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Detailed Analysis of Routing Protocols with Different Network Limitations

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ABSTRACT

In network communication field, routing protocols have got a significant role which are not only used in networks to handle the user data but also to monitor the different network environments. Dynamic routing protocols such as OSPF, EIGRP and RIP are used for forwarding user data to its destination by instantly detecting the dynamic changes across the network. The dynamic changes in the network can be in the form of topological changes, congestions, links failure etc. Therefore, it becomes a challenge to develop and implement dynamic routing protocols that fulfills the network requirements. Hence, each routing protocol has its own characteristics such as convergence activity, routing metric, routing table etc. and will perform differently in various network environments. This paper presents a comprehensive study of static and dynamic routing, along with dynamic routing protocols. Experiments that are conducted under various network limitations are presented using the OPNET tool. The performance of each of dynamic routing protocols are monitored and explained in the form of simulated results using network parameters. The results are analyzed, in order to provide a clear understanding of each protocol performance for the selection of the proper protocol for a given network environment.

Keywords: Dynamic Routing Protocols, Static Routing, OSPF, RIP, EIGRP, OPNET

1. INTRODUCTION

With the increasing demand of modern and sophisticated internet applications and the entire telecommunication field, the networking has been facing more complex challenges. For different applications, in order to route the user data towards its destination with minimum delays and packet losses, the routers in the network are configured with routing protocols. Routing protocols plays an important role in networking by balancing the network traffic by distributing of data across the network [1], [2], [3]. In general, routing is divided into two main categories such as static routing and dynamic routing, that are based on number of routing protocols. The role and functions of each routing protocol is different and is also versatile. Each protocol can be implemented across the network according to network designer needs and network applications requirements [4], [5]. However, the dynamic routing protocols are more applicable because of their diversity of by being able to adjust themselves to the network changing requirements. The three most prominent dynamic routing protocols are OSPF (Open Shortest Path First), RIP (Routing Information Protocol) and EIGRP (Enhanced Interior Gateway Routing Protocol) [6], [7], [8], [9].

There are numbers of challenges that may affect the performance of network and limits the data transmission across the network. These network challenges can be in the form of delays, congestions, links failures, packets losses etc., which may occur anytime in the network [10]. For various network scenarios, dynamic routing protocols are used. Dynamic routing protocols (OSPF, RIP and EIGRP) are different from the others in terms of routing process, convergence activity and its duration as well as routing metrics. Many research papers are published on the performance evaluation of these mentioned protocols with different network environments and parameters. The purpose of this research is to propose a protocol (with its existing characteristics) that would perform well balanced with the changing network environment and existing network challenges [1], [11]. According to [11] and [12], OSPF protocol has very accurate convergence activity but uses the highest CPU utilization. Whereas, RIP and EIGRP protocols have low CPU utilization but have less affective convergence activity. Although various approaches for analyzing performance of these protocols already exists still a lot of work needs to be done when taking into consideration networks parameters such as the link utilization, *IP* packets dropped, packets end-to-end delays and jitter for voice and video applications. Furthermore, these parameters must be analyzed under different network limitations such as congestion of various types across the networks.

This paper will first present a literature review of the static and dynamic routing with protocols. Later on, our conducted experiments and simulated results will be then analyzed. In these experiments, network routers are configured with OSPF, RIP and EIGRP routing protocols. The network routers that are configured with any of these routing protocols are referred as OSPF, EIGRP or RIP configured network. While video, voice applications and *IP* traffic are considered across the network in order to introduce the maximum data traffic and to increase the network congestion. Under these scenarios, each protocol performs routing of the traffic while trying to minimize the traffic delays or packets losses, which are been monitored in the form of simulated results. The OPNET tool is used as the networking tool to conduct these experiments.

2. STATIC ROUTING VERSUS DYNAMIC ROUTING

In communication networks, routers are the key network components that are used to route all traffic across the network. For forwarding the data to different routes in the network, routers use a routing table which is either manually or automatically configured. Routing tables contains the list of the best possible routes for data routing across the network [13]. In static routing, the routing tables are manually configured by the network administration. These routes are known as static routes and must be configured for all possible routers in the network. This approach of routing provides a full control over the network routers and is suitable for small networks. Static routing has zero fault tolerance because any change in the network environment (unexpected congestion or link drops across the network) cannot be managed or updated automatically. Every time this happens, the network must be updated or configured by the network administration intervention. Any router in a static routing configured network is unaware of any network change. Routers with this routing approach do not share any information across the network. However, by not sharing any information in the network causes decrease in the CPU utilization and also saves the bandwidth. Static routing is not practical approach for larger networks or for networks where any quick topological changes are expected [14], [15], [16].

Another approach of routing is the dynamic routing in which routers across the networks are automatically configured, maintained, and updated as needed [14]. Routers in the network, which is configured with dynamic routing protocols, will monitor any topological change and share this information across the network with other routers in the network. A dynamic routing is based on several routing protocols. Each of these protocols is different from the other, has its own network convergence activity, its convergence duration, and network's CPU utilization [11], [12]. However, routers use the dynamic routing protocol causes an increase in CPU utilization and also requires larger bandwidth for communication. Dynamic routing is a decent approach for larger networks and for networks where sudden topological changes can be expected. Dynamic routing is also known as adaptive routing because the network is constantly reconfigured in such a way that each router automatically updates its routing table according to any topological change. A network, where various types of congestions, delays and sudden link drops are expected, for such networks dynamic routing protocols are the only approach that has been used by the network administrators [11], [16].

3. DYNAMIC ROUTING PROTOCOLS

Dynamic routing is based on routing protocols. The most widely used dynamic routing protocols are; OSPF (open shortest path first), RIP (routing information protocol), and EIGRP (enhanced interior gateway routing protocol).

3.1 OSPF (Open Shortest Path First) Routing Protocol

In the mid of 1980's, Internet Engineering Task Force (IETF) introduced a dynamic routing protocol called as OSPF. It is a link state routing protocol [7], [16]. According to experiments and results presented in [11] and [12], OSPF proved itself to be an efficient protocol with a quick convergence response in the network. The network which is configured with OSPF protocol distributes the network information across the network and regularly monitors the topological changes. The routers use this protocol to regularly update and maintain their routing table. Whereas, this protocol uses Dijkstra algorithm in order to calculate the shortest path to route the data towards destination. However, the network using OSPF protocol has higher CPU utilization than RIP and EIGRP protocols configured networks [7], [16].

3.2 RIP (Routing Information Routing Protocol)

Routing Information protocol (RIP) belongs to distance vector routing protocols which are based on hop counting metrics [8]. However, RIP's hop count metrics is limited to 15 hops which make this protocol inappropriate for large networks. In 1988, RIP's first version was introduced as RFC 1058. Its second version (RIPv2) was published in 1998 as RFC 2453. The routers configured with a RIP configured network send and receive messages (Request Message and Response Message) in the regular time intervals across the network. This protocol convergence activity is based on a number of timers such as update timer, invalid timer, flush timer, and hold down timers. The protocol has less efficient convergence

activity with a low convergence activity duration. However, a RIP configured network is very efficient in CPU utilization when compared to other dynamic routing protocols [8], [11].

3.3 Enhanced Interior Gateway Routing Protocol (EIGRP)

In 1993, Cisco introduced a dynamic routing protocol, which was an enhanced version of the Interior Gateway Routing Protocol (IGRP) and named this protocol as Enhanced Interior Routing Protocol (EIGRP). In 2013, IETF published so called EIGRP protocol version named RFC 7868 [11]. Although it is a distance vector routing protocol, it has characteristics of both the link state and distance vector routing protocols. It is based on algorithm called DUAL (Diffusion Update Algorithm) [9]. The operation of this protocol is based on four basic components such as Neighbor Discovery/ Recovery, Reliable Transport Protocol (RTP), DUAL, and Protocol dependent module. As EIGRP protocol was developed by Cisco, it only supports Cisco routers [16], [9].

4. OBTAINED RESULTS

In order to analyze the performance of OSPF, RIP and EIGRP routing protocols, various parameters and network scenarios are considered in the form of experiments. The purpose of these experiments are to better understand the characteristics of these protocols under different network scenarios. To achieve this, the OPNET tool will be used. Fig. 1 represents the network topology which was used in our experiments.

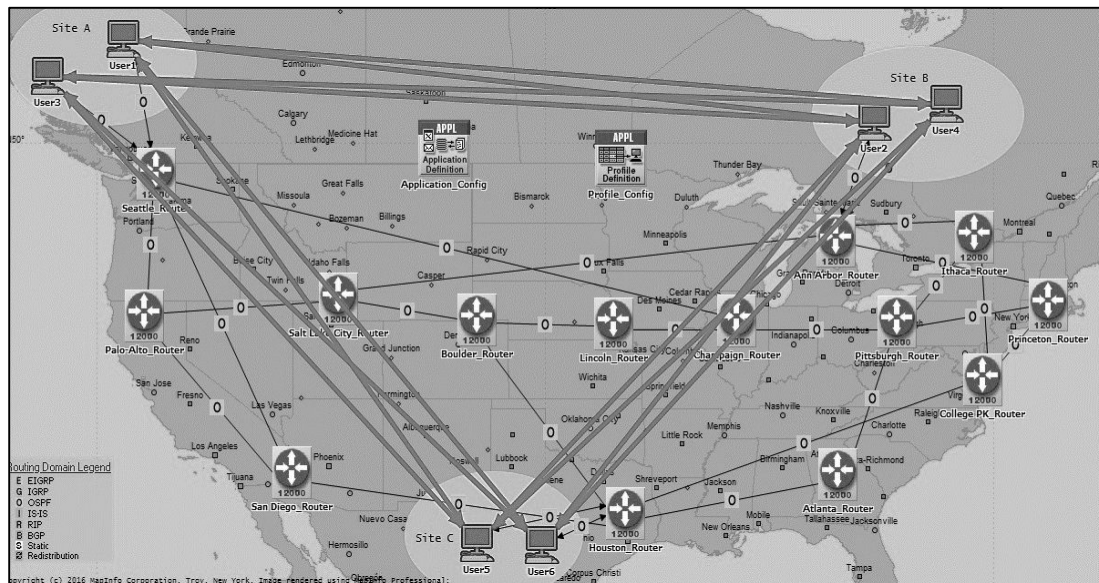


Figure 1. Network Topology

The network topology used in our experiments is mainly based on the NSFnet (National Science Foundation Network) topology which is actually 14 nodes network. In the experiments the users are located into three sites named as Site A, Site B and Site C. For congestion in the network, the network traffic is increased by using high data rate traffic of voice application, video conferencing application and *IP traffic* is also introduced as a *Demand IP Traffic* between the users, as shown in fig. 1. *IP traffic Demand* represents *IP* layer traffic flow between the specified source and destination nodes. By using the same network environment, the routers of the network are configured with three dynamic routing protocols (OSPF, RIP and EIGRP). Three experiments are conducted, based on the same network structure. In the first experiment, network routers are configured with OSPF routing protocol, named as OSPF configured network. For the second and third experiments, network routers are either configured with RIP or EIGRP protocols, called as RIP configured network and EIGRP configured network respectively. Due to congestion in the network, routing protocols try to manage the network traffic with minimum losses (packets loss, packets delays etc.). These losses within the network are analyzed by using parameters such as *IP* packets drops, links utilization, video application packets end-to-end delay and voice application packets end-to-end delay and jitter. The purpose is to understand the performance of each routing protocol with a given network structure and environment. The simulation time for each experiment was 10 minutes. The simulated results are collected and presented in the form of graphical representation.

Each routing protocol uses specific calculated routes/ links in order to forward the user data towards its destination. Link utilization is also referred to as the utilization that represents the consumption of the available network bandwidth (in percentage) by network traffic. For example, if the port is configured for 100Mbps (and is fully duplexed) and the port is transmitting data with 30% utilization while receiving data with a10% utilization, then the utilization would be referred to as 30% utilization. The purpose of calculating the link utilization is to knowing whether the link is overload. With the case of overload link utilization, the router`s interface may become overwhelmed and packets drops or losses can be expected. While in turns, the users will also experience lower data response time and throughput [17].

Fig. 2 represents the link utilization in three protocols configured networks. In RIP configured network is higher than the OSPF and EIGRP configured networks. Whereas, in EIGRP configured network, the link utilization is minimum. Higher link utilization can cause series damage to network traffic in the form of packets drops/ loss.

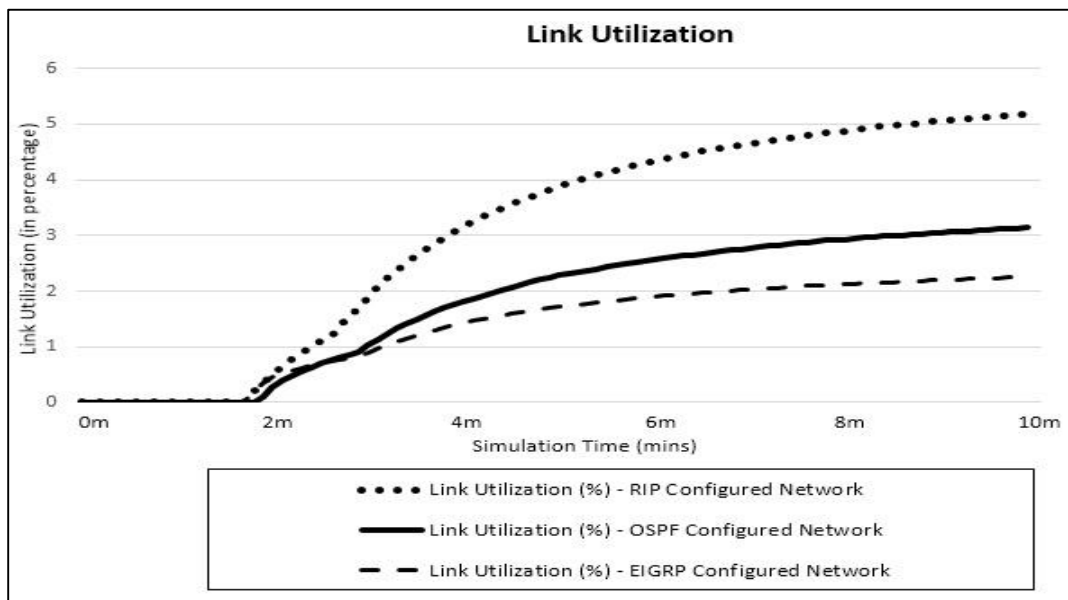


Figure 2. Link Utilization in OSPF, RIP and EIGRP Configured Networks

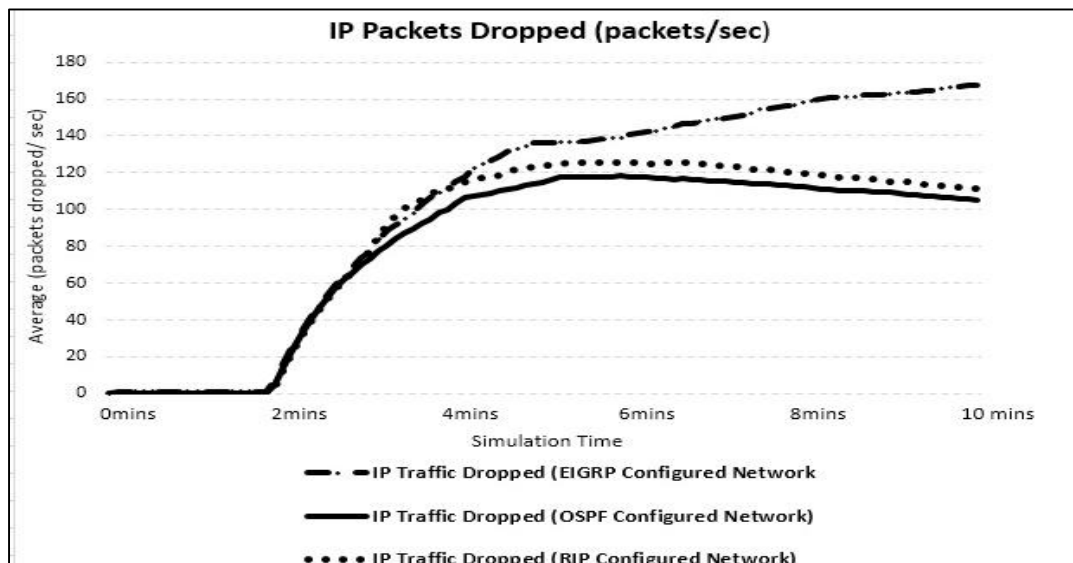


Figure 3. IP Data Packets Dropped in OSPF, RIP and EIGRP Configured Networks

Fig. 3 represents the outcome of three experiments in the form of *IP* packets dropped in OSPF, RIP and EIGRP configured networks. From the Fig. 3, it can be seen that in RIP configured network the number of packets dropped per second is much higher than OSPF and EIGRP configured networks. While in OSPF configured network, the number of *IP* packets dropped is lower than by the other two routing protocol configured networks.

In networking, end-to-end delay can be referred as an amount of time taken for data (in bits/ packets) to be transmitted from source to destination node. Whereas jitter is a form of delay that varies in time.

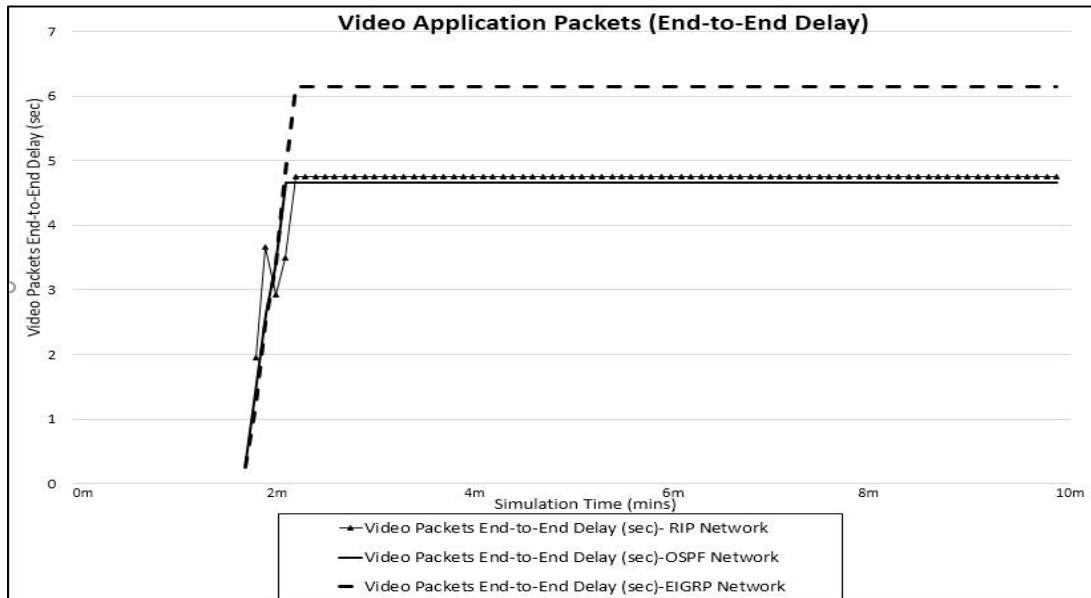


Figure 4. Video Application Packets End-to-End Delay in OSPF, RIP and EIGRP Networks

Fig. 4 represents the video application packets end-to-end delay in OSPF, RIP and EIGRP configured networks. In the results, the network which is configured with EIGRP routing protocol has got higher video packets end-to-end delays as compared to OSPF and RIP networks. Whereas, the packets end-to-end delays in OSPF network is slightly lower than the RIP configured network.

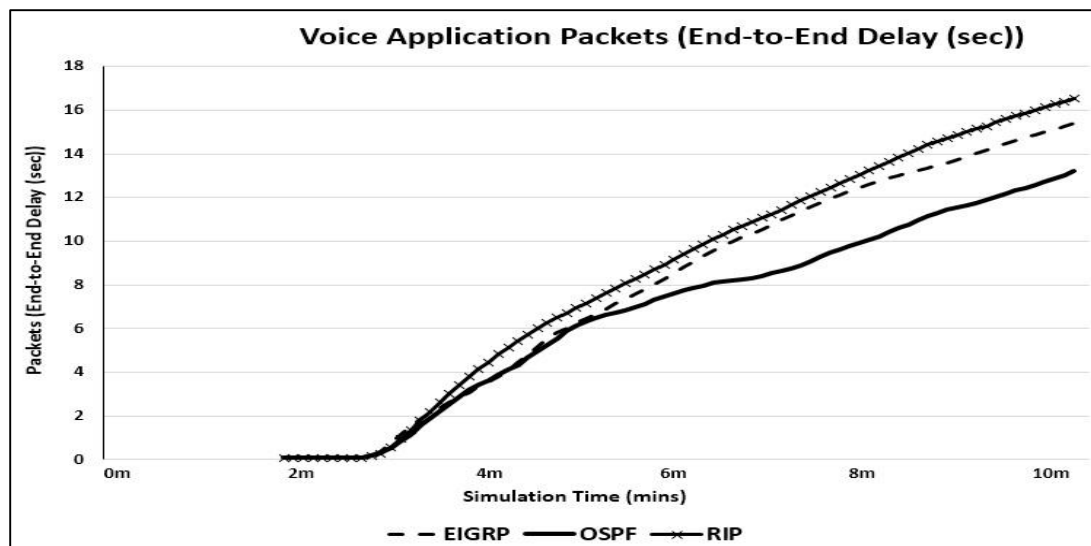


Figure 5. Voice App. Packets End-to-End Delay (sec) in OSPF, RIP and EIGRP Networks

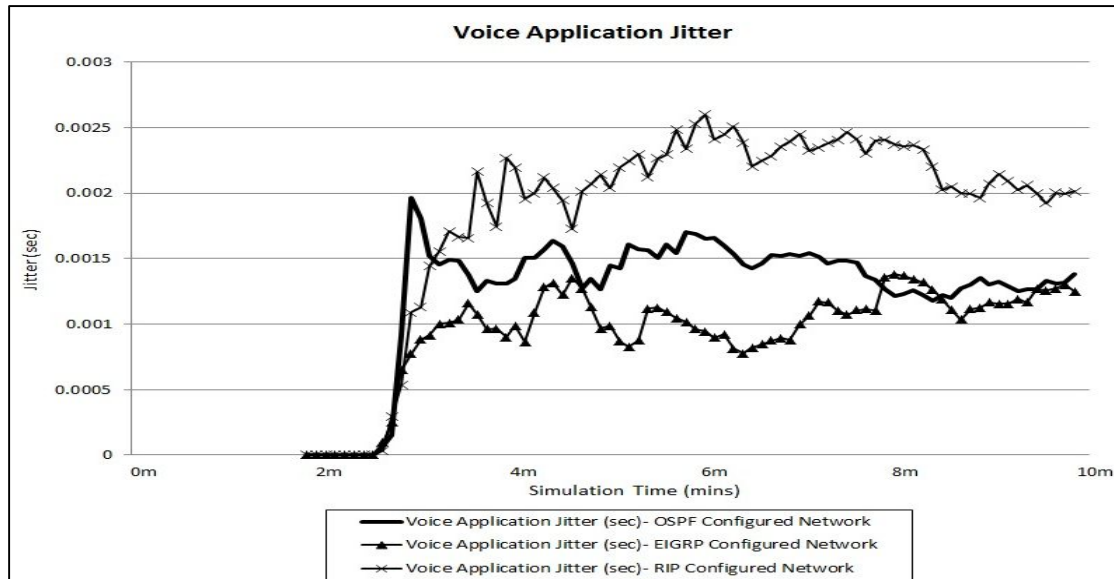


Figure 6. Voice Application Packets Jitter in OSPF, RIP and EIGRP Networks

Fig. 5 and fig. 6 represents the voice application packets end-to-end and jitter in OSPF, RIP and EIGRP configured networks. From fig. 5, voice application end-to-end packets delay at RIP configured network is higher than OSPF and EIGRP protocols configured networks. While in OSPF configured network, in the presence of congestion, the packets are routed and handled by OSPF protocol in such a way that there are least number of packets (in average) end-to-end delay from source to destination. According to our results in fig.6, the network which is configured with RIP protocol network has the maximum amount of jitter as compare to OSPF and EIGRP protocols configured networks. The network using EIGRP protocol for routing has the lowest jitter.

5. CONCLUSION

The purpose of the experiments was to analyze the performance of each dynamic routing protocol that how each protocol handles the network congestion with minimum packet delays or loss across the network. From the results, it can be concluded that during the congestion in the network, the network which is configured with OSPF protocol does routing job with minimum *IP* packet loss and video packets end-to-end delays. Whereas, EIGRP protocol configured network has minimum jitter and link utilization. While the network which is configured with RIP routing protocol can experience maximum *IP* packets loss, link utilization and voice application jitter and end-to-end delay, but will have minimum video packets end-to-end delays. Furthermore, it can have concluded that OSPF routing has utilize the links well balanced with minimum packets loss/ drops for all considered applications traffic.

REFERENCES

- [1] Wijaya, C., "Performance Analysis of Dynamic Routing Protocol EIGRP and OSPF in IPv4 and IPv6 Network," IEEE, 355-360 (2011).
- [2] Sai Kalyan, G. P. and Vara Prasad, D. V., "Optimal Selection of Dynamic Routing Protocol with Real Time Case Studies," IEEE, 219-223 (2012).
- [3] Jing, Z., "Centralized routing and distributed routing protocol for dynamic routing," IEEE, 1-4 (2012).
- [4] Kameda, H. and Zhang, Y., "Uniqueness of the Solution for Optimal Static Routing in Open BCMP Queueing Networks," Elsevier Science 22, 119-130 (1995).
- [5] Wang, D., Qian, X., Li, Y. and Jing, Y., "Routing strategy based on static and dynamic information," IEEE, 1644-1647 (2011).
- [6] Dey, G. K., Ahmed, M. M. and Ahmmmed, K. T., "Performance Analysis and Redistribution among RIPv2, EIGRP & OSPF Routing Protocol," IEEE, 21-24 (2015).
- [7] Moy, J., "RFC 1247-OSPF Version 2," IETF, July 1991, <https://www.rfc-editor.org/rfc/rfc1247.txt>
- [8] Malkin, G., "RFC 2453-RIP Version 2," IETF, November 1998, <http://www.rfc-base.org/txt/rfc-2453.txt>

- [9] Savage, D., Ng, J., Moore, S., Slice, D., Paluch, P. and White R., "Cisco's Enhanced Interior Gateway Routing Protocol (EIGRP)," IETF, 18 February 2013, <https://tools.ietf.org/html/rfc7868>
- [10] Jasem, H. N., Zukarnain, Z. A., Othman, M. and Subramaniam, S., "Evaluation Study for Delay and Link Utilization with the New-Additive Increase Multiplicative Decrease Congestion Avoidance and Control Algorithm," *Academic Journals* 5(23), 3719-3729 (2010).
- [11] Masood, M., Abuhelala, M. and Glesk., I., "A comprehensive study of Routing Protocols Performance with Topological Changes in the Networks," *IJEECS* 5(8), 31-40 (2016).
- [12] Thorenoor, S. G., "Dynamic Routing Protocol implementation decision between EIGRP, OSPF and RIP based on Technical Background Using OPNET Modeler," *IEEE*, 191 – 195 (2010).
- [13] Lee, H. Y. and Nakao, A., "Improving Routing Table Lookup in Software Routers," *IEEE* 19(6), 957 – 960 (2015).
- [14] Tetz, E., [Cisco Networking All-in-One for Dummies], John Wiley & Sons, (2011).
- [15] Boger, P., [Routing Protocols Companion Guide], Cisco Press, (2014).
- [16] Graziani, R. and Johnson, A., [Routing Protocols and Concepts, CCNA Exploration Companion Guide], Cisco Press, (2007).