A Comparative Study Enhancing Dynamic Routing in Computer Networks: Strategies for Optimal Performance using EIGRP

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***Abstract*— Computer networks have been stagnant for a long time since earlier computers could not connect and communicate with each other. Nowadays, computer networks have evolved so much that computers can easily process and share data through a network. But while the systems are now communicating, it doesn't mean the information is travelling flawlessly and there are no packet loss, meaning the loss of data.**

This brings us to different ways as how we can send and receive data, Internet protocols have been in place and are getting better with time. This research highlights the nuanced protocols incorporating dynamic routing that are being used like EIGRP referring to Enhanced interior gateway routing protocol and also shows a comparison with other protocols like OSPF standing for Open Shortest Path First, and RIP (Routing Information Protocol), also IGRP (Internal Gateway Routing Protocol).

***Keywords*— Computer networks, Dynamic routing, Packet loss, Data transmission, Internet protocols, Network communication.**

I. Introduction

Computers are becoming part of our daily lives. Our dependence on them is evident, ranging from managing everyday duties to engaging in social media interactions on sites like Instagram and X. Before standalone computers now require network connectivity to operate. Staying connected is now easier than ever thanks to the affordability of internet connection, whether via modems or local area networks (LANs).

The computers before were only incorporated with IPv4 addressing method. Each computer was able to communicate to another computer with the assigned IP address when it was connected to network. The IP address was used to be an identity of a device that is part of a network. While the computers could connect now, the IPv4 had some drawbacks, the no of addresses that was present at the time were not enough to assign every computer or node at the time, and some IP addresses could not be used as they were reserved by private enterprises. This paved the way to the development of IPv6, overcoming the issue of limited addresses being assigned by having a large pool of addresses.

Proper routing configuration is required to enable communication between machines on various networks. The data transmission may be interfered with if the routing table is incorrectly designed, or if a router is disabled or damaged or in the occurrence of a topology change resulting in problems like packet loss and delays. The most serious outcome might be the crucial data being lost in transit.
Wrong configurations can mess up the network causing endless data circulations and looping, clogging the network.
Plus, inefficient routing choices might slow down traffic, leading to bottlenecks and overall degraded network performance.

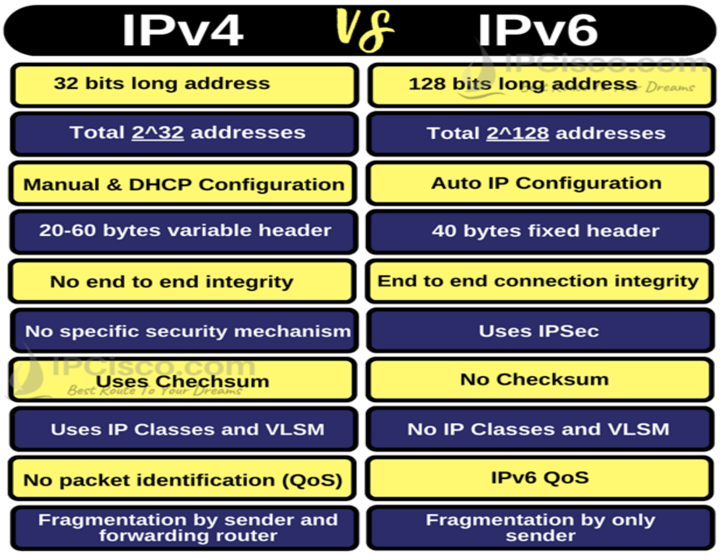

Figure 1. IPv4 vs IPv6 [10]

We can configure a router to set up a routing table using either static or dynamic routing. For smaller networks, static routing is often the way to go. It's simple to configure, saves on routing resources, and works efficiently in those cases. However, for larger networks, static routing can get tricky. As the network gets larger, it becomes more challenging for the network administrator to manage and stay on top of the routing table. With a growing network, the number of entries in the routing table increases, and how often they're updated and "how accurate those updates are" plays a big role in how well the network performs. If the network's layout changes, the routing table needs to be updated quickly to avoid packet loss or routing mistakes.

Fig. 2 below shows how routing protocols are categorised. Routing tables in the router can be configured when there is a dynamic routing protocol available. For routers within the same network, we use an Interior Gateway Protocol. Some well-known examples include Open Shortest Path First, Enhanced Interior Gateway Routing Protocol, Routing Information Protocol, and Intermediate System to Intermediate System. These protocols help ensure efficient communication and routing decisions within a network. When it comes to routing between different networks, we rely on Exterior Gateway Protocols, which facilitate the exchange of routing information across diverse network domains.

The approaches in dynamic routing in computer networks are mainly two, the distance vector protocol and link state protocol. Each of them has their own way of working. Distance vectors, just as EIGRP, forward packets through a set of routers between two items to determine the best route. They rely mostly on a set of metrics like hop count. The second one is much more complex- the method known as link-state protocols, which applies to Open Shortest Path

This would provide a view of the network as the whole topology map is to be made and through algorithms such as Dijkstra's, you have the ability to calculate paths of least distance. EIGRP can be used in both IPv4 and IPv6 networks, and also in OSPF, which differs with one having merits and demerits in routing efficiency and its management of the network. [7]

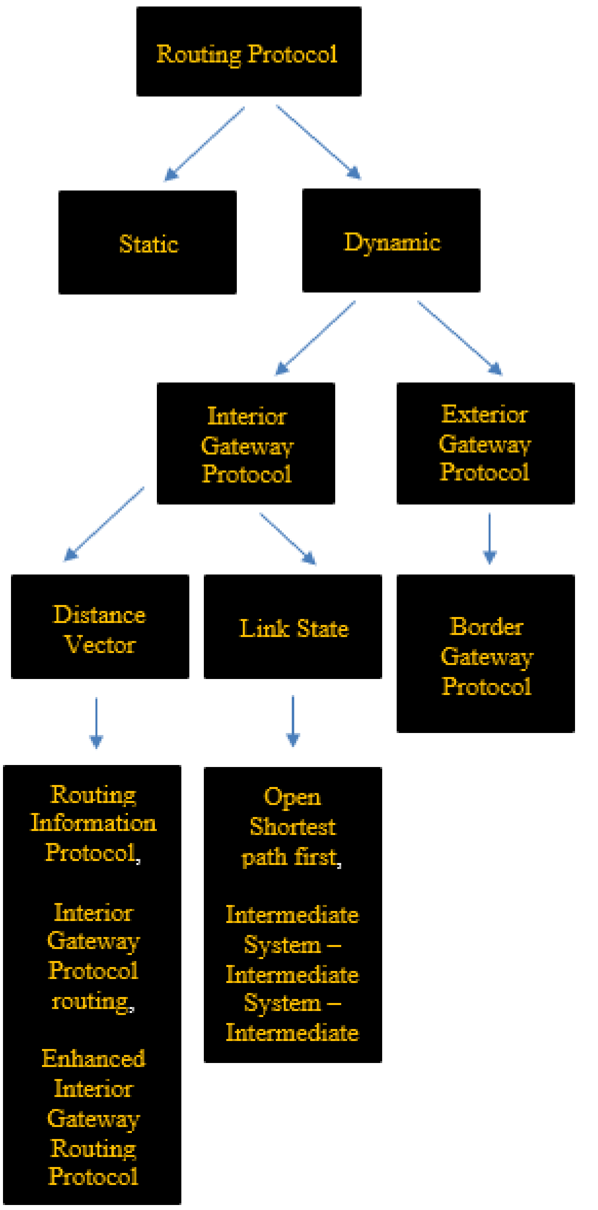

Figure 2. The classification of internet protocols

II. LITERATURE REVIEW

The Enhanced Interior Gateway Routing Protocol, a distance vector routing protocol, and Open Shortest Path First, a link-state protocol, are two essential routing protocols that have been discussed extensively. Both play crucial roles in managing how data is routed across networks, ensuring efficient and reliable communication.

Distance vector routing works by showing both the direction and distance to a destination. It uses the exit interface to point to the right path and the hop count to measure how far it is. The Bellman-Ford algorithm helps figure out the best route, with each router understanding the layout of links and nodes. Every router keeps track of a distance vector for each destination, making sure everything flows smoothly. The destination ID, shortest distance, and next hop make up the distance vector. In this scenario, every node communicates the shortest paths to its neighbor by passing along a distance vector. [2]

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In distance vector routing protocols, routers share network information with their neighboring routers, updating their routing tables based on the lowest-cost path to each destination. They only know the next hop and the associated cost, so they don't have a full picture of the entire network topology. The Enhanced Interior Gateway Routing Protocol, or EIGRP, is a more advanced version developed by Cisco to improve upon the older Interior Gateway Routing Protocol. EIGRP is a hybrid protocol that incorporates both distance vector and link-state features. It utilizes the Diffusion Update Algorithm (DUAL) to compute and update routes efficiently, making sure that fast convergence and routing are loop free. Even after getting to know all of this, EIGRP is Cisco-specific, which can limit its compatibility with equipment which do not belong to Cisco, and its command-line interface (CLI) management can be complex, presenting challenges for both understanding as well as teaching the protocol. [8]

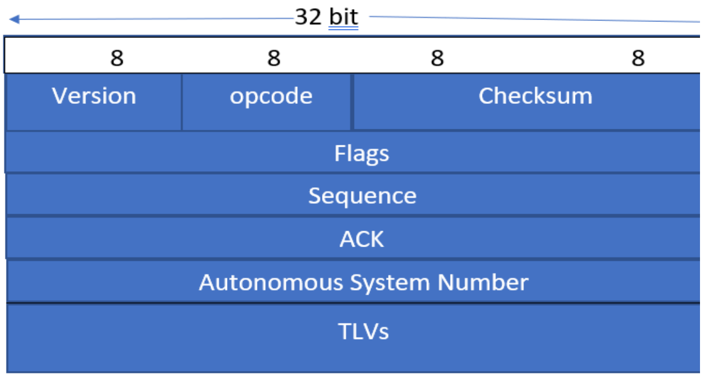

Figure 3. Packet format of EIGRP

Key Advantages to Recognize :

• The set up is simple
• routes are loop free
• Has a backup route for the routing network.
• Has minimal convergence time and minimal bandwidth usage
• Provides support for classless inter-domain routing (CIDR) and variable-length subnet mask (VLSM).
• Authentication is supported.

The following are the drawbacks of EIGRP:
• It is regarded as a Cisco proprietary routing protocol.
• Routers made by other suppliers are unable to use EIGRP.

Link-state routing protocols, often referred to as shortest-path routing protocols, help find the best route from the source to the destination by calculating the shortest path. Each router in the network keeps a complete link-state database, commonly known as the LSDB, which contains detailed information about the network's topology. This database is created from link-state advertisements exchanged among routers, providing insights into all interfaces and their states.
Using this LSDB, routers implement Dijkstra's Shortest Path First algorithm to identify the most efficient route for forwarding packets across the network. This approach ensures that each router has a consistent view of the network structure, allowing them to make informed decisions about routing packets, especially after any changes in the network topology. Since the database is the same across all routers, it effectively describes the network layout.

OSPF identifies the shortest path between routers inside one AS by using the Dijkstra algorithm. Dijkstra's algorithm determines the shortest path based on its computations of the cost of each accessible link to the router's network. OSPF, developed by the Internet Engineering Task Force (IETF) Interior Gateway Protocol (IGP) working group, is a link-state routing protocol designed to distribute routing information across an AS. By maintaining a link-state database (LSDB) that reflects the network topology, OSPF enables routers to compute the most efficient paths to all destinations within the AS using the Dijkstra Shortest Path First (SPF) algorithm.[4]. OSPF packet header is shown in the Fig 4 below.

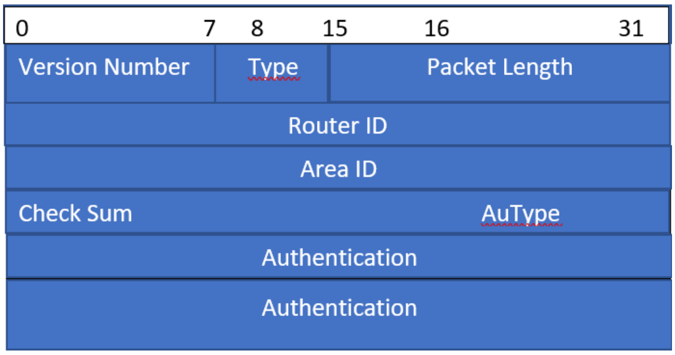

Figure 4. OSPF packet header

OSPF offers five distinct types of packets. Every packet in the OSPF process serves a certain function. OSPF packet types are listed below:

1. "Hello" packet

2. Description of the database

3. Request packet for link state

4. Update for the link state

5. Link state acknowledgement packet

In OSPF, the cost of a path through an interface is known as the metric. This metric is determined based on the bandwidth of each interface. The calculation method is illustrated in the figure 5 below.

$$\text{Cost} = \frac{10^8}{\text{Bandwidth(bps)}}$$

Figure 5. OSPF metric calculation

There are several advantages to the Open Shortest Path First routing system. It is compatible with many systems and is not exclusive to Cisco. OSPF consistently finds loop-free pathways, ensuring efficient data transfer. Because it uses little bandwidth and adjusts routes fast in response to network changes, it is resource-efficient.

Additionally, by allowing many routes for a single destination network and basing routing decisions on interface prices, OSPF provides flexibility. It also supports Variable Length Subnet Mask, or VLSM, which improves the efficiency of IP address distribution. [1]

On the other hand, OSPF has drawbacks. It can be challenging to configure, which could present problems for network managers. Additionally, OSPF uses more memory, which can be a drawback in settings with constrained resources.

III. RESEARCH GAPS AND PROBLEM FORMULATION

The necessity to handle a number of issues that have come as computer networks have gotten bigger and more complicated has fueled the development of routing protocols.

Back in the day, we started with the Routing Information Protocol (RIP) for routing data. It was pretty simple and based on the number of hops needed to get from point A to point B. Basically, RIP would choose the path with the fewest hops. But as networks grew bigger, RIP started showing its age. It could only handle up to 15 hops, which was a real limit for expanding networks. Plus, it didn't adapt quickly to changes because it updated info only occasionally. So, for larger and more dynamic networks, RIP just couldn't keep up.

To tackle the issues with RIP, Cisco came up with the Interior Gateway Routing Protocol (IGRP). It was a step up and took into account things like reliability, delay, and bandwidth, making it a bit smarter than RIP. But even though IGRP was an improvement, it still

Figure 6. Limitations of Traditional Routing Protocols

struggled with the growing demands of expanding networks. Setting up and managing routing tables was tricky, and it wasn't the best at using resources efficiently. So, more advancements were needed to keep up with the increasing complexity.

This introduced yet more limitations in both RIP and IGRP, as networks continued to advance even further. Increased routing problems in the network were highlighted by the call for a faster convergence, less congestion within a network, and much more scalability. These problems revealed an opening door to design a more complex protocol, that were better suited to handle the complexity of a modern network system.

IV. SUGGESTIONS

We recommend taking advantage of the Enhanced Interior Gateway Routing Protocol beyond its usual settings to boost our network's performance and reliability. EIGRP already has a reputation for tackling the issues faced by older protocols like RIP and IGRP. It offers better scalability, quicker convergence, and more efficient use of resources. Our goal is to spread these benefits more broadly across our network.

Strategic Expansion of EIGRP

1. Expanding the Scope of Cost-Based Routing: EIGRP's cost-based routing has been pretty good in a lot of places, but I think we should start using it in more areas of the network. This way, we can make sure we're picking the best routes not just based on distance, but also taking into account things like available bandwidth and reliability. It'll help improve the overall performance of the network and make everything run smoother. [5]

Limitation	Description	Impact	Statistics
Scalability	Difficulty handling large networks	Decreased performance	RIP: 15-hop limit
Convergence Time	Slow response to network changes	Increased downtime	RIP: 60 seconds average
Routing Table Instability	Frequent updates, oscillations	Network congestion	Routing table flaps
Resource Utilization	Inefficient bandwidth usage	Reduced efficiency	Routing protocol overhead

2. Optimizing Bandwidth Utilization: A neat feature of EIGRP that cuts down on unnecessary traffic on the network is that it only updates routes that have actually changed, rather than sending updates about all routes. In turn, this means less routing info exchanged between routers, which helps make better use of bandwidth and cuts down on the extra load from routing updates. [6]

3. Wider Application of Classless Inter-Domain Routing: In certain areas of the network, managing Internet Protocol addresses has become easier due to Enhanced Interior Gateway Routing Protocol's support for Variable Length Subnet Masks. This feature enhances the flexibility of our Internet Protocol address allocation, allowing us to adapt more easily as the network expands and evolves over time.

4. Simplified Configuration and Maintenance Throughout the Network: In some areas of our network, especially dealing with IP addresses has become a whole lot easier because of EIGRP's support for Variable Length Subnet Masks. Let us handle IPs way more flexibly, which would be super useful as our network expands and changes. Just in general terms,

it enables us to keep things running smoothly and adapt as we expand.

5. Scalability for Future Growth-It is only with time that our network will continue to evolve; in fact, the scalability of EIGRP becomes even more important in helping and supporting future enhancements and modifications to our network. Its application to future network improvements and expansions will strongly ensure our infrastructure remains robust and flexible.

Strategy	**Goal**	**Benefits**
Making a better the Cost based Routing	Optimize route selection	Improved performance, reliability, and better bandwidth utilization
Optimize Fast Convergence	Accelerate network recovery	Reduced downtime, improved uptime
Optimize Bandwidth Utilization	Minimize network traffic	Improved performance, reduced congestion
Wider Application of CIDR	Efficient IP address management	Increased flexibility, better resource allocation
Simplified Configuration and Maintenance	Reduce administrative burden	Improved network stability, easier management
Scalability for Future Growth	Prepare for network expansion	Enhanced network resilience and adaptability

Figure 7. EIGRP Expansion Strategies

V. OBJECTIVES

- Improved Network Performance

The improved use of EIGRP cost-based routing will provide a network-wide performance benefit. It will consider factors such as reliability and bandwidth in addition to distance so as to improve route selection, reduce latency and accelerate the transfer of data.

- Enhanced Network Reliability

Using EIGRP's Diffusing Update Algorithm (DUAL) in more parts of the network can really boost reliability. It speeds up how quickly the network adjusts when there are changes or issues, so there's less downtime. This means a smoother experience for users and less overall disruption.

- Optimized Bandwidth Utilization

Optimizing bandwidth utilization through EIGRP's selective update mechanism can significantly reduce unnecessary routing updates. This approach helps alleviate network congestion, leading to faster data transmission speeds and more efficient use of available bandwidth

- Efficient IP Address Management

Expanding the use of Classless Inter-Domain Routing with EIGRP's support can enhance IP address management throughout the network. CIDR enables more efficient and flexible allocation of IP addresses, better accommodating future network growth and modifications.

- Simplified Network Management

EIGRP's straightforward configuration and maintenance procedures can significantly streamline network management. This reduces administrative burden, enhances network stability, and simplifies management tasks as the network scales over time.

- Scalability for Future Growth

EIGRP's built-in scalability is key for our future network growth. By taking advantage of what EIGRP offers, we can set up our network to handle expansion and changes smoothly, making sure our infrastructure stays strong and flexible.

VI. COMPARISON OF TECHNIQUE

To make it easier to compare these protocols, the table below breaks down some key features of EIGRP, RIP, OSPF, and IGRP. It looks at things like how each protocol works, how quickly they adjust to changes, how well they scale, and the amount of administrative work they require.

Feature	EIGRP	RIP	OSPF	IGRP
Type of protocol	Distance Vector	Distance Vector	Link-State	Distance Vector
Limit of Hop Count	None	15 hops	None (limited by network size)	255 hops
Time taken to converge	Faster	Slower	Faster	Slower
Prevention of loop	Split Horizon with Poison	Split Horizon	Link-State Database	Split Horizon

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	Reverse			
Usage of Resource	Moderate	Low	Higher	Moderate
Configuration of Complexity	Medium	Low	High	Medium
Scalability	High	Low	High	Medium
Security	Proprietary (Cisco)	Not Secure	More Secure	Proprietary (Cisco)
Cost-Based Routing	Yes	No	Yes	Yes
Load Balancing Factor	Limited	No	Yes	No

VII. RESULT AND DISCUSSION

The projected expansion of the EIGRP network is expected to yield several significant benefits. By leveraging EIGRP's advanced cost-based routing capabilities, the network will gain more precise and optimized routing decisions, which take into account factors such as reliability and bandwidth in addition to distance. This approach will enhance overall network performance by minimizing latency and accelerating data transmission, aligning with EIGRP's goal of providing efficient and reliable network routing solutions. [11]

The continued extension of quick convergence support from EIGRP to additional network partitions using the mechanism provided by DUAL, called Diffusing Update Algorithm, will provide much higher network reliability. It is also going to be resultant in increasing the network uptime. This will be together with a stable experience from the users' side through minimizing any amount of downtime during changes or failures being there in the network through its efficient convergence mechanisms provided by EIGRP for smooth and consistent [12]

In this manner, by filtering out routing updates in EIGRP, we could remove unnecessary updates that increase network congestion. This would therefore make data transmission faster and really put the available bandwidth to good use.

The usage of Classless Inter-Domain Routing with EIGRP would also extend the classful utilization of CIDR that helps manage IP addresses more efficiently and flexibly. We will thus be better prepared for future network growths or changes.

Ultimately, the network will be simpler to maintain because to EIGRP's ability to streamline configuration and maintenance procedures. In addition to lowering administrative burden and enhancing stability, this will help the network become more scalable and flexible over time.

VIII. CONCLUSION

To wrap it up, there's a lot we can do to boost our network's performance, reliability, and scalability by rolling out EIGRP more widely. By taking advantage of EIGRP's strengths like smart routing decisions, fast adjustments, and efficient bandwidth use—we can really enhance how the network handles current needs and gears up for future growth. Plus, using CIDR more and simplifying setup procedures will make the network more adaptable and easier to manage.

In the end, these upgrades will ensure we have a more robust, efficient, and reliable network. This will position us well to meet the organization's evolving needs.

IX. FUTURE SCOPE

The future scope for dynamic routing is:

- The dynamic optimization of routing based on current network conditions through automation and AI-driven methodologies, which maximizes resource efficiency and reduces latency and downtime.
- Use Software-Defined Networking to make routing more programmable and adaptable. This would enable routing paths to be dynamically altered in response to current network conditions, enhancing responsiveness and efficiency.
- Look into developing hybrid routing protocols that combine the advantages of Enhanced Interior Gateway Routing Protocol with those of other protocols, such as Border Gateway Protocol or Open Shortest Path First..
- Include cutting-edge security measures in dynamic routing protocols to defend against DDoS attacks and route hijacking.

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