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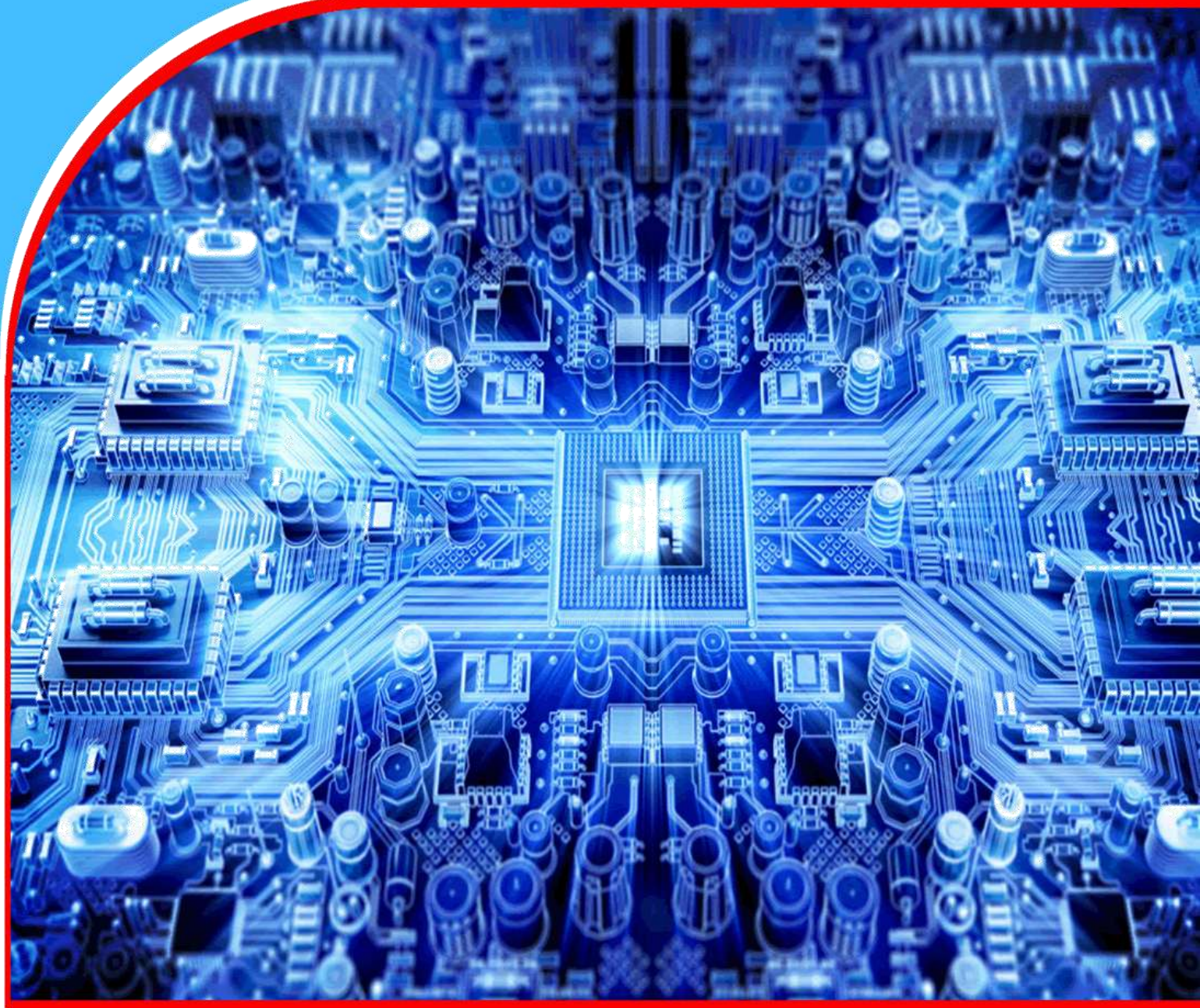

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ABSTRACT

This paper evaluates the performance of routing protocols such as OSPF, EIGRP and IS-IS in an enterprise network. Routing protocols are rules that govern the best route to transfer data between various nodes in networks. These rules are used in the transmission of information from the transmitting end to the receiving end. Routing protocol's main responsibility lies in determining the best way routers communicate with each other in order to forward any kind of network traffic using the optimal path. The evaluation of routing protocols was achieved by measuring packet end-to-end delay, packet delay variation, Jitter, Ethernet delay, traffic sent and received parameters by employing OPNET simulator software using Http, Video conferencing and Voice data types. The results shows that OSPF_IS-IS combined protocols outperforms the of OSPF_EIGRP and OSPF protocols by 60%.

Keywords: *Dynamic Routing Protocols, OSPF, IS-IS, EIGRP, OPNET Simulator*

I. INTRODUCTION

Routers learn all the routing updates and other information with the help of using routing protocols like IS-IS, EIGRP, OSPF and BGP[1]. These are further divided into two categories like interior and exterior routing protocols. Interior routing protocols are implemented in a single autonomous system (AS). Like IS-IS, EIGRP and OSPF are interior routing protocols whereas exterior routing protocol are implemented in two or more autonomous system (As) like BGP and EGP etc. In other words, dynamic routing protocols are used to determine the best route for the traffic of information to a group of nodes in a geographic area, where some data packets are transmitted from a source node to multiple destination nodes. The proposed protocols are based on the dynamic routing algorithm. It fulfils the requirements of routing in fixed infrastructure networks. The key concept used in these protocols are that, every node in the network has full knowledge of the network. Therefore, every node knows where the other nodes are located and are able to calculate the best path to reach the destination of a packet. Dynamic routing protocols such as OSPF, EIGRP and IS-IS are used for forwarding user data packets to its destination[3]. These routing protocols play an important role in today's networks. They are used to facilitate the exchange of routing information between routers. They dynamically share information between routers and they automatically update routing tables whenever there is topological changes and determine the best path to transmit data packets to its destination[4]. The main tasks of dynamic routing protocols are the discovery of remote networks, collecting and maintaining information about the paths to these networks. They are also used for the selection of the best paths to remote networks and finding new best path[5]. However, dynamic routing protocols allows routers to select the best path when there is a real time logical network layout change[6].

II. RELATED WORK ON ROUTING PROTOCOLS

Research on the evaluation of routing protocols have been done but never exhausted. Most of these researches are aimed at comparison of different routing protocols by analyzing the convergence and throughput of the protocols as a solution. Farhangi et al [7] states that the combination of protocols showed better results rather than what a single protocol configuration can provide. They showed that combination of three routing protocols such as EIGRP, OSPF and IS-IS and applying these mixed protocols to a semi-mesh topology proposes better results in performance for end-to-end delay, packet delay variation, Voice Jitter and Link throughput parameters. Krishnan et al [8] also explored two eminent protocols namely, Enhanced Interior Gateway Routing Protocols (EIGRP) and Open Shortest Path First (OSPF) protocols. The evaluation of these routing protocols was performed based on the quantitative metrics such as Convergence Time, Jitter, End-to-End delay, Throughput and Packet Loss through the simulated network models. The evaluation results showed that EIGRP routing protocols provides a better performance than OSPF routing protocols for real time applications. Through network simulations, they proved that EIGRP is more CPU intensive than OSPF and hence they uses a lot of system power. Therefore, EIGRP is a greener routing protocol and provides for greener internetworking. Anjana and Kummari [9] also described the importance of each of these routing protocols, their usage, advantages and disadvantages. When the data packet is being transferred in the network layers, the path determination and switching is done using these protocols.

Pattaramalai and Suwat [10] made performance comparison of routing protocols between OSPF and EIGRP when an internet link fails. OSPF and EIGRP protocols are mostly used nowadays because it is interesting to do experiments with these two protocols. They setup experiments to find out the retransmission time and rerouting time from both protocols when there is a link failure in a data transmission path. They discovered that before there is a link failure, the average

transmission times is 18.7ms with OSPF and 18.4 with EIGRP. Then the average transmission times increases to 28ms and 27.5ms for OSPF and EIGRP respectively after a link fails. Additionally, they also discovered that rerouting time is 5s using EIGRP shorter than 8.8s using OSPF. Finally, their research experiment results showed that EIGRP is better than OSPF in both retransmission time and rerouting time after a link fails. Sendra et al [11] presented a survey and a test performance of the main interior gateway IP routing protocols although some of them can work with other non-IP protocols that are used inside the Autonomous Systems. They wanted to know which routing protocol provides the lowest delay path, the lowest number of hops, the lowest convergence time and how the traffic sent through the network have different behavior depending on the routing protocol running in it, among others. Finally, they concluded by providing some advises to the IP network designers and administrators. Their work helped them to take the best election depending on their case. Lubobya et al [12] also proposed a network model for wireless mesh IP video surveillance by exploiting the advantages of mesh networks and investigated the performance of OSPF and AODV routing protocols for such a model in terms of throughput, jitter, packet loss and delay.

III. ROUTING PROTOCOLS

Routing protocols are a set of rules that governs how computer systems communicate with each other across networks. These are rules that are followed when transmitting data from the transmitter to the receiver. Routing Protocols also function as the common medium by which different hosts, applications or systems communicates. Data messages are exchanged when computers communicate with one another using IP routing [8]. Routing is clearly one of the most important functions of IP routing, otherwise, packets would never actually get anywhere. Routing is the process of deciding along which path to send packets. The first routing decision is made on the host when it prepares to send a packet. Additional routing decisions are made on any routers (either dedicated hardware devices or hosts that deal with routing as well as any other function) on the way to the destination. The aim of all routing decisions is to get any given packet to its destination in the best way possible. How "best" definition may vary depending on the requirements of the application that is actually generating the traffic. The routing tables and the routes are created and maintained using a combination of two routing methods: static and dynamic [13]. The common routing protocols are OSPF, IS-IS and EIGRP.

A. Open shortest path first (OSPF)

Open Shortest Path First was introduced as an improvement to RIP, offering faster convergence time and many configurable parameters[14]. Link-state routing protocols are also known as shortest path routing protocol as they compute the finest path in the network which is the shortest path available from the source network to the destination network. Each router that is joined into the routing domain will hold the link in the state databases which consist of a router that is listed in the network with every router that has the same database. The database is then used to describe the network topology[15]. All routers in the OSPF network gets the same routing table containing the shortest path to other routers[16].

B. Intermediate system to Intermediate system (IS-IS)

IS-IS is a link state routing protocol introduced by ISO. It is a link-state routing protocol that is used by network devices to determine the best way to deliver data packets. The protocols use controlled flooding to broadcast link-state information through a network[17]. Each router running IS-IS sends hello packets to every interface that has IS-IS enabled in order to discover its neighbors and establish adjacencies. If the information contained in hello packets meets the

criteria for forming an adjacency, then routers that share a common data link will become IS-IS neighbors [7].

C. *Enhanced Interior Gateway Routing Protocol (EIGRP)*

EIGRP is a classless distance vector routing protocol that use the concept of an autonomous system to describe a set of contiguous routers that run the same routing protocol and share routing information that includes the subnet mask in its route updates. This is a very big deal because by advertising subnet information, this robust protocol enables us to use VLSM and permits summarization to be included within the design of EIGRP networks[11]. The Enhanced Interior Gateway Routing Protocol (EIGRP) was developed by Cisco and is not an open standard. EIGRP is a routing protocol that is a Cisco proprietary. Although Cisco submitted a portion of EIGRP to the IETF for consideration as a potential standard, the entire protocol has not been accepted as a standard and remains proprietary to Cisco [18] [17] [19]. EIGRP is a hybrid protocol having features of both Link State Routing and Distance Vector Routing [20].

IV. REDISTRIBUTION OF ROUTING PROTOCOL

The use of a routing protocol to advertise routes that they are learned by another routing protocol such as static routes or directly connected routes is called redistribution. Whereas running one routing protocol throughout your entire IP internetwork is desirable. Multi-protocols routing are common for a variety of reasons such as company mergers, multiple departments managed by multiple network administrators and multi-vendor environments. Route redistribution can be one-way, that is one protocol receives the routes from another or two-way that is both protocols receive routes from each other. Routers that perform redistribution are called boundary routers because they border two or more ASs or routing domains [1].

D. *Redistribution*

Redistribution is the sharing of routing information about routes that the router has learned with other routing protocols and is planning to redistribute routes to other networks. Redistribution is basically the injection of routes learned from one routing domain, static routes or directly connected routes to another routing domain[21]. Redistribution of routing protocols is also defined as the use of routing protocols to advertise roads that are learned by some other ways, such as by another routing protocol, static configuration or directly connected roads. Running different routing protocols is often a part of designing a network. In any case, having a multi-protocol environment makes redistribution a necessity [22].

V. SIMULATION METHOD

In order to analyze the performance of OSPF, IS-IS and EIGRP protocols, OPNET Riverbed Modeler Academic Edition 17.5 was used to analyze the performance of these routing protocols. The network topology was designed in the network simulator consisting of Routers, Switches, Cables, Servers, IP Cloud for Internet and workstations (Computers). In this topology, three different Network scenarios, that is OSPF alone, OSPF combined with IS-IS (OSPF_IS-IS) and OSPF combined with EIGRP (OSPF_EIGRP) were designed and configured using routing protocols in order to observe how these routing protocols actually perform.

VI. SIMULATION SETUP

The implementation of a realistic model of the system in OPNET involves an algorithm that is used during the implementation. Simulation can be defined to show the eventual real behavior of the selected system model. It is used for performance optimization on the basis of creating a

model of the system in order to gain an insight into their functioning. The diagram shows Network Outline Plane for protocol evaluation. Figure 1.0 shows Simulation Setup.

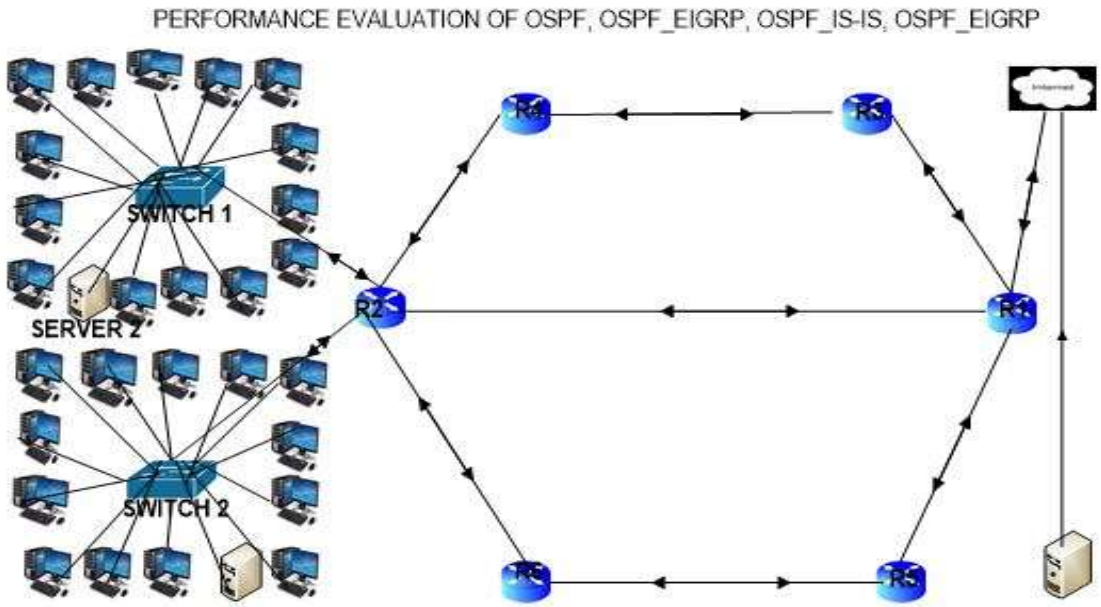

Figure 1: Evaluation of Routing Protocols.

Routing Protocol Plane is created and we have analyzed the performance of all the Interior Gateway Protocols. The three network models are configured and run as first scenario with OSPF alone, second scenario with OSPF combined with IS-IS (OSPF_IS-IS) and the third scenario is where OSPF is combined with EIGRP (OSPF_EIGRP) concurrently. The measured network performance of these routing protocols have been done.

In this paper, Optimized Network Engineering Tools such as OPNET Modeler 17.5 has been used as a simulation environment. OPNET is an object oriented, discrete event and the general purpose network simulator. Simulation modeling, data collection and analysis were a method of collecting data for this project. Simulation modeling and analysis is a technique for improving or investigating a network performance. It is a cost-effective method for evaluating the performance of resource allocation and model translation, verification, validation, experimental design, and analysis[23]. It is built using the Control End to End delay, Packet Delay Variation, Jitter, Voice Traffic sent and received, Ethernet Delay for video Conferencing and HTTP data traffics sent and received.

VII. RESULT & DISCUSSION

In this section, we have analyzed the results of Routing protocol's performance by means of using OPNET simulator incorporating OSPF, IS-IS and EIGRP routing protocols by computing end to the estimation and assumption of the real system by using simulation of the Network design on the simulator.

A. Video Conferencing Packet Delay Variation

Packet Delay Variation is the differences in end-to-end delay for video packets in one-way flow and with any packet loss being ignored. This parameter is defined as a delay of the data packets at the receiving end. On the transmitting end, data packets are transmitted continuously in the transmitting channel. Figure 2.0 illustrates packet delay variation for voice and video conferencing traffic.

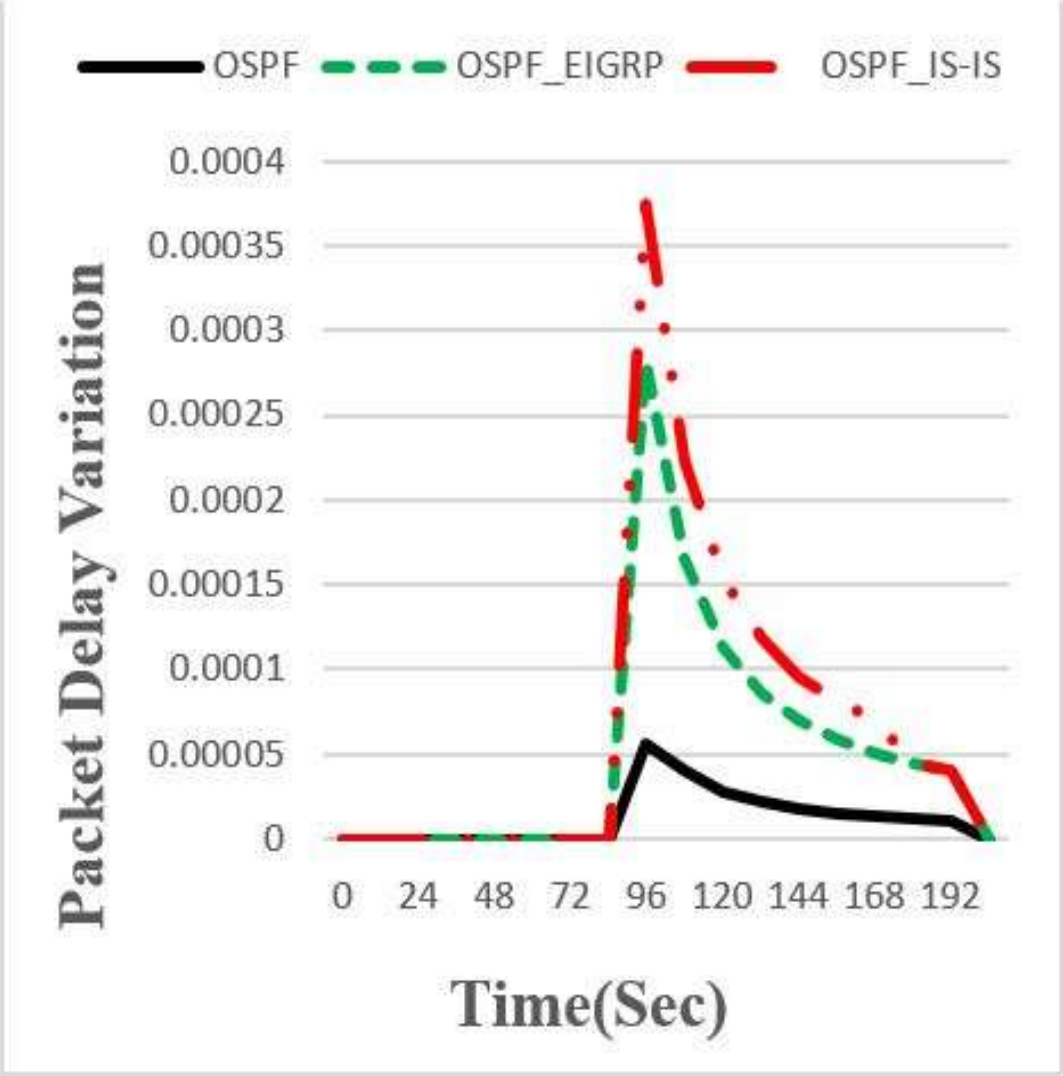

Figure 2: End-to-End Delay Variation

According to the figure, the combined OSPF and IS-IS (OSPF_S-IS) scenario have higher packet delay followed by the combined OSPF and EIGRP (OSPF_EIGRP) while OSPF shows the lowest packet delay variation of routing protocols.

B. Voice Jitter

Voice Jitter is defined as the variation in the delay of received data packets. At the transmitting end, packets are transmitted in a continuous data stream with the packets spaced apart. Due to network congestion, improper queuing and errors configuration, this stream can steady become full or the delay between each data packets can vary instead of remaining constant. Jitter is an important quality of service (QoS) factor in the evaluation of network performance. It is one of the important issues in packet based network for real time applications. Jitter plays a very important role for determining the rate of traffic congestion and for improving performance of a voice network. This means that the factor must be as small as possible. Figure 3.0. illustrates voice jitter.

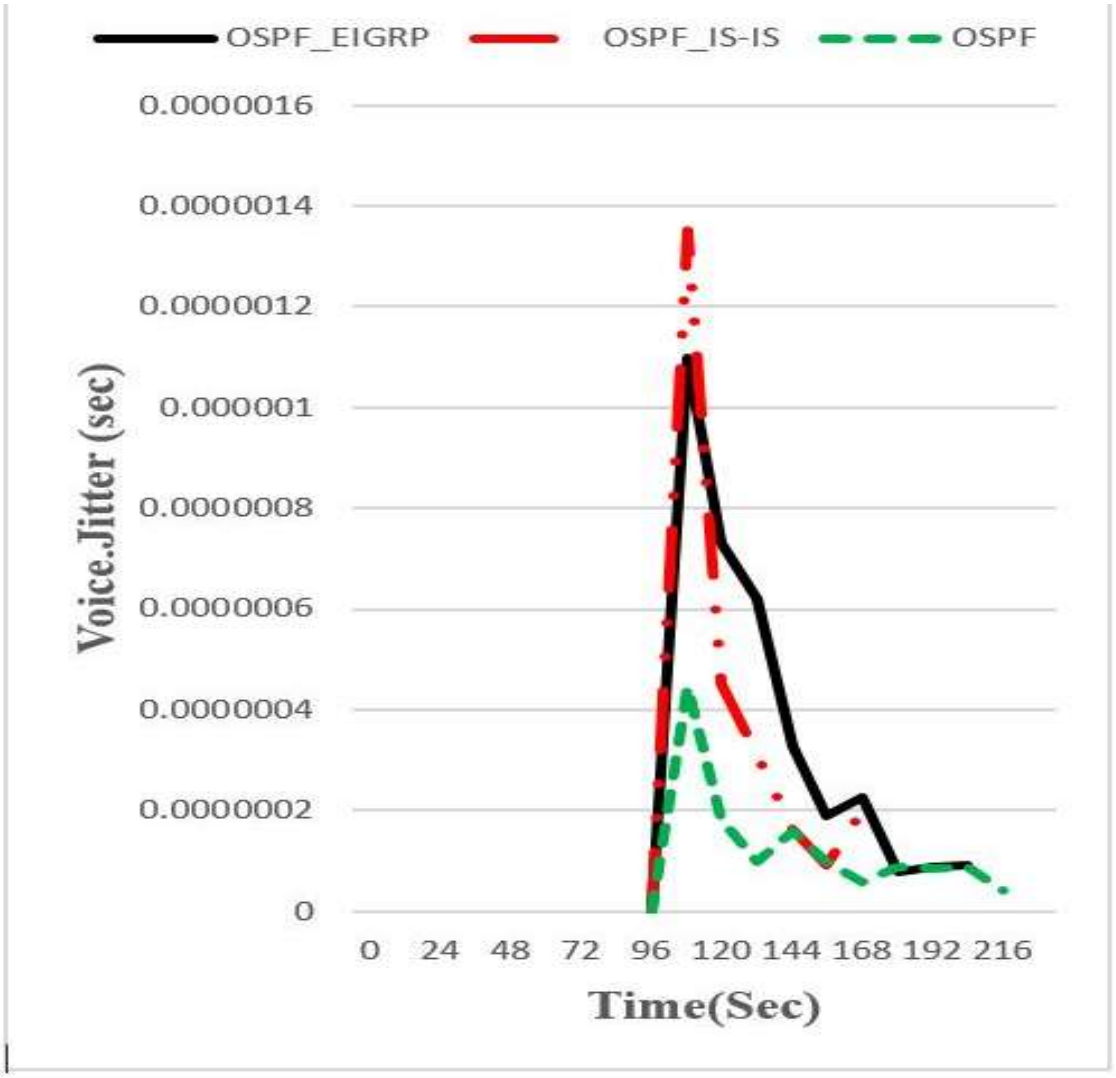

Figure 3: Voice Jitter

According to the figure 3.0, OSPF alone has the lowest voice jitter, followed by the combined OSPF and EIGRP (OSPF_EIGRP) while OSPF and S-IS (OSPF_S-IS) scenario shows the highest voice jitter performance of the protocols.

C. Video Conferencing Traffic Sent

Traffic Sent in Video Conferencing is the amount of Video Conferencing Data traffic that is transmitted during data transmission. It is the video conference routing traffic that is transmitted and it is also the performance measuring parameters that is used for the calculation of routing information transmitted by the routers to its adjacent routers. This parameter also calculates the routing traffic that is transmitted by the router in packets/Second. Through the generated graphs of routing information that is transmitted, we have analyze as which node in the network sends and how much routing information is sent to its destination. Figure 4.0 shows Video Conferencing Traffic Sent. Figure 4.0 shows video conferencing traffic.

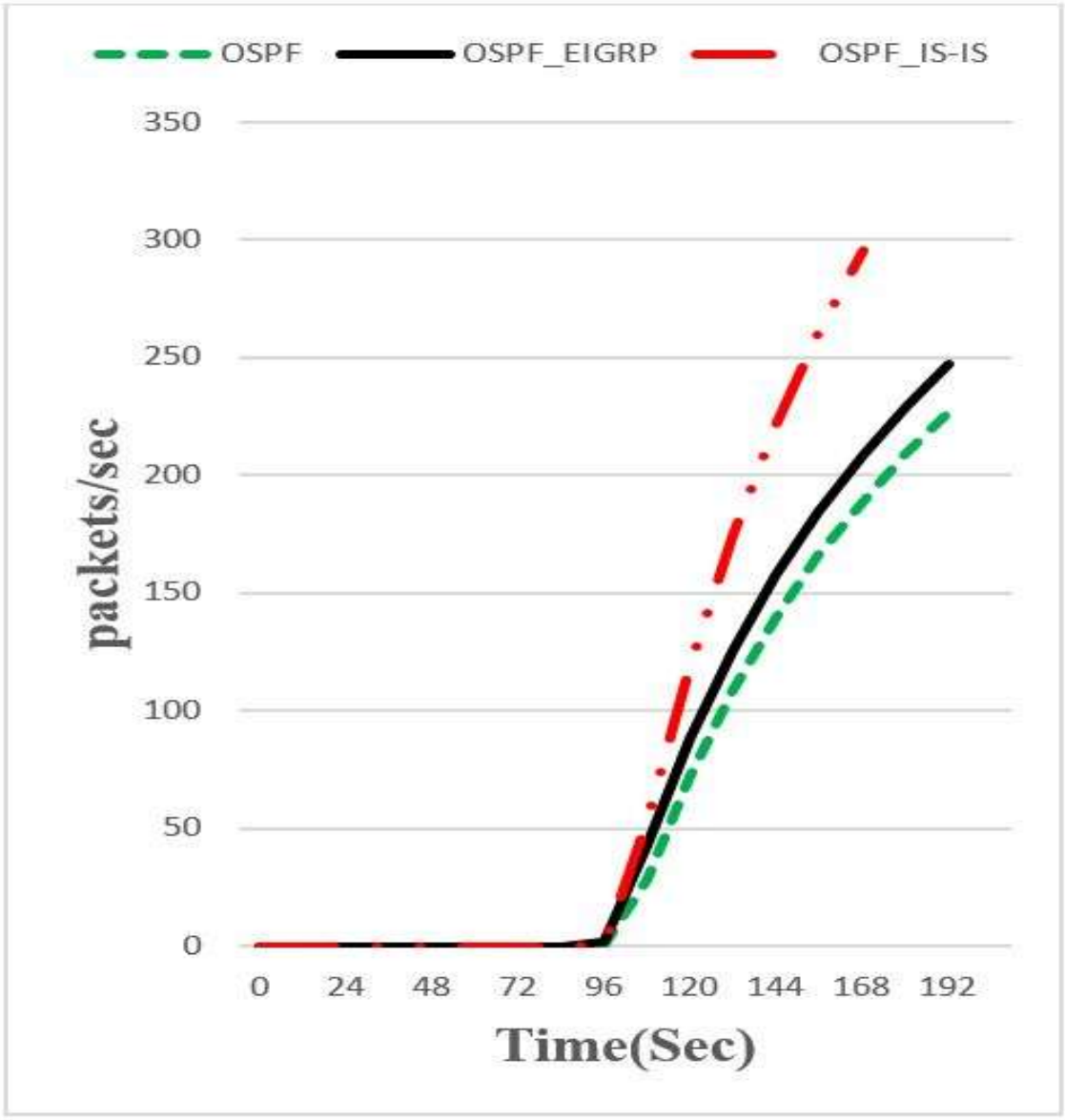

Figure 4: Traffic Sent

According to the figure, the combined OSPF and S-IS (OSPF_S-IS) is able to send more traffic followed by the combined OSPF and EIGRP (OSPF_EIGRP), while OSPF alone has the least traffic sent. The scenario shows the performance of the protocols.

D. ***Voice Traffic Received***

Voice Traffic received refers to the amount of Voice Data that is received during communication. It is the performance evaluation parameters that describes the routing of voice traffic of the routing protocol received from its adjacent routers that carries routing table information of any neighbor router. This parameter measures received routing traffic in bit/second. figure 5.0 shows voice traffic received.

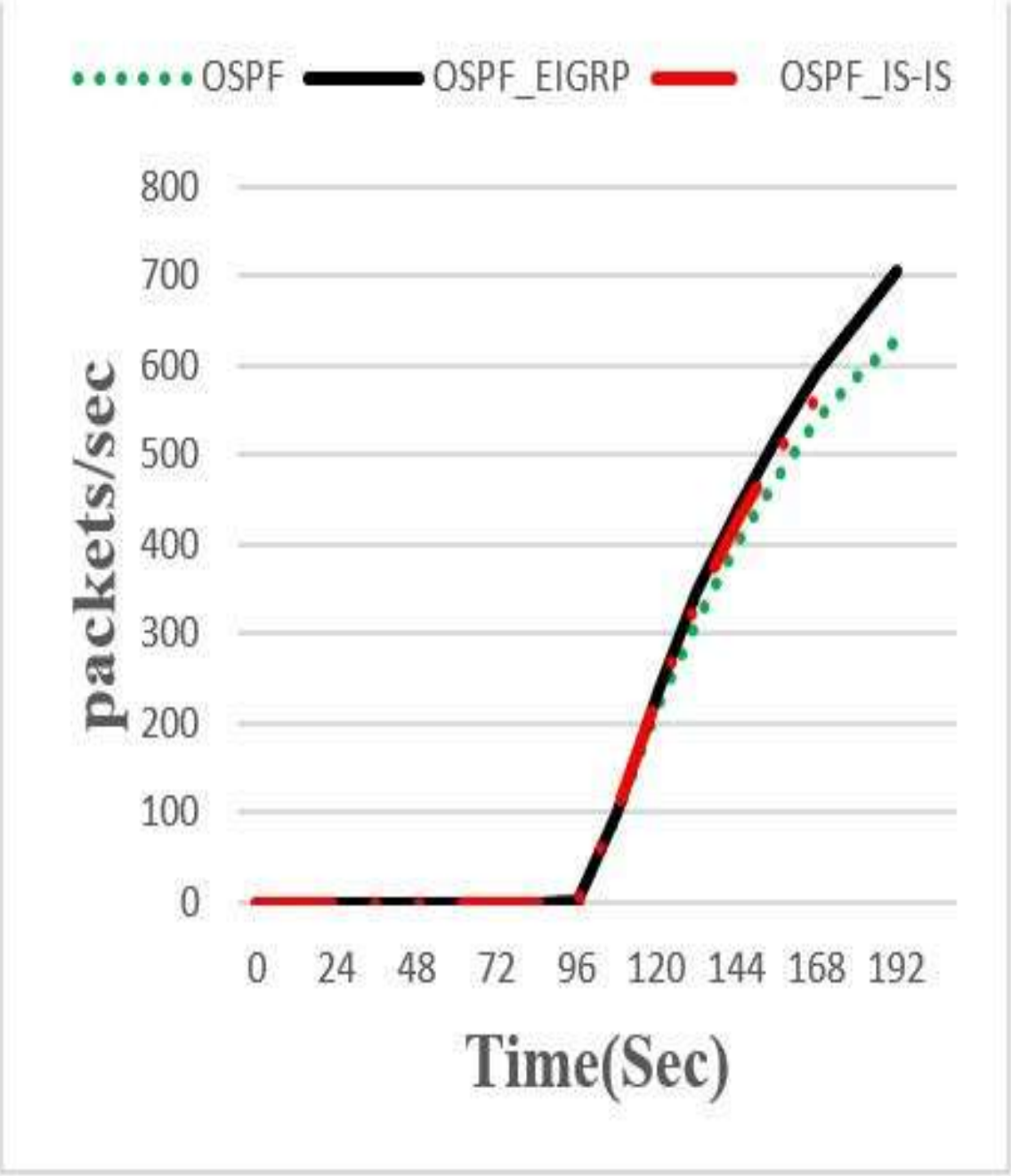

Figure 5: Voice Traffic Received

From the simulation result, the combined OSPF and EIGRP (OSPF_EIGRP) is able to receive more voice data Traffic then followed by OSPF alone while the combined OSPF and IS-IS (OSPF_IS-IS) is able to receive less data traffic during the voice data transmission.

E. ***HTTP Traffic Sent.***

The Hypertext Transfer Protocol (HTTP) is the protocol that is used to request and serve web content. HTTP is a plaintext protocol that runs on port 80. HTTP Packets Sent is the amount of http packets transmitted during data transmission. HTTP (Hypertext Transfer Protocol) is perhaps the most popular application protocol used in the Internet (or The WEB). Heavy HTTP application is used during the configuration in OPNET. Figure 6 shows HTTP Packets sent.

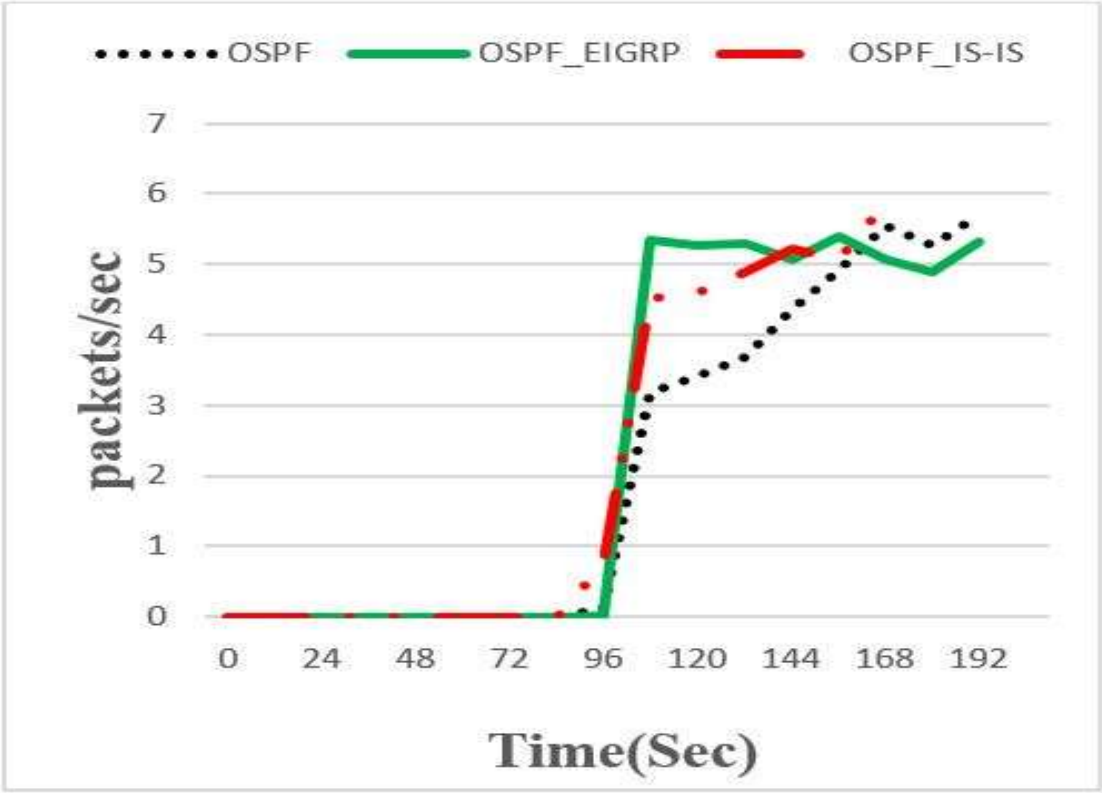

Figure 6: HTTP Traffic Sent

From the simulation result, the combined OSPF and EIGRP (OSPF_EIGRP) is able to send more HTTP Traffic then followed by the combined OSPF and IS-IS (OSPF_IS-IS) while OSPF alone has the least HTTP traffic sent during the data transmission.

VIII. CONCLUSION AND FUTURE WORK

Interior gateway routing protocols like, OSPF, EIGRP and IS-IS are widely used in enterprise networks. In this paper, comparative performance analysis of these protocols has been presented. Performance of routing protocols has also been evaluated and analyzed on the Video Conferencing Packet Delay Variation, Jitter of Voice, Voice Traffic Received and transmitted, HTTP Packets transmitted and receive, Ethernet Delay.

Results shows that the combined OSPF_IS-IS protocols are able to send mote HTTP traffic than other protocols weather combined or not. The combined OSPF_EIGRP also shows that it is able receive more Voice Traffic followed by OSPF while OSPF_IS-IS receives less Voice Traffic and have the highest end-to-end delay performance with OSPF having the best (least) end-to-end delay.

The recommendations to the researchers for future work is that the Researcher should be able to expand the research on the effects of jitter and end- to-end delay for the case of OSPF and EIGRP in a Software-defined Wide Area Network (SD-WAN). This can provide great importance of information for traditional routing protocols so that they can determine as which routing protocol between the two is suitable for SD-WAN. Software-Defined Wide Area Networking (SD-WAN) is a transformative technology that simplifies the IT infrastructure control and management by delivering a virtual WAN architecture that securely connects users to their applications.

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