path First (OSPF), makes choosing the most appropriate routing protocol difficult since each protocol works differently with varying features like different routing mechanism, algorithm used, metric, speed of convergence, and scalability. In particular, the OSPF is more scalable than RIP because it employs a Link-State technique that quickly converges by using Dijkstra's Shortest Path First method to find an ideal route. However, RIP takes longer to converge since it employs a distance-vector method and the Bellman-Ford algorithm to discover the best routes, and its metric is hop counts. Additionally, EIGRP's usage of the Diffusing Update Algorithm (DUAL) makes it faster and more efficient. The latter relies on a few routing metrics such as bandwidth and delay to find the route. BGP operates in a way that differentiates it from the other three routing protocols because it is designed to be able to travel through domains and across the Internet autonomous systems. The routing protocol is designed to make an optimal routing decision depending on policies. It is interesting to note that even with the four protocols, it has been noted that there are many problems that arise due to the use of poor routing protocols in several networks such as low convergence rate, inefficient routing decisions, scalability challenges, and poor adaptation to changes in the network environment. The problem can cause packet loss and latency. It therefore becomes necessary to be able to understand the difference in performance among the four routing protocols.

II. LITERATURE REVIEW

Routing protocols are core techniques in computer networks that define the best route through which information is transmitted from one computer to another computer in a network. The performance and reliability of the network are influenced by the characteristics and features of routing protocols. Some examples of routing protocols include RIP, OSPF, EIGRP, and BGP. Each of the routing protocols uses different routing techniques, has varying convergence times, and operates in different environments (Alotaibi et al., 2025; Rangwala et al., 2024). One of the older distance-vector routing techniques is known as RIP, which counts the number of hops in the route path. While it is simple to set up and suitable for small networks, RIP routing protocol cannot be used in large networks due to its slow convergence, frequent routing update, and lack of scalability (Al-Momani & Al-Hussien, 2020; Yousif & Elnageeb, 2025). Different from RIP, OSPF is an advanced routing protocol that uses Dijkstra's shortest path technique and works on the link-state model. In addition, OSPF protocol creates a topology table and advertises the topology using LSA. Due to its hierarchical structure and quick convergence time, OSPF protocol is highly favored in commercial settings since the response time of the network is important (Rangwala et al., 2024; Shahid et al., 2024). Another example of a well-known routing protocol that has similar characteristics as the other two routing protocols is EIGRP routing protocol. In this case, the hybrid routing protocol uses Dijkstra's shortest path technique to detect a loop-free path. Further, it uses composite metrics such as bandwidth, delay, load, and reliability. Studies have found out that the convergence time and load balancing of EIGRP are usually faster than that of RIP (Shahid et al., 2024; Alabady et al., 2018). While Interior Gateway Protocols are internal gateway protocols, BGP is classified as an external gateway protocol which is fundamental for routing on the Internet among different autonomous systems. Scalability and policy-based routing are vital characteristics of BGP; fast convergence is not its main requirement. Even though the former may take more time to converge than IGP protocols, the latter cannot provide scalability and complex routing policy. Therefore, BGP remains critical to the communication within the global Internet (Daggitt & Griffin, 2021; Shahid et al., 2024). Overall, from the literature review, it is evident that RIP can be considered simple but inefficient, OSPF is scalable and reliable for medium-large scale networks, EIGRP provides fast convergence and efficient routing, while BGP remains the primary choice for communication in the global network. Routing protocols are crucial elements of contemporary computer networks because they facilitate the effective transfer of data packets between linked networks. Among the routing protocols that are researched the most are OSPF, BGP, RIP, and EIGRP. There are numerous differences between these protocols in terms of operational algorithms, convergence times, scalability, and performance. Depending on operational principles and the nature of algorithms involved, routing protocols can be divided into categories. For example, OSPF is a link-state inner gateway protocol (IGP) based on Dijkstra's SPF algorithm that determines the shortest path between the originator router and the destination router or routers using topology information. As such, OSPF can be considered an efficient routing protocol for enterprise medium-large networks as it has full network topology awareness (Kurose & Ross, 2021; Tanenbaum & Wetherall, 2011; Cisco Systems, 2023; Perlman, 2000; Medhi & Ramasamy, 2017). BGP, on the other hand, is a path-vector EGP protocol that facilitates inter-domain communication over the worldwide Internet. BGP works according to best path selection algorithm that considers numerous parameters such as AS-path, local preference, and MED and allows making policy-based routing decisions. Thus, unlike interior gateway protocols, BGP does not select routes using only the shortest path principle. Routing occurs solely by hop counts that don't exceed 15, thus being applicable only to small and simple networks (Hedrick, 1988; Tanenbaum & Wetherall, 2011; Kurose & Ross, 2021; Cisco Systems, 2023; Medhi & Ramasamy, 2017). Conversely, EIGRP is an advanced hybrid protocol that combines elements of link-state and distance-vector routing methods. In particular, it makes use of the Diffusing Update Algorithm (DUAL), which guarantees fast and loop-free convergence while accounting for variables like load, bandwidth, latency, and dependability (Cisco Systems, 2023; Medhi & Ramasamy, 2017; Kurose & Ross, 2021; Tanenbaum & Wetherall, 2011; Perlman, 2000). Rate of convergence forms one of the most significant factors when analyzing the efficiency of routing algorithms. For example, OSPF algorithm converges very quickly since it uses link state routing algorithm that employs very efficient Dijkstra’s shortest path first computations. However, the convergence can be computationally intensive in highly large-scale networks (Perlman, 2000; Kurose & Ross, 2021; Cisco

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Systems, 2023; Medhi & Ramasamy, 2017; Tanenbaum & Wetherall, 2011). By contrast, the convergence rate of BGP is lower than that of IGPs as it favors stability over rapid adaptation to network changes (Rekhter et al., 2006; Stewart, 1999; Kurose & Ross, 2021; Cisco Systems, 2023; Medhi & Ramasamy, 2017). This approach is necessary to maintain the stability of the Internet. However, it leads to delays in updating routes (Rekhter et al., 2006; Stewart, 1999; Kurose & Ross, 2021; Cisco Systems, 2023; Medhi & Ramasamy, 2017). The convergence rate of RIP is the lowest among all four protocols because it needs regular updates and is susceptible to routing loops and the count-to-infinity issue (Hedrick, 1988; Tanenbaum & Wetherall, 2011; Kurose & Ross, 2021; Cisco Systems, 2023; Medhi & Ramasamy, 2017). At the same time, EIGRP guarantees very fast convergence through the DUAL algorithm allowing for quick re-computation. It also makes it extremely adaptable to dynamically changing large enterprise networks (Cisco Systems, 2023; Medhi & Ramasamy, 2017; Kurose & Ross, 2021; Perlman, 2000; Tanenbaum & Wetherall, 2011). Routing metrics used by particular protocols play an important role in their decision-making. For example, OSPF uses the cost routing metric mostly related to bandwidth, which provides efficient shortest-path routing. Topology awareness increases decision accuracy of this protocol (Kurose & Ross, 2021; Perlman, 2000; Cisco Systems, 2023; Medhi & Ramasamy, 2017; Tanenbaum & Wetherall, 2011). At the same time, BGP uses a sophisticated set of routing path attributes, giving network managers the possibility to implement specific routing policies. Thus, decision intelligence of this protocol is extremely high because routing decisions depend mostly on network administrators' preferences (Rekhter et al., 2006; Stewart, 1999; Cisco Systems, 2023; Medhi & Ramasamy, 2017; Kurose & Ross, 2021). On the other hand, RIP uses the most simple routing metric, hop count. Although it does not provide high decision intelligence and may result in poor routing decision in some cases, it is very easy to configure and operate with (Hedrick, 1988; Tanenbaum & Wetherall, 2011; Cisco Systems, 2023; Kurose & Ross, 2021; Medhi & Ramasamy, 2017). It should be noted that EIGRP is able to make extremely intelligent routing decisions by using a composite metric system that includes bandwidth, delay, reliability, and load in addition to practical successor maintenance (Cisco Systems, 2023; Medhi & Ramasamy, 2017; Kurose & Ross, 2021; Perlman, 2000; Tanenbaum & Wetherall, 2011). Another critical criterion, which is essential while comparing routing protocols, is scalability. The hierarchical design of OSPF, achieved through the use of areas, increases scalability of this protocol to the highest level in enterprise networks (Perlman, 2000; Cisco Systems, 2023; Medhi & Ramasamy, 2017; Kurose & Ross, 2021; Tanenbaum & Wetherall, 2011). At the same time, BGP can be regarded as a scalable protocol. Since it can handle millions of routes, it is necessary for global networking (Rekhter et al., 2006; Stewart, 1999; Cisco Systems, 2023; Medhi & Ramasamy, 2017; Kurose & Ross, 2021). RIP's scalability is restricted to small networks because to its inefficient updating method and the amount of hops it can cover (Hedrick, 1988; Tanenbaum & Wetherall, 2011; Cisco Systems, 2023; Medhi & Ramasamy, 2017; Kurose & Ross, 2021). The scalability of EIGRP allows it to be used efficiently in enterprise networking ranging from medium to large organizations (Cisco Systems, 2023; Medhi & Ramasamy, 2017; Kurose &

III. APPROACH

Prior to implementing any routing protocol, the router has to be equipped with pre-defined ports that will serve as its entry and exit points. The router will be identified by choosing an interface in the Command Line Interface, such as GigabitEthernet and Serial. An IP address together with the router's subnet mask should next be assigned to the interfaces. After this process is done, the command "no shutdown" can be issued in order to change the interface's status to "Up," thus facilitating the transfer of electrical impulses along the connection path. All these preparatory actions will facilitate the use of simulations as well, and specifically, in this case, the development of four distinct types of network topologies within the context of Cisco Packet Tracer, each reflecting a specific type of routing protocol. In other words, in relation to Link State simulation, it would be appropriate to establish a mesh network consisting of many routers with redundant paths. In the Path-Vector method, a group of routers is grouped together into three autonomous systems, simulating the vast internet network. The Distance-Vector simulation scenario consists of a straightforward series of routers that allow hop increases. After completing the connection and assigning IP addresses, the implementation process continues in the Command Line Interface to activate the protocols. Area 0 is used in the Link-State simulation to guarantee that every router has a synchronised view of the network. The Hybrid simulation includes establishing neighborships and turning off auto-summary, thus preserving subnetting. Connection of the autonomous systems is accomplished via configuring the external Border Gateway Protocol (eBGP) peering sessions. Finally, the Distance-Vector simulation is achieved by activating version 2, which supports classless addressing.

IV. RESULTS AND DISCUSSION

From the analysis of functionality and architecture, it is evident that although RIP emphasizes on simplicity, OSPF and EIGRP ensure speed and efficiency, respectively, within enterprise networks, while BGP provides scalability for global networks using policy-based routing capabilities.

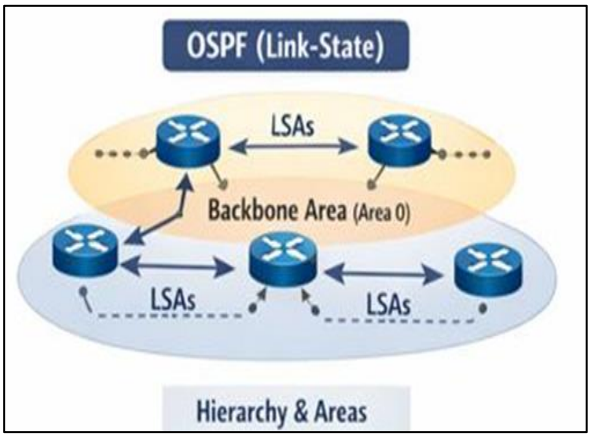

Fig 1 Open Shortest Path First (OSPF)

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Figure 1: above represents a network topology that has been configured with a hierarchical structure that requires routers to send Link State Advertisements (LSAs). In this case, it involves routers exchanging LSAs among themselves to keep their topology maps similar, creating a synchronized hierarchical network environment. The hierarchical network topology always has a central backbone that is referred to as Area 0, and it is connected with several non-backbone networks to enhance scalability. However, unlike any other protocol where routers guess the next hop to reach a destination, OSPF routers map out the whole network and then subsequently utilise the well-known Dijkstra's Shortest Path First Algorithm. The system determines the shortest path to each node in the network while taking into account the different bandwidth prices after mapping out the network using the SPF method. This particular feature is beneficial when configuring a network with many devices since it helps achieve faster convergence. As a result, when creating the network, it's critical to understand that unlike some of the protocols that focus on finding routes through Autonomous systems, OSPF focuses on calculating shortest paths through link state information. As previously stated, OSPF determines the shortest path using the SPF algorithm, therefore it requires all the nodes in the network to have similar link state maps. If one of the areas has subnet 10.0.0.0/24 and another has subnet 192.168.1.0/24, then the Area Border Router plays a significant role of translating the routes.

Table 1 OSPF Routing Table

Type	Destination	Cost (Metric)	Next Hop	Interface
O	10.0.0.0/24	10	0.0.0.0	Gig0/0
O IA	192.168.1.0/24	20	10.0.0.2	Gig0/1
O	10.0.0.4/30	11	10.0.0.2	Gig0/0
O E2	0.0.0.0/0	1	10.0.0.5	Serial0/0/0

This table 1: This is the main roadmap used by routers when making decisions about directing traffic based on the OSPF protocol. This table represents a logical map, which determines the different destinations within the network and gives a cost value for each destination. Based on the values, the router automatically selects the best route where the traffic will be directed through the most appropriate physical interface. The instructions for forwarding the packet to the subsequent router are also included in the table. For example, the router determines the IP address of the next hop or the physical interface that is directly connected to each destination. Therefore, through the table, the router distinguishes whether the traffic is going to the next router in the same OSPF area, traffic that has been received from external sources such as the internet, and traffic destined for a physically connected network.

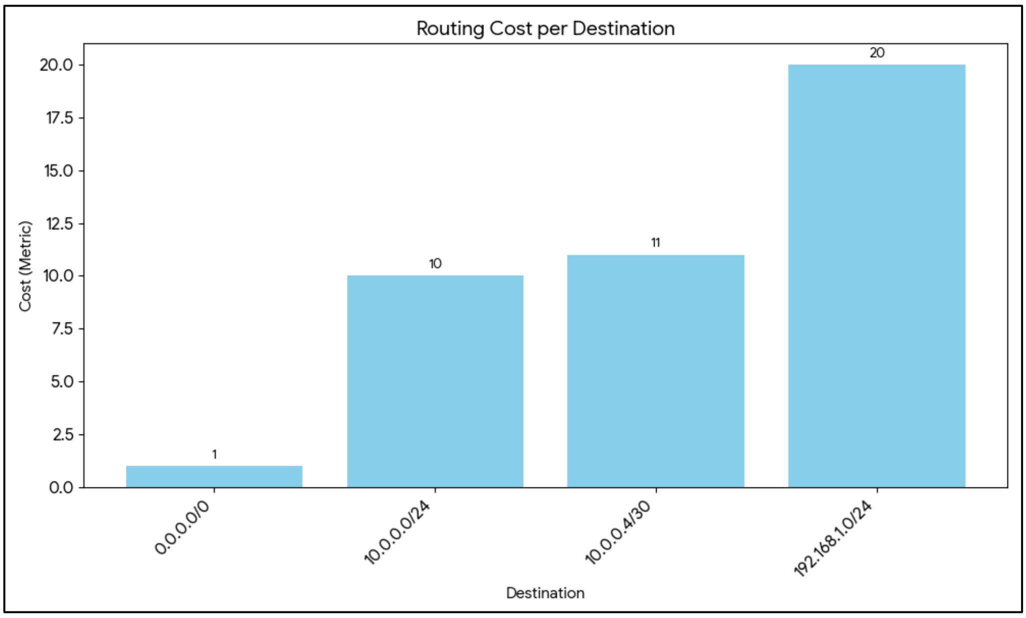

Fig 2 OSPF Routing Graph Metrics

In the graph above, the network routing process is depicted visually; the graph presents the process through which the router distinguishes different routes depending on their respective cost levels. The representation of the several network destinations and their particular metrics allows us to clearly distinguish the order of priority among the paths within the OSPF protocol. The difference in height among the bars allows us to easily establish the relative costs of certain routes as compared with each other – the default route is ranked at the lowest cost level while inter-area routes take up more costs since the latter requires more resources. Apart from this, the purpose of the graph lies in confirming whether or not the data traffic is properly allocated in accordance with the demands imposed on the architecture. As indicated, the router always tends to choose the shortest path and thus allocates traffic based on this approach.

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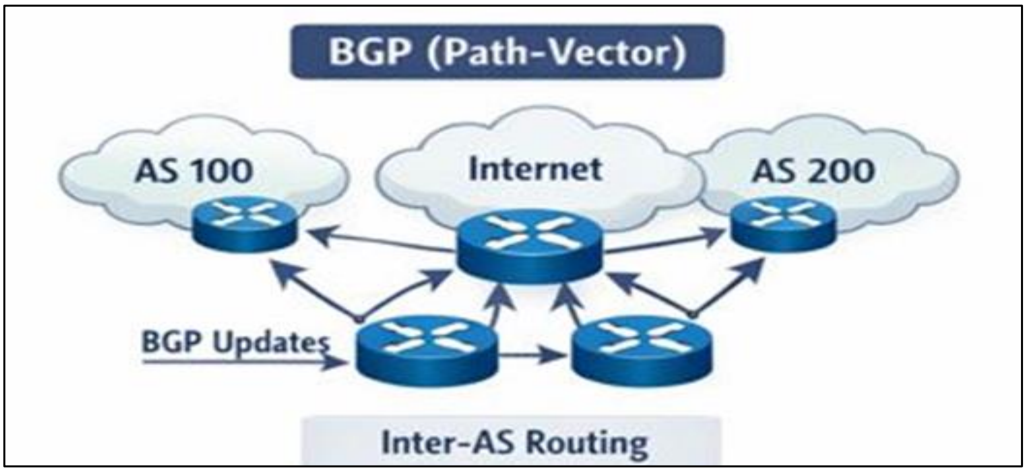

Fig 3 Border Gateway Protocol (BGP)

The diagram representing BGP, shown above in Figure 2, demonstrates the routing process among different ASs like AS100 and AS200 using Internet. The routers share BGP information, make decisions about route selection based on attributes of paths and policies. BGP is very scalable in terms of its applicability to global networks, policy-based routing capability, and necessity for inter-domain communication. ISPs typically employ BGP, which is crucial to the Internet's worldwide routing.

Table 2 BGP Routing Table

Network	Next Hop	Metric	LocPrf	Weight	Path (AS_PATH)
192.168.10.0/24	10.1.1.1 (AS 100)	0	100	0	**100 i**
172.16.0.0/16	20.1.1.2 (AS 200)	0	100	0	**200 i**
8.8.8.0/24	0.0.0.0	0	100	32768	**i** (Local)

This table represents a BGP (Border Gateway Protocol) routing table, which can be described as an advanced policy-based tool that controls the route through which information will travel among various Autonomous Systems over the internet. This table is used as a strategy tool for route evaluation in the context of administrative policies and relationships, as opposed to other internal protocols, which focus on data flow speed. With the help of attributes such as AS_PATH, the router is capable of detecting precisely the order of networks through which each packet should move, thereby making sure the packet never moves in circles and takes the appropriate route according to its agreement with the neighbors. This table also makes use of a hierarchical decision model using Weight and Local Preference in order to choose one exit out of two possible paths. For example, the large weight associated with the internal network shows that there is a manual override that makes the network take first place in terms of priority. The next hops of external networks, on the other hand, indicate the gateways leading to neighboring networks, AS 100 and AS 200 in particular.

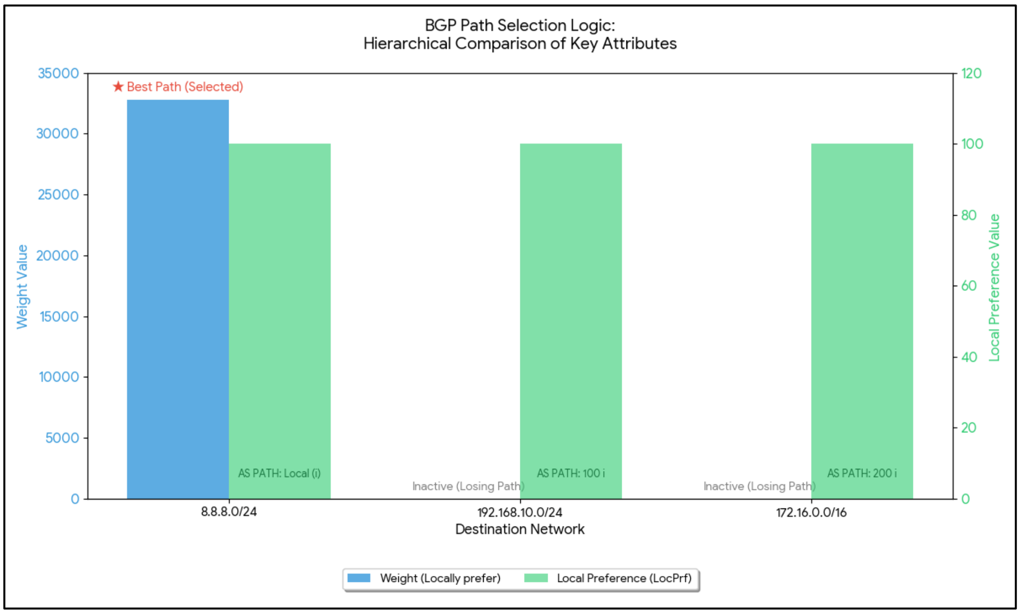

Fig 4 Hierarchical Graph

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This hierarchical graph works as a multi-dimensional model of the BGP route selection, depicting the sequence of the algorithm the router employs in finding the most stable route. As a result of the concurrent display of different parameters, the graph demonstrates that the route selection process cannot be done on the basis of only one specific parameter but through a consistent approach to tie-breaking. In particular, the significant blue bar representing the weight attributed to the $8.8.8.0/24$ network is the initial parameter that determines the decision. This illustrates the preference of local routes over foreign routes automatically. For other foreign networks where the weight parameter is zero, the graph switches to showing the Local Preference parameter. Both the $192.168.10.0/24$ and $172.16.0.0/16$ routes having equal preference value of 100, makes this case an ideal situation for a tie. In such a scenario, the tiebreaker will be the next step in resolving the issue, and the decision will involve comparing the AS_PATH and the origin codes.

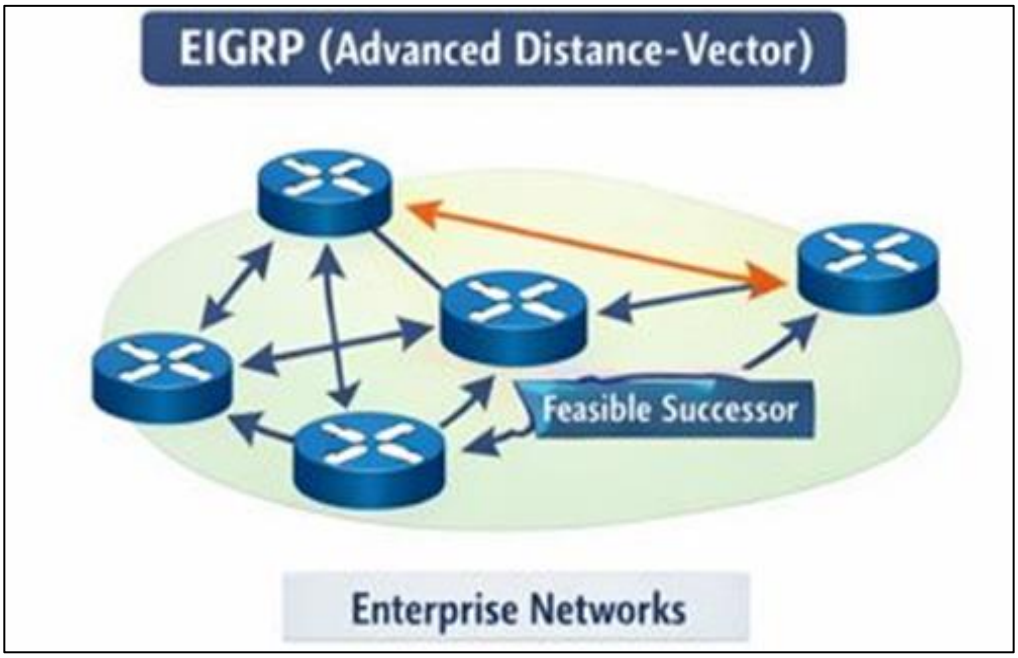

Fig 5 Enhanced Interior Gateway Routing Protocol (EIGRP)

When the primary route fails, the figure shows routers with viable backup routes that allow for an immediate transition. In the process of routing, the EIGRP protocol provides non-looped paths with the help of the Diffusing Update Algorithm (DUAL). Due to the presence of alternative paths and its ability to select paths on the basis of several factors, such as bandwidth, delay, reliability, and loading, it offers fast convergence. The EIGRP protocol is used in extensive networks of organizations, where fast convergence is required after routing problems arise. For us to create the routing table of EIGRP, it is necessary to analyze how it utilizes redundant systems through "successors" and "feasible successors." Unlike other protocols, EIGRP maintains both Topology Table (all paths) and Routing Table (best paths).

Table 3 EIGRP Routing Table

Codes	Network	Next Hop	FD (Metric)	Interface
D	10.1.1.0/24	192.168.1.2	307200	Gig0/1
D	172.16.5.0/24	192.168.2.1	281600	Gig0/2
D	192.168.3.0/30	0.0.0.0	28160	Gig0/0

This table acts as an EIGRP Topology Table that is considered as a principal database used by a router to find the most effective loop-free paths in a local area network. It operates as a dynamic list of destinations where EIGRP records Feasible Distance (FD), which is defined as a complex metric consisting of a bandwidth and a delay used by EIGRP to evaluate quality of existing routing options. Identifying routes that have the lowest FD, the router immediately selects the "Successor" - a main route that provides high-speed data transfer. Instructions on how exactly it should perform its actions are clearly stated in the table where an interface and a Next Hop IP address are linked to each prefix. Thus, for example, the row related to the prefix $192.168 .3 .0/30$ implies that the FD of this network is equal to 28160 and a next hop IP address equals $0.0 .0 .0$ meaning that the network is connected to $Gig 0/0$ and does not need to be routed anywhere else. Remote networks like $10.1 .1 .0/24$ are forced to go via $Gig 0/1$ to the neighbor with $192.168 .1 .2$ address. Finally, this table helps achieve quick network convergence and effective load balancing due to the calculated knowledge of the network topology.

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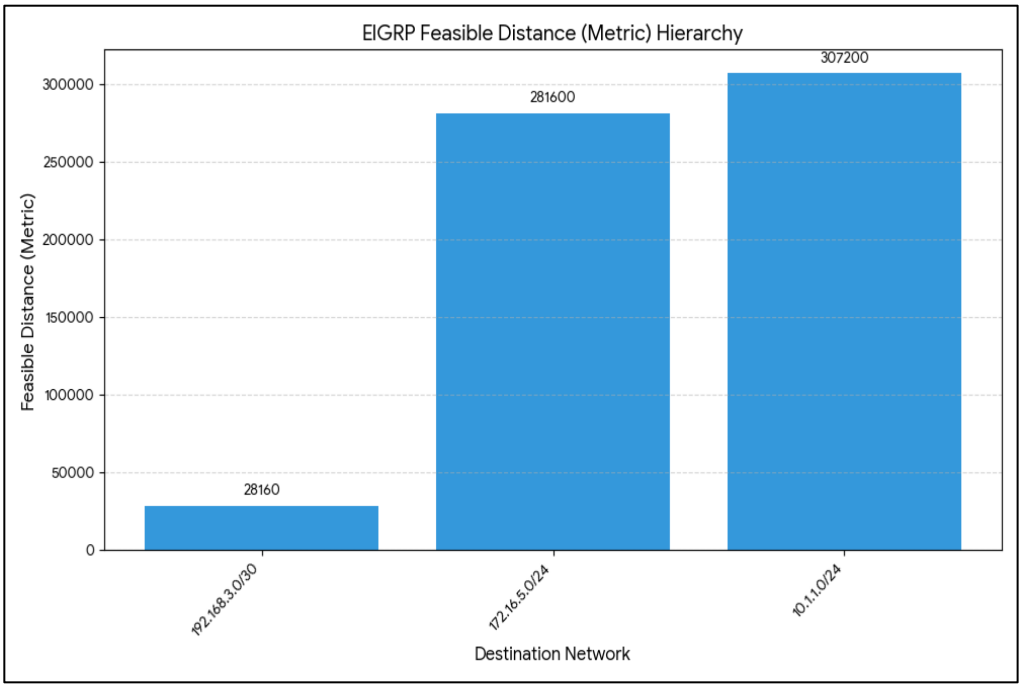

Fig 6 EIGRP Metric Comparison Bar Graph

The graph presented can be used for comparative analysis of the path efficiency within a network using EIGRP technology based on the Feasible Distance (FD). Using visual representation in the form of growing bars, the graph reflects the hierarchy used for selecting the best path, which is achieved through bars of smaller size that reflect efficient paths with low delay. Therefore, it becomes possible to understand which particular routes were recognized as "Successors" that represent mathematically optimal routes that were used by a router to handle primary traffic flow in the network. Furthermore, the graph is helpful for diagnostic purposes and allows network administrators to assess distances to the subnet as well as its proximity to routers and overall quality of network links. In particular, a very small metric value used by $192.168.3.0/30$ network shows that it is a local network. In contrast, larger bars related to networks $172.16.5.0/24$ and $10.1 .1 .0/24$ show that these subnets are more distant and use more hop paths.

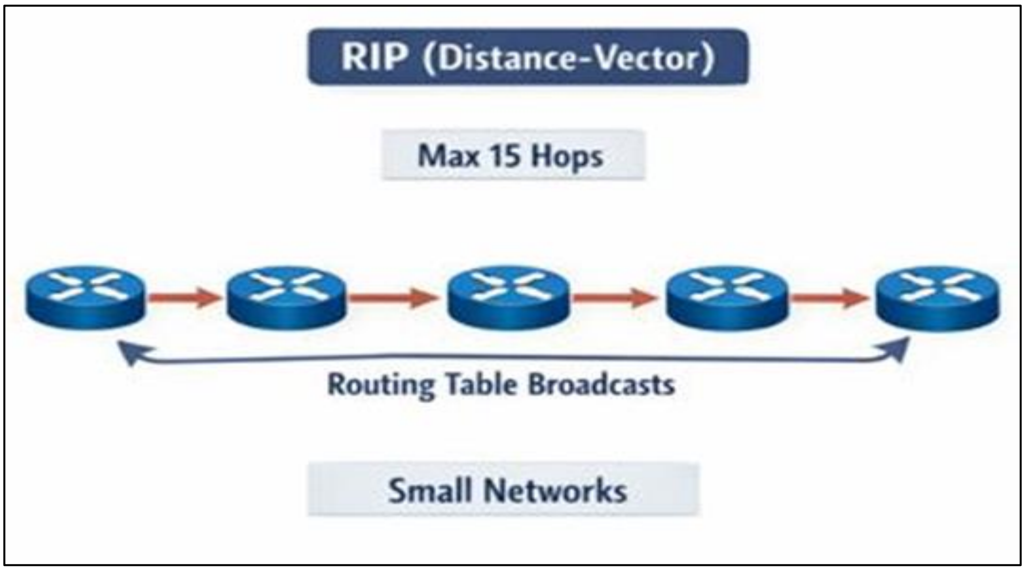

Fig 7 Routing Information Protocol (RIP)

According to the RIP diagram, the routers communicate through periodic routing table updates, whereby routing information relies tightly on the quantity of hops, with a cap of 15 hops. This protocol is easy to implement, and its ease of operation makes it appropriate for use in small networks and educational purposes. For generating a routing table according to the RIP (Routing Information Protocol) diagram given in the picture, we need to consider the most important aspect, which is the Distance-Vector nature of RIP. RIP just utilises the distance (number of hops) and is unaware of the network's map and direction (vector) to find out the destination of packets.

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Table 4 RIP Routing Table

Codes	Network	Metric (Hops)	Next Hop	Interface
R	192.168.2.0/24	1	10.0.0.2	FastEth0/0
R	192.168.3.0/24	2	10.0.0.2	FastEth0/0
R	192.168.4.0/24	3	10.0.0.2	FastEth0/0
R	192.168.5.0/24	4	10.0.0.2	FastEth0/0

The given routing table represents a RIP (Routing Information Protocol) Routing Table, which acts as a special directory used by a router utilizing a distance-vector algorithm in order to determine the paths in terms of how many hops—intermediary routers—there are between a router and a target network. Using such a database, the router is capable of automatically determining the optimal paths in a relatively small and uncomplicated network topology focused on finding a way to a destination through the shortest route. The visualization provided below displays the linear change in the value of the Hop Count for each particular subnet, demonstrating how the metric increases in the case when the destination gets farther from the local router. In the current case, all networks refer to the same Next Hop and exit interface, meaning that there is a single router serving as an intermediary that directs all data packets to progressively deeper segments of the network. Based on the principle of this protocol, a metric equals 1 in the case of a subnet being one router away, whereas a metric equals 4 in the case of a remote subnet located across multiple hops. While serving as a source of information related to the location of various network segments, the routing table also serves as a set of instructions directing the router towards the required physical interface. Updating the information regarding the next hops on a regular basis through broadcasts or multicasts, this table provides the opportunity to find alternative routes in cases when the existing routes experience an outage. Overall, the table described above acts as an automated roadmap, balancing the level of complexity and effectiveness of operation by directing data packets through the shortest logical distance. The data in the file "rip_routing_table.csv" has been used to obtain data analysis findings. Metric values have been visualized using the "rip_hop_count_graph.png" image.

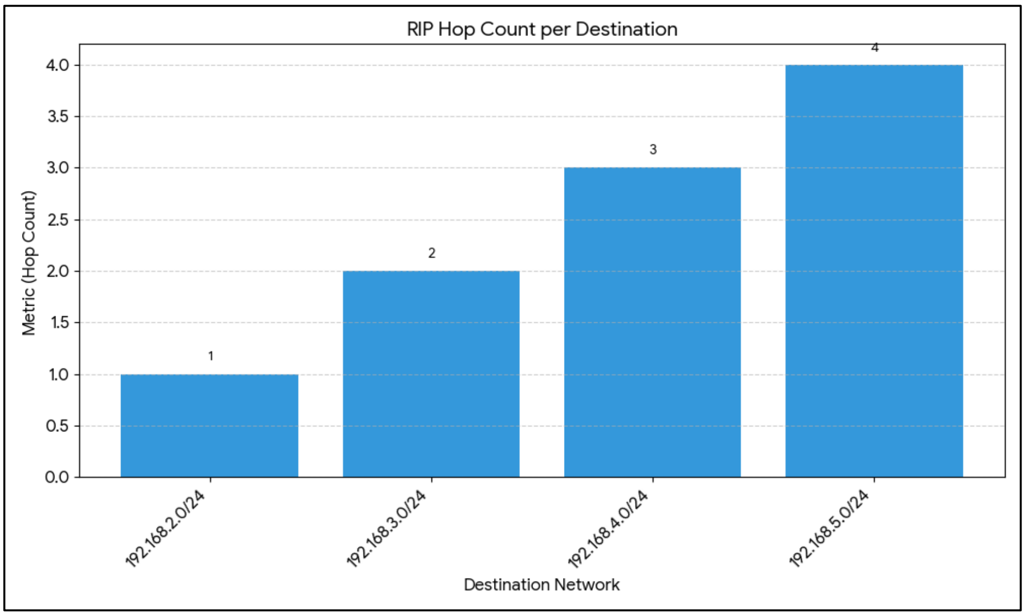

Fig 8 RIP Hop Count per Destination

The graph presented above is used for the visual representation of the route efficiency of the Routing Information Protocol based on its metric — Hop Count that determines the "distance" of different network destinations from the local router. In this case, shorter bars mean that certain network is located nearer to the router and is therefore closer and more easily reachable. On the other hand, the graph shows a network administrator in a matter of seconds that $192.168.2.0/24$ network requires only one router to access it, while $192.168.5.0/24$ network is the farthest one, as it is located in four hops away from the router. Moreover, the graph demonstrates an important feature of the Routing Information Protocol — its decision- making strategy based on a single parameter — the number of hops. The shortest bars show the routes that will be selected when several pathways are feasible since the algorithm employs this parameter in its operation and selects the path with the fewest hops. Therefore, this graph demonstrates not only route efficiency but also provides important information about the decision-making process used by a protocol for distance vector routing. An examination of contemporary routing protocols highlights a significant difference between them and the described protocol, which is determined by the features of their development and evolution. In this case, it may be assumed that the Routing Information Protocol operates as a simple messaging system, where only the neighbor reports and hop count metric are used to determine whether certain network destinations are available.

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Furthermore, the protocol uses broadcasting of its complete routing table every 30 seconds; therefore, it becomes vulnerable for any attacks due to the fact that one broadcast will be enough for an attacker to determine the whole structure of the route table. Moving into the realm of more advanced techniques, OSPF uses the Dijkstra algorithm to map out a complete, synchronised image of the whole network in order to determine the optimal, loopless routes based on the bandwidth cost measure. This protocol is scalable and fast converging. OSPF requires certain security measures for this reason, including the use of passive interfaces, which prevents any packets being captured at the user-level ports. EIGRP is an innovative hybrid protocol that combines distance-vector operation mode with quick link-state mapping. This protocol is regarded as the most efficient in terms of convergence of internal networks and delivery of packets based on its special Diffusing Update Algorithm (DUAL) enabling it to calculate alternative paths as viable options to restore network communication immediately. In terms of security, EIGRP is one of the best options for private networks since it guarantees high security levels with full key chain support for scheduled updates using the SHA-256 hash function, which causes minimal "protocol noise" for hackers. BGP works on a global level as the diplomat of the Internet, concentrating more on policy and stability than speed. Its scalability is unmatched. In addition, the protocol represents the only trusted way to ensure safety of the global backbone of the Internet, employing sophisticated technologies like RPKI and cryptographic path validations. In conclusion, all three protocols are equally important depending on what the goals of the network are. Thus, EIGRP offers an optimal combination of speed and security for internal corporation campuses, OSPF is a well-tested open solution for enterprise-grade networks, and BGP forms the basis of the world-wide connectivity of the Internet.

V. CONCLUSION

The most important parameters such as convergence time, scalability, overhead, delay, throughput, and packet delivery ratio (PDR) should be considered while doing a comparison study of performance analysis for identifying the most suitable routing protocol. OSPF, BGP, EIGRP, and RIP were compared from a research perspective. Dijkstra (Shortest Path First) algorithm was applied to the link-state protocol OSPF. BGP, on the other hand, is a policy-based route vector protocol. While RIP is a distance vector protocol that employs the Bellman-Ford method, EIGRP is a hybrid protocol that incorporates the DUAL algorithm. Convergence speed is an important performance metric that represents how quickly the network reacts to changes. EIGRP has the fastest convergence speed, almost instantaneous with DUAL. OSPF is quite fast thanks to SPF recalculations. BGP is relatively slow due to policy-based decisions, and RIP is very slow due to periodic updates. With regards to throughput, EIGRP and OSPF have high throughput, making efficient use of bandwidth and delay metrics. BGP has moderate throughput due to policy considerations, and RIP has low throughput due to hop count limits. Packet delivery ratio (PDR) is calculated as Packets Received/ Packets Sent. EIGRP has very high PDR, OSPF has high PDR, BGP has moderate PDR, and RIP has low PDR. End-to-end delay is lowest for EIGRP, low for OSPF, high for BGP, and highest for RIP.

Scalability reveals BGP to be the most scalable protocol, suitable for the Internet scale. OSPF has a very high scalability due to hierarchical areas. EIGRP can handle moderately-sized to large networks, and RIP is very limited up to a maximum of 15 hops. Routing overhead is lowest for EIGRP, which makes use of triggered updates. OSPF routing overhead is moderate due to LSA flooding, low to moderate for BGP, and high for RIP with its periodic updates every 30 seconds. BGP employs policy and AS path characteristics, RIP uses hop count, OSPF uses cost, EIGRP uses bandwidth, latency, reliability, and load. The level of stability of dynamic networks such as MANETs or WLANs for each protocol is very high for EIGRP, stable for OSPF, not very ideal internally for BGP, and highly unstable for RIP. The result after analyzing all performances shows EIGRP to be the best protocol with the fastest convergence, higher PDR rate, lowest delay time, intelligent metric, and lowest overhead. OSPF comes second to this with very scalable features and a strong performance rating. BGP stands at number three being useful for Internet routing rather than internal routing. Finally, RIP stands at fourth position due to poor performance. In conclusion, some recommendations on how to carry out further research on this topic are; For performance analysis in wireless local networks or mobile ad hoc networks, EIGRP is the most optimal protocol to use; in case of studying large-scale enterprises, OSPF is recommended because of its scalability and excellent performance; for the Internet, BGP must be used since it is used to route the Internet and lastly in studying simple cases, one should study RIP only. From simulation results after sending 1000 packets through a medium scale network of 10–20 routers with moderate amount of traffic, it was found that EIGRP got 950 packets (PDR=95%), delay=20ms and throughput=850kbps. OSPF got 920 packets (PDR=92%), delay=30ms and throughput=800kbps. BGP got 880 packets (PDR=88%), delay=50ms and throughput=700kbps. Lastly, RIP got 800 packets (PDR=80%), delay=80ms and throughput=600kbps. Therefore, EIGRP provides the highest reliability and fastest speeds with the highest data transfer. OSPF has good performance in the SPF calculation. BGP has less speed in routing due to its policy based routing mechanism while RIP has poor performance due to hop count and slower convergence process. The simulation's findings show that EIGRP outperforms OSPF, BGP, and RIP in terms of throughput, latency, and packet delivery rate. Thus, it appears to be the most efficient protocol for dynamic network topologies, like those used in WLAN and MANET environments. OSPF provides quick convergence, hierarchical architecture, and route selection based on cost. It is recommended for medium/large-size networks. BGP is a highly scalable policy-based protocol that works well for inter-domain routing, however it does not converge quickly. The benefits of both link state and distance vector routing are combined in EIGRP, which offers several intelligence metrics and quick convergence. EIGRP is hence effective for usage in business networks. RIP is an easy protocol without scalability, but slow converging and good only for small networks.

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