



**A PROPORTIONAL PERFORMANCE INVESTIGATION
ROUTE RELOCATION AMONG THREE DIFFERENT
ROUTING PROTOCOLS USING OPNET SIMULATION**

FATIMA

And

SAMIA BINTE ALAM

Submitted to the

Department of Electrical and Electronic Engineering

Faculty of Sciences and Engineering

East West University

In partial fulfillment of the requirements for the degree of
Bachelor of Science in Electrical and Electronic Engineering
(B.Sc. in EEE)

SUMMER, 2018

**A PROPORTIONAL PERFORMANCE INVESTIGATION ROUTE
RELOCATION AMONG THREE DIFFERENT ROUTING
PROTOCOLS USING OPNET SIMULATION**

FATIMA

And

SAMIA BINTE ALAM

Submitted to the

Department of Electrical and Electronic Engineering

Faculty of Sciences and Engineering

East West University

In partial fulfillment of the requirements for the degree of
Bachelor of Science in Electrical and Electronic Engineering (B.Sc. in EEE)

SUMMER, 2018

Approved By

Thesis Advisor

Fakir Mashuque Alamgir

Chairperson

Dr. Mohammad

Mojammel Al Hakim

Abstract

In today's real-world scenario, using multiple dynamic routing protocols for forwarding packets has become a normal job for the network administrators. Therefore, the route redistribution is an important issue in an enterprise network that has been configured by multiple different routing protocols in its routers. In this study, we analyze the performance of the combination of three routing protocols in each scenario and make a comparison among our scenarios. We have used the OPNET 17.5 simulator to create the two scenarios in this paper by selecting three different routing protocols from the distance vector and link state routing protocols in each scenario. In the first scenario, we have configured the network routers with EIGRP, IGRP, and OSPF that is named EIGRP_IGRP_OSPF in our simulation. Here EIGRP is used on the server side and OSPF is used on the client side. The OSPF_IGRP_ISIS scenario is a mixed from EIGRP, IGRP, and IS-IS protocols that is the second scenario and OSPF is used on the server side and IS-IS is used on the client side. The third scenario is OSPF_IGRP_EIGRP that is the route redistribution among OSPF, IGRP, and IS-IS protocols and OSPF is used on the server side and EIGRP is used on the client side. The simulation results showed that the performance of the EIGRP_IGRP_ISIS scenario is better than the other scenarios in terms of network convergence time, throughput, video packet delay variation, and FTP download response time. In contrast, the OSPF_IGRP_ISIS has less voice packet delay variation, video conferencing and voice packet end-to-end delays, and queuing delay as compared with the two other scenarios. On the other hand, the performance of the OSPF_IGRP_EIGRP scenario has the better FTP upload response time, and voice jitter.

Authorization page

We hereby declare that we are the sole authors of this thesis. We authorize East West University to lend this thesis to other institutions or individuals for the purpose of scholarly research.

Fatima

(ID#2013-2-80-010)

Samia Binte Alam

(ID#2013-2-80-056)

We further authorize East West University to reproduce this thesis by photocopy or other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

Fatima

(ID#2013-2-80-010)

Samia Binte Alam

(ID#2013-2-80-056)

Acknowledgements

At first, we would like to start by praising the Almighty Allah (sbw) that the thesis was able to reach the end. We would like to express our heartfelt thanks and gratitude to Assistant Professor, FAKIR MASHUQUE ALAMGIR, Department of Electrical and Electronic Engineering, East West University, for his continuous supervision, guidance, constructive suggestions, and endless support during this research work, without his help, this thesis work would have not been completed. We would also like to thank DR.MOHAMMAD MOJAMMEL AL HAKIM, Chairperson, Department of Electrical and Electronic Engineering and to all the faculty members and staffs of the department whose direct or indirect help made this work a successful one. We express thanks to our family and friends who directly or indirectly helped and encouraged us during this work, whose names are needless to mention here.

TABLE OF CONTENTS

Abstract	3
Authorization page	4
Acknowledgements	5
TABLE OF CONTENTS	6
LIST OF TABLES	7
LIST OF ILLUSTRATIONS	8
1. Introduction	9
1.1 KEY TERMINOLOGIES	9
1.2 BRIEF OVERVIEW	16
1.3 REPORT ORGANIZATION	19
2. Related Study	19
3. THE PROPOSED NETWORK	22
3.1. The Route Redistribution among EIGRP, IGRP and IS-IS Routing Protocols	24
3.2. The Route Redistribution among OSPF, IGRP and IS-IS Routing Protocols	25
3.3. The Route Redistribution among OSPF, IGRP and EIGRP Routing Protocols	26
4. THE RESULTS ANALYSIS	27
4.1. Network Convergence Time	27
4.2. Queuing Delay	28
4.3. Throughput	29
4.4. Video Conferencing Packet Delay Variation	30
4.5. Video Conferencing Packet End to End Delay	30
4.6. Voice Jitter	31
4.7. Voice Packet Delay Variation	32
4.8. Voice Packet End to End Delay	33
4.9. FTP Download Response Time	34
4.10. FTP Upload Response Time	35
5. CONCLUSIONS	37
Reference	39

LIST OF TABLES

Table 3.1. Link failure and recovery.	23
<hr/>	
Table 4.1 The performance parameters comparisons among the proposed scenarios in terms of the percentage of mean value.	36
<hr/>	
Table 5.1 The performance parameters comparisons among the proposed scenarios.	38
<hr/>	

LIST OF ILLUSTRATIONS

Figure 3.1: The EIGRP_IGRP_ISIS scenario	24
Figure 3.2: The OSPF_IGRP_ISIS scenario	25
Figure 3.3: The OSPF_IGRP_EIGRP scenario.	26
Figure 4.1: The network convergence duration.	27
Figure 4.2: The queuing delay in the link between SW2 and R11.....	28
Figure 4.3. The throughput in the link between SW2 and R11.	29
Figure 4.4: The video conferencing packet delay variation	30
Figure 4.4: The video conferencing packet delay variation	31
Figure 4.6: The voice jitter.	31
Figure 4.7: The voice packet delay variation	32
Figure 4.8: The voice packet end-to-end delay.	33
Figure 4.9: The FTP download response time.	34
Figure 4.10: The FTP upload response time.	35

1. Introduction

1.1 KEY TERMINOLOGIES

The key terminologies used in the paper are defined below:

I. Autonomous System (AS):

Autonomous system is a heterogeneous network. Autonomous system is a unit of router policy of a single network or a collection of networks that is controlled, managed, governed and supervised by a common network administrator or a single administrative entity or organization. This subnetworks assigned by 16 digit identification number (AS number) by Internet Assigned Numbers Authority (IANA).

II. Border Gateway Protocol (BGP):

The Border Gateway Protocol (BGP) is an inter-Autonomous System routing protocol that manages how packets are routed across the Internet. BGP is an exterior gateway protocol as is designed to exchange routing information among Autonomous Systems (AS). BGP is the path-vector routing protocol. Border Gateway Protocol (BGP) is an Internet Engineering Task Force (IETF) standard, and the most scalable of all routing protocols.

III. BGP-4:

Border Gateway Protocol Version 4 (BGP-4), documented in RFC 1771, is the current exterior routing protocol used for the global Internet. The major enhancement was the support for Classless Inter-Domain Routing and use of route aggregation to decrease the size of routingtables. BGP4 has been in use on the Internet since 1994.

IV. Classless inter-domain routing (CIDR):

CIDR is Classless Inter-Domain Routing used in IP addressing and routing. CIDR is a standard way for routing network traffic in the internet, which developed in the 1990s. It allocates IP addresses in a more flexible manner as compared to the original system of Internet Protocol (IP) address classes. In this way, it increases the number of available IP addresses with extensive use of Network Address Translation (NAT). With CIDR, one

entry in the routing table entry represents a combination of networks existing in the forward path. This network aggregation in a single address is known as Supernet.

V. Domain Modeling Language (DML):

A domain model is a system on a state of preoccupation that describes selected aspects of a zone of knowledge relating to a certain domain. The model can then be used to solve problems related to that domain. The language that is used to create the model is called Domain Modeling Language (DML) for that certain domain. For example: HTML is used in web page domain.

VI. Distance Vector:

Distance vector routing protocol is used to finding best path for data pass from source to destination based on distance. Distance vector routing allows the routers to automatically find the destination inside the networks with shortest path based on matrices or costs that are associated to each link.

VII. Enhanced Interior Gateway Routing Protocol (EIGRP):

EIGRP is a distance vector routing protocol and the enhanced version of Interior Gateway Protocol (IGRP). EIGRP is proprietary to CISCO Systems. Thus, it can only be seen in the CISCO devices.

VIII. External BGP (eBGP):

External BGP establishes between two different Autonomous systems. If two neighbouring routers of different AS connected using BGP then it is eBGP. It is the point-to-point connection between peered autonomous systems. External BGP used for connecting the organization of the different network on the internet.

IX. File Transfer Protocol(FTP):

The File Transfer Protocol (FTP) is a standard network protocol used to transfer the computer files between the source to destination on a computer network. FTP is built on a client-server model architecture and uses separate control and data connections

between the client and the server.[1] FTP users may authenticate themselves with a clear-text sign-in protocol, normally in the form of a username and password, but can connect anonymously if the server is configured to allow it. For secure transmission that protects the username and password, and encrypts the content, FTP is often secured with SSL/TLS (FTPS). SSH File Transfer Protocol (SFTP) is sometimes also used instead; it is technologically different.

X. Finite State Machine (FSM):

A state machine a set of input or output events / a set of states/ a function that maps states and input to output/ a description of the initial state. Thus, a finite state machine is one that has a limited or finite number of possible states. The FSM can change from one state to another in response to some external inputs.

XI. Inter-domain routing (IDR):

Inter-domain routing (IDR) is the system of exchanging routing information between domains. Each domain is composed of a group of routers and hosts that are managed by the same organization. The domains are known as Autonomous Systems (AS).

XII. Internet Engineering Task Force(IETF):

The Internet Engineering Task Force (IETF) is an international organization of network designer, operators and researchers who used to do the evolution of the internet architecture and the smooth operation of the internet. It's purpose is to make the Internet work better by producing high quality, relevant technical documents that influence the way people design, use and manage to work.

XIII. Interior Gateway Protocol (IGP):

Interior Gateway Protocol (IGP) is a routing protocol. Commonly, it is used for exchanging routing information within the same Autonomous System (AS). There are two types of IGP : distance-vector routing protocols and link-state routing protocols. Examples of IGP are: OSPF, EIGRP, IS-IS etc.

XIV. Interior Gateway Routing Protocol (IGRP):

Interior Gateway Routing Protocol (IGP) is a type of distance vector routing protocol. Commonly, it is used for exchanging routing information within the same Autonomous System (AS). It uses maximum hops then RIP for a large network. IGRP is a classful routing protocol and it uses bandwidth, delay, reliability and load as it's metric.

XV. Intermediate system to Intermediate system (IS-IS):

IS-IS is a link-state Interior Gateway Protocol (IGP), used to distribute IP routing information throughout a single Autonomous System (AS) in an IP network. IS-IS is a link-state routing protocol, which means that the routers exchange topology information with their nearest neighbours. Each IS-IS router distributes information about its local state to other routers using a Link State PDU (LSP) message. Each router uses the received messages to build up an identical database that describes the topology of the AS. From this database, each router calculates its own routing table using a Shortest Path First (SPF) or Dijkstra algorithm. This routing table contains all the destinations the routing protocol knows about, associated with a next hop IP address and outgoing interface.

XVI. Internet Service Provider (ISP):

An Internet Service Provider (ISP) is a company or organization that provides connections to its users to connect to the Internet. Internet service providers may be organized in various forms, such as commercial, community-owned, non-profit, or otherwise privately owned. An ISP has the equipment and the telecommunication line access required to have a point-of-presence on the Internet for the geographic area served. The larger ISPs have their own high-speed leased lines so that they are less dependent on the telecommunication providers and can provide better service to their customers.

XVII. Link-State routing protocol:

Link-state routing protocol is used to the every nodes information in the network. The basic concept of the link-state routing is the every node in the map or connected in the

network is used and then each node independently calculates the shortest path and finds the possible destination in the network.

XVIII. Multiple Exit Discriminator (MED):

The MED attribute is a BGP metric. The MED provides a dynamic way to influence another AS in the way to reach a certain route when there are multiple entry points for that AS. BGP MED is a non-transitive optional attribute and thus the receiving AS cannot propagate it across its AS borders. However, the receiving AS may reset the metric value upon receipt, if it so desires.

XIX. Multiprotocol Label Switching (MPLS):

MPLS is a packet-forwarding technology, which uses labels in order to make data forwarding decisions. MPLS directs data from one network node to the next based on short path labels rather than long network addresses, avoiding complex lookups in a routing table. In an MPLS network, data packets are assigned labels. Packet-forwarding decisions are made solely on the contents of this label, without the need to examine the packet itself. MPLS operates at a layer that is generally considered to lie between traditional definitions of OSI Layer 2 (data link layer) and Layer 3 (network layer), and thus is often referred to as a layer 2.5 protocol.

XX. Minimum Route Advertisement Interval (MRAI):

The MRAI as per the specification is the amount of time that a BGP speaker will wait before passing on successive route updates for the same prefix. This timer acts to rate-limit updates, on a per-destination basis. [BGP] suggests values of 30s and 5s for this interval for eBGP and iBGP respectively.

XXI. Network Layer Reachability Information (NLRI):

NLRIs are the prefixes that can be reached through the advertising BGP neighbor. NLRI) is exchanged between BGP routers using UPDATE messages. An NLRI is composed of a LENGTH and a PREFIX. The length is a network mask in CIDR notation (eg. /25) specifying the number of network bits, and the prefix is the Network

address for that subnet. The NLRI is unique to BGP version 4 and allows BGP to carry super-netting information, as well as perform aggregation.

XXII. Open Shortest Path First (OSPF):

Open Shortest Path First (OSPF) is a routing protocol for Internet Protocol (IP) networks. It uses a link state routing (LSR) algorithm and falls into the group of interior gateway protocols (IGPs), operating within a single autonomous system (AS). The OSPF algorithm will calculate the most efficient way for data to be transmitted using Dijkstra's algorithm. If there are several routers on a network, OSPF builds a table (or topography) of the router connections. When data is sent from one location to another, the OSPF algorithm compares the available options and chooses the most efficient way for the data to be sent. This limits unnecessary delays in data transmission and prevents infinite loops.

XXIII. RIB for locally used routes (Loc-RIB):

BGP speakers receive routing updates from other peers, processes the information for local use and then advertise selected routes to different peers based on predefined policies. In order for BGP to be able to perform its functions, it stores this information in a special type of database called the BGP Routing Information Base. BGP Routing Information Base consists of three parts: The Adj-RIBs-In, The Local RIB, The Adj-RIBs-out. The local routing information base stores the resulted information from processing the RIBs-In database's information. These routes are used locally after applying BGP policies and decision process.

XXIV. Requests For Comment (RFC):

Requests for comment (RFCs) cover many aspects of computer networking, including protocols, procedures, programs, and concepts, as well as meeting notes, opinions, and sometimes humor. The Internet Engineering Task Force (IETF) and the Internet Society (ISOC), the principal technical development and standards-setting bodies for the Internet publishes RFCs and are act to govern the Internet.

XXV. Routing Information Base (RIB):

The Routing Information Base RIB is the location in which all IP Routing information is stored. The RIB is not specific to any routing protocol rather; it is the repository where all the routing protocols place all of their routes. Routes are inserted into the RIB whenever a routing protocol running on the router learns a new route. When a destination becomes unreachable, the route is first marked unusable and later removed from the RIB as per the specifications of the routing protocol they were learnt from. It is important to note that the RIB is not used for forwarding IP datagrams, nor is it advertised to the rest of the networks to which the router is attached.

XXVI. Routing Information Protocol (RIP):

The Routing Information Protocol (RIP) is a distance-vector, interior gateway (IGP) routing protocol used by routers to exchange routing information. RIP uses the hop count as a routing metric. RIP prevents routing loops by implementing a limit on the number of hops allowed in a path from the source to a destination. The maximum number of hops allowed for RIP is 15. In most networking environments, RIP is not the preferred choice for routing as its time to converge and scalability are poor compared to EIGRP, OSPF, or IS-IS. However, it is easy to configure, because RIP does not require any parameters unlike other protocols. RIP uses the User Datagram Protocol (UDP) as its transport protocol, and is assigned the reserved port number 520.

XXVII. Virtual Private Network (VPN):

A VPN is created by establishing a virtual point-to-point connection through the use of dedicated connections, virtual tunneling protocols, or traffic encryption. VPN extends a private network across a public one in such that the users identity / location is encrypted. A VPN user can securely access a private network and share data remotely through public networks. A VPN is technically a WAN (Wide Area Network), the front end retains the same functionality, security, and appearance as it would on the private network.

1.2 BRIEF OVERVIEW

The advent of the large networks in the 21st century that have affected our daily lives prominently, where the large network might operate multiple different routing protocols in its infrastructure in order to be connected, therefore; the route redistribution becomes an important issue in its routers configuration. The route redistribution is a fundamental process in the routing protocol for a large network that uses multiple diverse routing protocols. A Routing is a basic process for choosing the shortest path from multiple paths in order to forward a packet from source to destination nodes at a minimum cost. The routing protocols can be classified into interior and exterior gateway protocols. Border Gateway Protocol (BGP) is an exterior gateway protocol. BGP is used to distribute routing information among autonomous system (AS) on the internetwork that is a distance vector routing protocol. An interior gateway protocol is used to distribute routing information between gateways within an AS. It is classified into distance vector and link state routing protocols. A distance vector algorithm constructs a vector that contains costs to all other nodes and advertises a vector to its neighbours whereas each node in a link state algorithm advertises the state of the link to its neighbours and the cost of each link. A distance vector routing protocol is a hop count metrics and the next hop presents a direction. It is based on the Bellman-Ford algorithm to compute the optimal path. Routing Information Protocol (RIP) is a distance vector routing protocol that measures its metrics by counting the number of hops between source and destination nodes. RIP selects the minimum number of hops for reaching a destination. RIP allows a maximum hop count of 15 hops in a path, in the case of the hop count exceeding 15 hops for reaching a destination network, it is considered unreachable network. RIP updates its full routing table with its closest neighbours every 30 seconds, and the administrative distance in the RIP is 120 [1].

Interior Gateway Routing Protocol (IGRP) is based on a distance vector routing protocol, and IGRP handles maximum hop count up to 255 hops, where 100 is a default hop count in IGRP. IGRP sends a full routing table every 90 seconds, and the hold down timer of IGRP is 280 seconds. The administrative distance of IGRP is 100, and IGRP uses bandwidth, delay, reliability, load, and maximum transmission unit (MTU) in its metric, where bandwidth and delay are default metric in IGRP [2].

Enhanced Interior Gateway Routing Protocol (EIGRP) is an enhancement of IGRP that uses diffusion update algorithm instead of hop count compared with IGRP to select the optimal path between the source and destination nodes. The administrative distance used by EIGRP is 170 for external routes outside the local AS and 90 for routes originating within the local AS. EIGRP is a successor to the IGRP consequently they are compatible in their operation, where the used metric in one protocol can be translated into the metrics of the other protocol. EIGRP sends updates only when changes made, and the only changes part are transmitted, not the entire routing table. This will cause rapid convergence and reduce the load of routing protocol [3].

A link state routing protocol is based on Dijkstra's algorithm to find the optimal path between the source and destination nodes. Open Shortest Path First (OSPF) and Intermediate System to Intermediate System (IS-IS) are a link state routing protocol. The Internet Engineering Task Force (IETF) as interior gateway Protocol standardizes OSPF. The OSPF is designed to support large networks efficiently. OSPF protocol is used to find the optimal for the information to reach a particular destination. OSPF uses cost as its metric, which is computed based on the bandwidth of the link. OSPF has no hop-count limit and its administrative distance is 110, it supports the classless protocol. OSPF advertises the status of directly connected links using Link-State Advertisements (LSAs). OSPF sends updates (LSAs) only the part that has changed and only when a change has taken place. LSAs are additionally refreshed every 30 minutes [4, 5].

The IS-IS is standardized link-state routing protocol that is an interior gateway protocol for the Internet. IS-IS is designed to move information efficiently within a computer network. It exchanges topology information with their nearest neighbours and distributes IP routing information throughout a single AS in an IP network. IS-IS executes the Shortest Path First (SPF) algorithm on the information in the link-state database in order to obtain the optimal path to each destination on the network, thereafter stores the pairs of the destination and next-hop as a result of computing the SPF algorithm into IS-IS routing database. IS-IS executes directly on the data link layer, Because it was developed as part of the OSI network protocols and not part of TCP/IP, IS-IS doesn't use IP addresses. IS-IS addresses are called NETs, or network entity titles [6, 7].

The enterprise networks are created from multiple routers that are running different routing protocols in order to distribute their route information; we need to configure the route

redistribution into routers in the network. The route distribution exchanges the route information between two diverse routing protocols that require the common border router. The common border router executes routing processes in both routing protocols. The border router may be configured to redistribute routes from one routing protocol to the other, and vice versa. The route redistribution is needed in case of company mergers, multiple departments managed by multiple network administrators, multi-vendor environment, and split of two independent routing domains [8, 9]. The route redistribution has two main objectives. The first objective is to exchange route information between diverse routing protocols for connectivity purposes. The second objective is the alternative links in case of a network failure, the routing protocol should be able to support alternate forwarding paths to each other. In addition, most of the existing solutions apply to scenarios with only two routing protocols, but large operational networks usually include more than two routing protocols in the network [10]. The route redistribution might face some issues during running multiple diverse routing protocols due to each routing protocol has its characteristics such as metrics, administrative distance, convergence rate, classful and classless capabilities. Each routing protocol uses different metrics in order to compute the shortest path. IGRP and EIGRP have the same metrics, but they are different in the administrative distance, and a network convergence time [11]. OSPF metric is based on bandwidth, but IS-IS metric is based on the cost of link utilization, delay, expense and error, where Cisco implementation uses cost only [12, 13]. Each routing protocol has a different network convergence time such as EIGRP convergence time is faster than IGRP. A network convergence is the status of a set of routers that have the same topological information about the network of which operating. When a link fails or recovers thereafter a set of routers needs to run their routing protocols in order to advertise their routing information with neighbours to form the same topological information about their network.

The most researchers have been focused on the comparison and analysis of the performance of dynamic routing protocols and the route redistribution between two different routing protocols. They did not consider the comparison and analysis of the performance of the route redistribution among three different routing protocols in various scenarios on the same network [14, 15, 16]. In this study, we analyze and compare the performance of the route redistribution among three different routing protocols that are configured on the same network. We have created three

scenarios on the same network topology, where the combination of EIGRP, IGRP, and IS-IS, OSPF, IGRP, and IS-IS, and OSPF, IGRP, and EIGRP.

The main goal of this study is to analyze and compare the performance of the three scenarios in terms of convergence duration time, queuing delay, throughput, voice jitter, voice and video conferencing packet delay variations, voice and video conferencing packet end to end delays, FTP upload response time, and FTP download response time.

1.3 REPORT ORGANIZATION

Our paper is organized as follows: In section 2, we review briefly about the performance analysis of dynamic routing protocols and the route redistribution of different routing protocols. We describe the three scenarios of the proposed network that have been created by the OPNET 17.5 simulator in section 3. In section 4, we analyze and compare the performance of three scenarios. We present our conclusions in section 5.

2. Related Study

In "Performance Comparison of Mixed Protocols Based on EIGRP, IS-IS and OSPF for Real-time Applications" [14] analysis and comparison was done on the performance of the route redistribution between two diverse dynamic routing protocols by using OPNET. The simulation results showed that the performance of the mixed three protocols EIGRP, OSPF and IS-IS in terms of end to end delay, packet delay variation, voice Jitter and link throughput outperforms the other two combination from the same three routing protocols. Dey et al. [15] investigated a comparative performance analysis of dynamic routing protocols. They showed how to transmit data among different networks that are used different dynamic IP routing protocols based on route redistribution systems in Cisco packet tracer simulator. In "Comparison Route Redistribution on Dynamic Routing Protocol (EIGRP into OSPF and EIGRP into IS-IS)" [16] a comparative performance analysis of route redistribution on dynamic routing protocol by using

Graphical Network Simulator (GNS3) was done. The simulation results showed that the route redistribution EIGRP into IS-IS has less delay and packet loss compared with the route redistribution EIGRP into OSPF but in terms of throughput the combination of EIGRP and OSPF has better result. Jayaprakash and Saroja [17] analyzed the performance of RIP, OSPF, IGRP and EIGRP routing protocols. They concluded that EIGRP is the fastest router convergence time in their simulation. Hamza and Mohamed [18] presented the performance comparison between distance vector and link state. They showed in the simulation that OSPF has a better performance than RIP in terms of average throughput and packet delay in different network sizes. Nigam et al. [19] presented theoretical analysis of RIP, EIGRP and OSPF routing protocols. Nazumudeen and Mahendran [20] analyzed the performance of dynamic routing protocols by using Cisco packet tracer simulator. They concluded that EIGRP has better performance among dynamic routing protocols. Ali et al. [21] presented a comparative study of IGP and EGP routing protocols. They evaluated the performance of load balancing and redundancy via different autonomous system. They simulated and analyzed the combination of EIGRP and OSPF in large network and they obtained that combination is the best for large network but the combination of EIGRP and RIPv2 is more suitable for small size network. Archana [22] simulated and analyzed of EIGRP, RIP and OSPF in wired local area network by using Cisco Packet Tracer. Sendra et al. [23] presented a survey of main interior gateway IP routing protocols in details. They tested a performance of EIGRP, RIPv1, RIPv2 and OSPF routing protocols. Verma and Bharddwaj [24] reviewed RIP and OSPF routing protocol and addressed the development in both protocols. They found that OSPF outperforms RIP in terms of throughput and packet delay. Vetrivelan et al. [25] surveyed the performance evaluation of dynamic routing protocols in terms of jitter, convergence time and end to end delay. Kumar et al. [26] implemented of experiment of the route redistribution between EIGRP and OSPF routing protocol in computer network by using GNS3 emulator. Lakshmi and Rao [27] studied the designing issues of protocols at the network layer and reviewed the existing routing protocols for wired and wireless networks. Vasudha et al. [28] presented the modelling and simulation of WAN based on the OPNET to investigate the performance of integration of RIP with OSPF. They studied behavior of FTP traffic, wireless load and delays. Abdulkadhim [29] concluded in his study that the convergence time of OSPF is faster than RIP. He simulated RIP, OSPF and EIGRP on the OPNET and He noticed from his analysis of the simulation that EIGRP has the minimum impact on the network. Asher [30]

discussed the routing IP protocol and summarized the features of RIP, OSPF, IS-IS, IGRP, EIGRP and BGP routing protocols. Rathi and Singh [31] described the distance vector and link state routing protocols in details. They simulated the distance vector and link state routing protocols with both IPv4 and IPv6 on GNS3 emulator. Their simulation showed that EIGRP outperforms the distance vector protocols, and OSPF is the best link state routing protocols. Sandhu et al. [32] simulated RIP, EIGRP, IGRP, and OSPF routing protocols on the OPNET simulator and they observed two factors: throughput and queuing delay on both ends transmitter and receiver. Their conclusion was the throughput, utilization, and delay of EIGRP outperforms other routing protocols in experiment. Grang et al. [33] discussed OSPF in details and compared it with other interior routing protocols. Shubhi and Shukla [34] presented the theoretical and practical analysis of the distance vector and link state routing protocols. They simulated the distance vector and link state routing protocols in MATLAB. The result of simulation showed that distance vector routing protocols have periodic updates, low utilization of CPU and memory and high simplicity compared with link state routing protocols. Sonam et al. [35] described the analysis of IS-IS, IGRP, and RIP dynamic routing protocols working on FTP, remote login and videoconferencing applications based on increasing number of packets per second sent. They used the OPNET simulator to evaluate the dynamic routing protocols and the results of simulation showed that IS-IS has best performance than IGRP and RIP in case of increasing number of packets in the given scenario. Jelodar and Nikravesht [36] assessed RIPv1 and OSPFv2 routing protocols in terms of convergence and sending protocols traffic by using the OPNET simulator. They observed from the simulation that OSPFv2 is more efficient than RIPv1 protocols. Prasad et al. [37] studied and analyzed RIP, OSPF and EIGRP routing protocols in terms of bandwidth is used during convergence. IQBAL and KHAN [38] described RIP, OSPF and EIGRP routing IP protocols in details. They simulated three routing protocols for supporting voice, video and HTTP traffic on the OPNET. The simulation showed that EIGRP performance was stable most of the time when there were flapping links and OSPF performance was improved when there were more flapping links in the network. Kumar et al. [39] analyzed the performance of RIPv2 in Cisco packet tracer in terms of routing update, convergence time, invalid timer, hold timer and flush-out timer parameters. They optimized these parameters to improve quality of service and make RIP fast. Patel et al. [40] analyzed the performance of OSPF and EIGRP routing protocols in terms of route summarization and route redistribution in

GNS3. Syed & Ambore [41] presented the comparative analysis in behavior of RIP and OSPF in IPv4 and IPv6 using G.711 CODEC with riverbed modeler 17.5. Their simulation results showed that OSPFv3 has lesser a traffic sent than RIPng when a call is placed from one end to the other although OSPFv3 has more a traffic sent than OSPFv2 however OSPFv3 outperforms OSPFv2, RIPv2 and RIPng in terms of packet delay variation, moreover, RIPng has better results in terms of traffic dropped, end to end delay, and jitter. Wijaya [42] analyzed the performance parameters of EIGRP and OSPF in IPv4 and IPv6 network by using the GNS3 and Cisco packet tracer simulators, and the simulation results showed that EIGRP is better than OSPF in terms of performance parameters. Gurupandi et al. [43] proposed a new form interconnection to overcome the limitations of route election and route redistribution, permit the configuration of a resilient and efficient routing system. They demonstrated a simulation of the route redistribution among RIP, OSPF, and EIGRP on Cisco packet tracer.

3. THE PROPOSED NETWORK

We have used the OPNET 17.5 to create the proposed network as shown in Figure 1. In the proposed network, we have 11 routers that are Ethernet4_slip8_gtwy and all the routers are connected together with point to point (PPP) by using Digital Signal 3 (DS3) link model, where DS3 link speed is 44.736 Mbps, whereas the R4, R5, R6, and R7 routers are the border routers which are used for exchanging different route information in the network. In addition, we have SW1 and SW2 switches that are Ethernet16_switch node model and are connected with the two end points in the network by a 100BaseT link in which operating at 100 Mbps. Figure 1 shows three Ethernet servers that are connected with SW1 switch via an Ethernet connection, where a VoiceServer is used to provide a voice service, a VideoServer is used to support a video conferencing, and an FTPServer is used to provide a File Transfer Protocol (FTP) service.

Furthermore, our proposed network consists of an Ethernet local area network (LAN) in which is connected with a SW2 switch via a 100BaseT link. A LAN is configured to support 25 users for using FTP with a low load. We have four Ethernet workstations in the proposed network that are used to support the real time applications, where the two workstations have been configured for a

voice service with a low quality and silence suppressed, and the other two have been configured for a video conferencing service with a low resolution video. In order to analyse the network convergence duration time of the proposed network, we applied a Failure Recovery node that is the simulator of fails in nodes or links of the real communication networks. The links between the following nodes: R11 R8, R6 R4, and R4 R2 are an important communication link in the proposed network due to the path between source and destination nodes is the shortest path

(R11 R8 R6 R4 R2 R1) as compared with the other path (R11 R10 R9 R7 R5 R3 R1), so during our simulations, we apply failure recovery events as shown in Table 1, where the time is given in second. The total simulation time for each scenario is taken to be 600 seconds.

Link	Fail	Recover
R11 R8	180	240
R6 R4	300	360
R4 R2	420	480

Table 3.1. Link failure and recovery.

We have created the three scenarios that have been configured from a combination of three different routing protocols for each scenario on the same network. In section 3.1, we describe the configuration of the first scenario. We describe the configuration of the second scenario in section 3.2. In section 3.3, we discuss the configuration of the third scenario.

3.1. The Route Redistribution among EIGRP, IGRP and IS-IS Routing Protocols

The first scenario is the EIGRP_IGRP_ISIS that is a combination of EIGRP, IGRP, and IS-IS protocols. In Figure 1, we configured the redistribution parameters of IGRP protocol in the R4 and R5 border routers in order to redistribute the route information of IGRP protocol into EIGRP protocol. The redistribution parameters of EIGRP protocol have been configured to advertise its routing information into IGRP protocol. In the R6 and R7 boundary routers, we configured the redistribution parameters of IGRP protocol to distribute the route information of IGRP protocol into IS-IS protocol, and the redistribution parameters of IS-IS protocol are configured to redistribute the route information of IS-IS protocol into IGRP protocol as demonstrated in Figure 3.1.

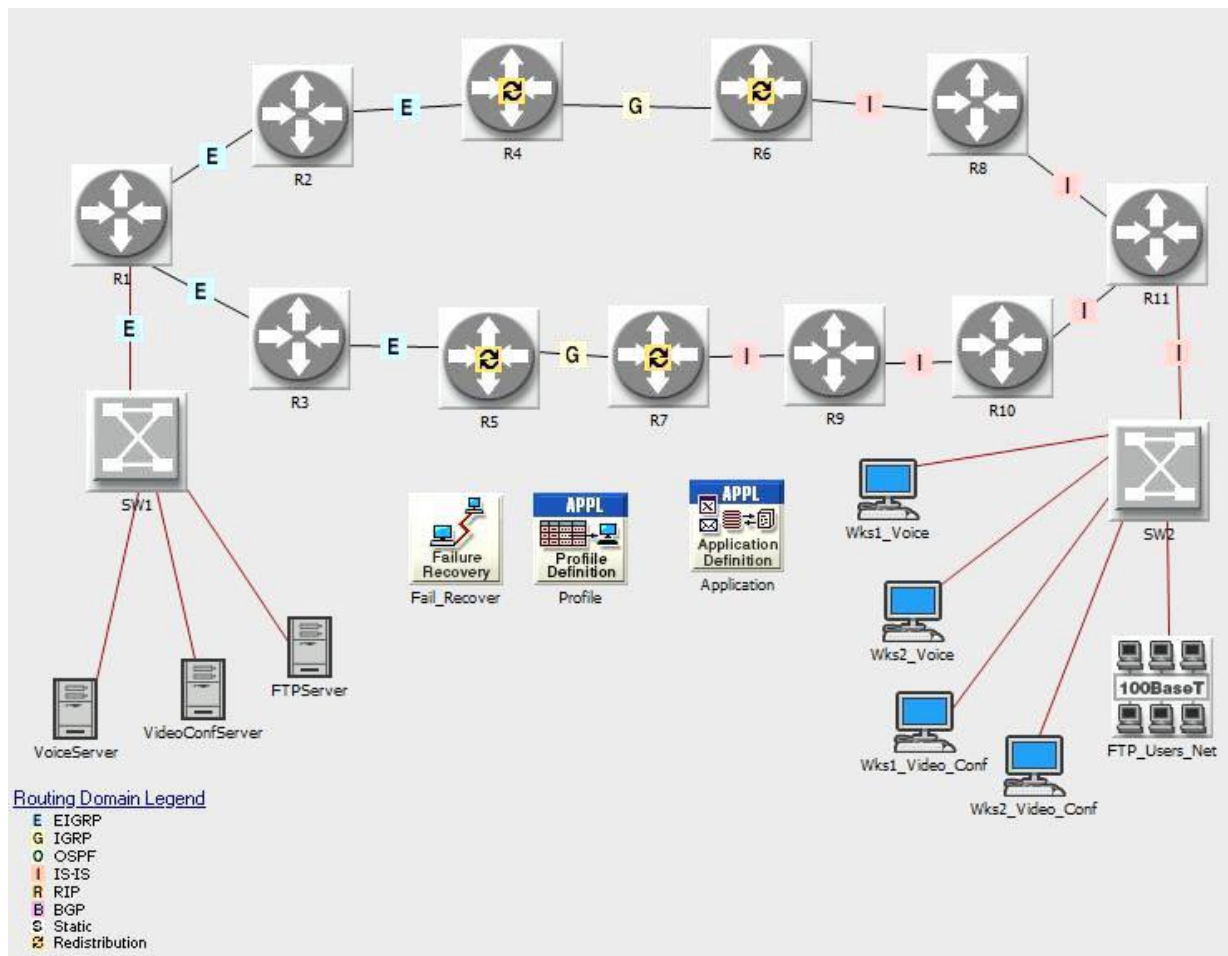


Figure 3.1: The EIGRP_IGRP_ISIS scenario

3.2. The Route Redistribution among OSPF, IGRP and IS-IS Routing Protocols

The second scenario is the route redistribution among OSPF, IGRP, and IS-IS which is named the OSPF_IGRP_ISIS scenario. We configured the redistribution parameters of OSPF protocol in the R4 and R5 boundary routers to redistribute the route information of OSPF protocol into IGRP protocol, and vice versa as shown in Figure 2. In the R6 and R7 border routers, we configured the redistribution parameters of IGRP protocol to distribute the route information of IGRP protocol into IS-IS protocol, and the redistribution parameters of IS-IS protocol are configured to redistribute its route information into IGRP protocol as depicted in Figure 3.2.

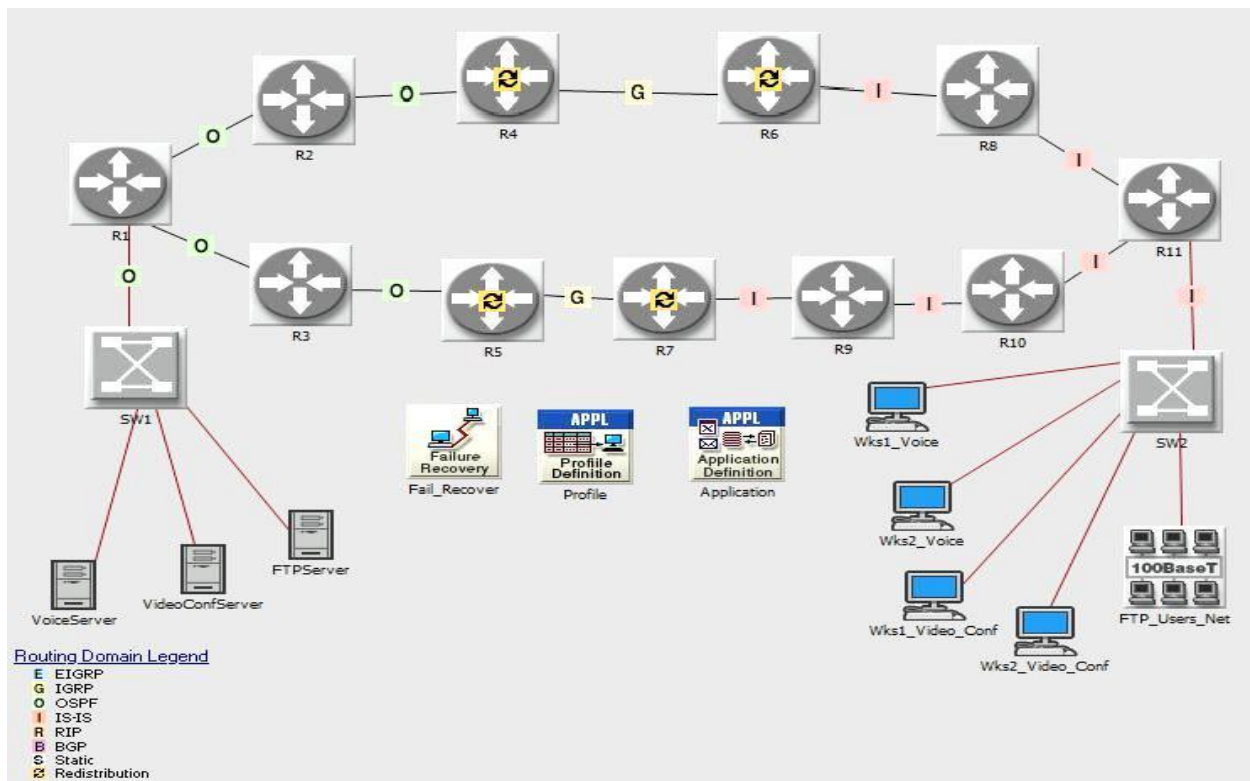


Figure 3.2: The OSPF_IGRP_ISIS scenario.

3.3. The Route Redistribution among OSPF, IGRP and EIGRP Routing Protocols

Figure 3 shows the third scenario that is the route redistribution among OSPF, IGRP, and EIGRP which is named the OSPF_IGRP_EIGRP scenario. In the R4 and R5 border routers, we configured the redistribution parameters of OSPF protocol to redistribute the route information of OSPF protocol into IGRP protocol, and vice versa as illustrated in Figure 3. We configured the redistribution parameters of IGRP protocol in the R6 and R7 border routers to distribute the route information of IGRP protocol into EIGRP protocol, and the redistribution parameters of EIGRP protocol are configured to advertise its route information into IGRP protocol as shown in Figure 3.3.

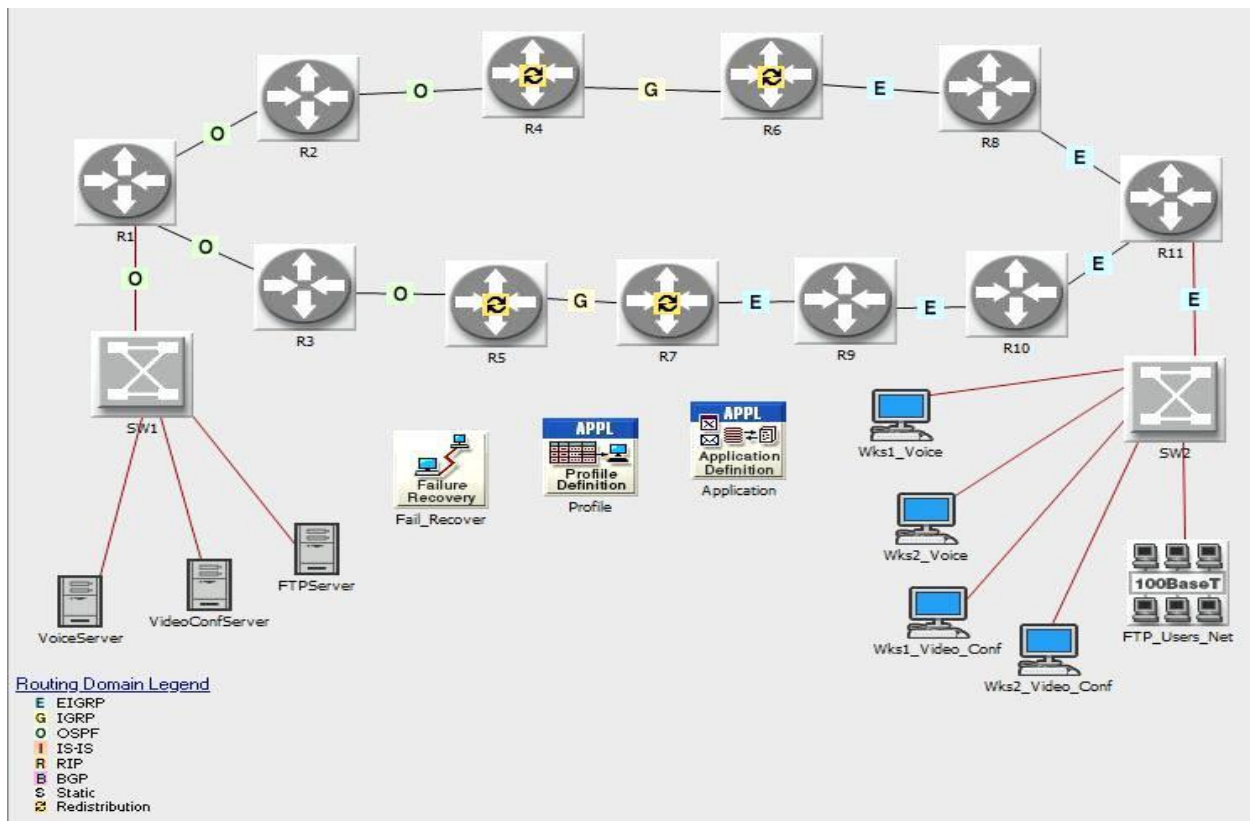


Figure 3.3: The OSPF_IGRP_EIGRP scenario.

4. THE RESULTS ANALYSIS

This section presents the results that obtained from the simulations of the three scenarios in this paper therefore, we analyse and compare the simulation results of the proposed scenarios then we make a decision about the scenarios in terms of the fitting applications for each scenario.

4.1. Network Convergence Time

We applied a Failure Recovery node as shown in Table 3.1 in order to analyse an average convergence duration time of the proposed network in this study, where a convergence duration time is how fast the convergence to reach a stable state in the network when a link in network failed or recovered.

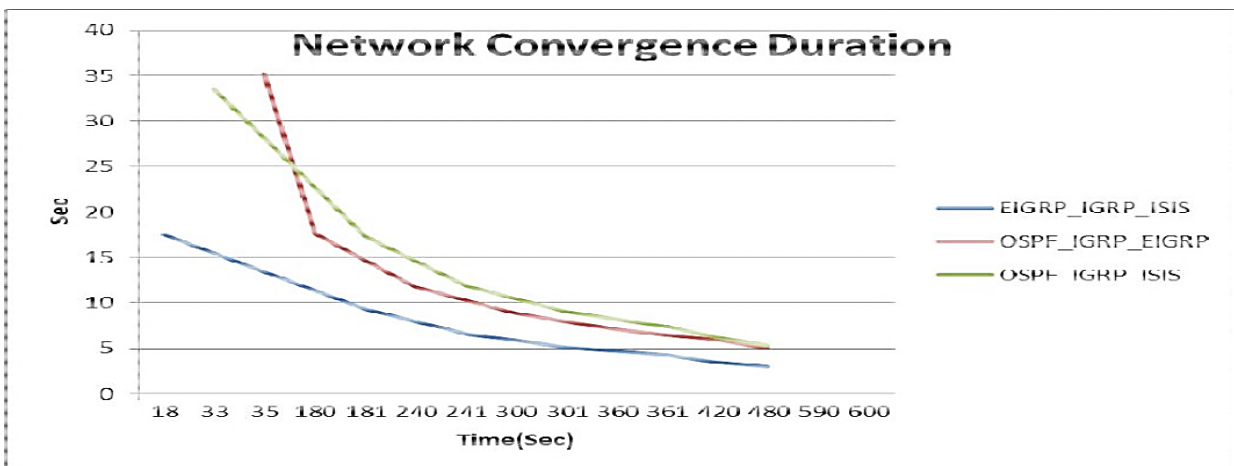


Figure 4.1: The network convergence duration.

Figure 4.1 shows the convergence time of the EIGRP_IGRP_ISIS scenario that has a better performance than the other scenarios since it has less convergence time before failures to be occurred in the network and after network recovery among the other scenarios. Therefore, the convergence duration time in the route redistribution among three protocols EIGRP, IGRP, and IS-IS is the fastest one in network convergence time.

4.2. Queuing Delay

The queuing delay is the packet time to enter the transmitter channel queue until the last bit of the packet is transmitted. It is used to measure a delay of point to point therefore we have measured the queuing delay in the link between SW2 and R11. We can see from Figure 4.2 the OSPF_IGRP_EIGRP scenario that has less the queuing delay before failure occurrence in the link between R11 and R8 thereafter the OSPF_IGRP_ISIS scenario outperforms the other scenarios in terms of the queuing delay because the OSPF_IGRP_ISIS is a mixed from the two link state routing protocols and one distance vector routing protocol and at the beginning, the link state routing protocols need much time to converge the network due to build their topological database thereafter they need less time to converge the network compared with the distance vector routing protocols consequently they withstand multiple links failure occurred in the network. Therefore, The OSPF_IGRP_ISIS scenario is less the queuing delay than the other scenarios.

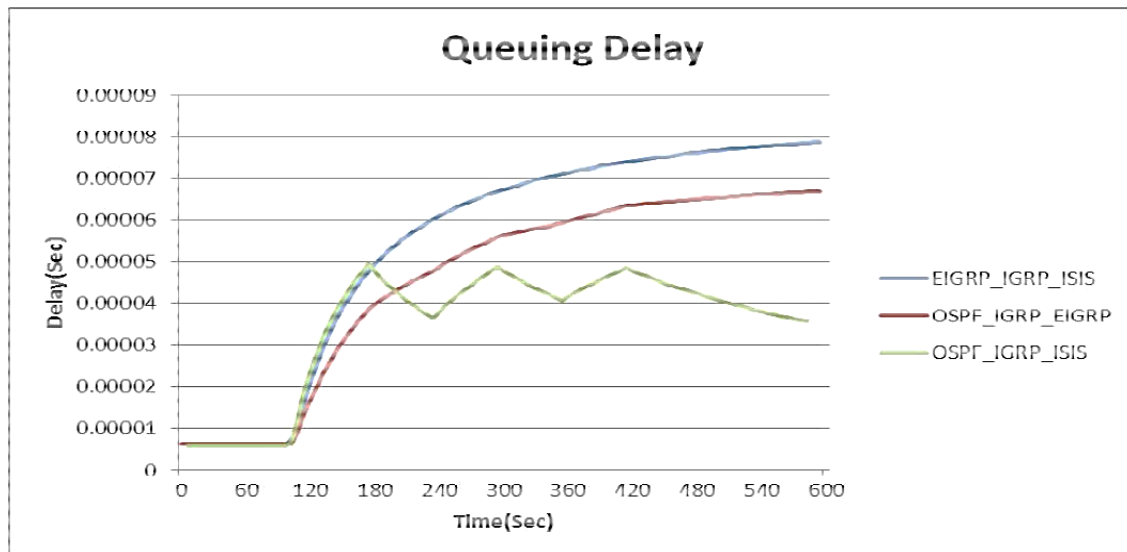


Figure 4.2: The queuing delay in the link between SW2 and R11

4.3. Throughput

Figure 4.3 shows the throughput of the link between SW2 and R11, where the throughput is the average number of packets successfully received by the receiver channel per seconds. At the beginning the three scenarios have the same throughput, thereafter failure or recovery in links are occurred as shown in Table 1. We can see the OSPF_IGRP_EIGRP that has higher throughput than the others do, but the EIGRP_IGRP_ISIS becomes better in terms of the throughput after three times of failure or recovery occurrences as shown in Figure 6. Thus, the throughput of the EIGRP_IGRP_ISIS scenario is better than the other scenarios, in case of multiple links failure or recovery are occurred in the network.

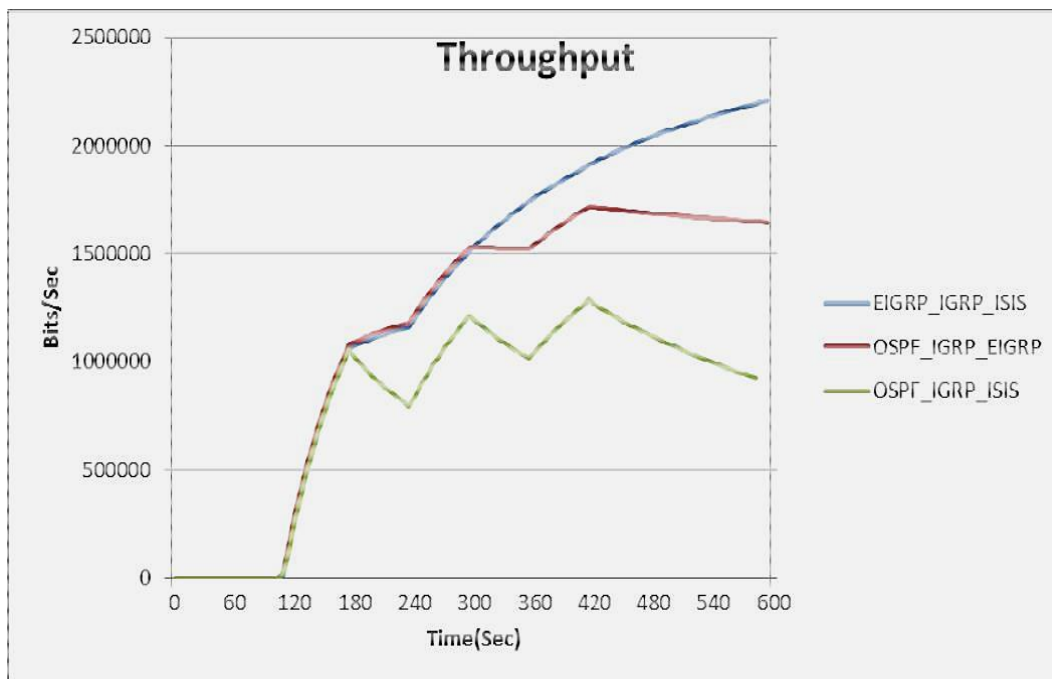


Figure 4.3. The throughput in the link between SW2 and R11.

4.4. Video Conferencing Packet Delay Variation

The EIGRP_IGRP_ISIS scenario is more stable than the others due to the difference between the values is closed to zero therefore it is the best performance in terms of the packet delay variation as shown in Figure 4.4.

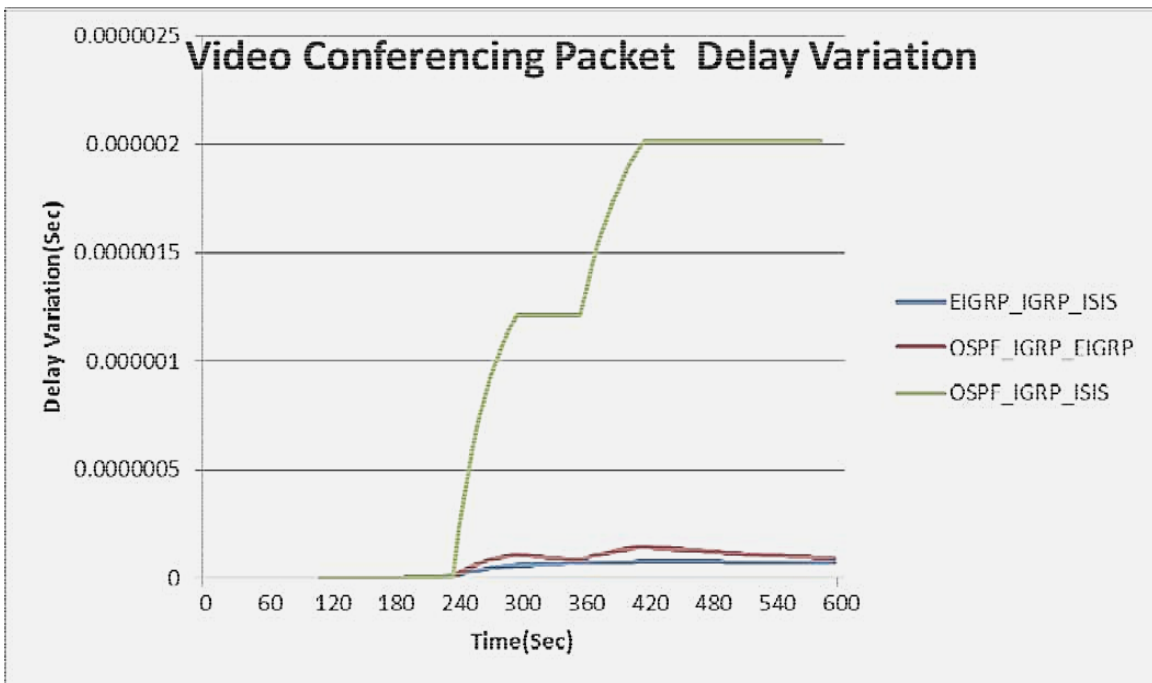


Figure 4.4: The video conferencing packet delay variation

4.5. Video Conferencing Packet End to End Delay

Figure 4.5 demonstrates the end to end delay of video conferencing service, where the end to end delay is the taken time to transmit a packet over the network from the sender to the receiver. As seen in Figure 4.5, the OSPF_IGRP_ISIS scenario has less packet end to end delay before failure or recovery in the links are occurred and after occurrence consequently it is better than the other scenarios in terms of the video conferencing end to end delay. We conclude from Figure 4.4 and

Figure 4.5 that the EIGRP_IGRP_ISIS scenario is better slightly than the OSPF_IGRP_ISIS scenario for video conferencing service.

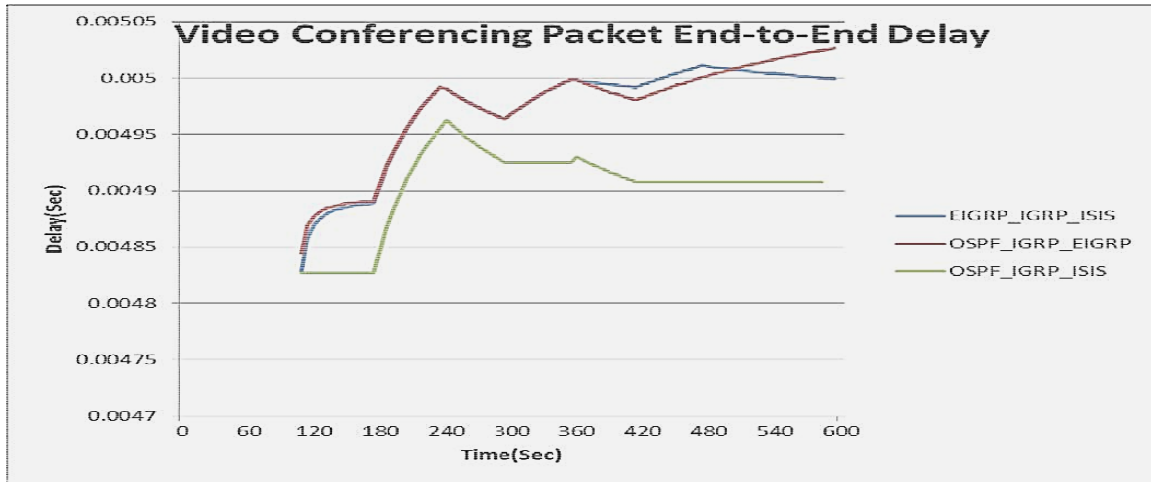


Figure 4.5: The video conferencing packet end to end delay.

4.6. Voice Jitter

The OSPF_IGRP_EIGRP scenario is better voice jitter from among the two other scenarios as seen in Figure 4.6, where a jitter is a variation in delay time of received packets.

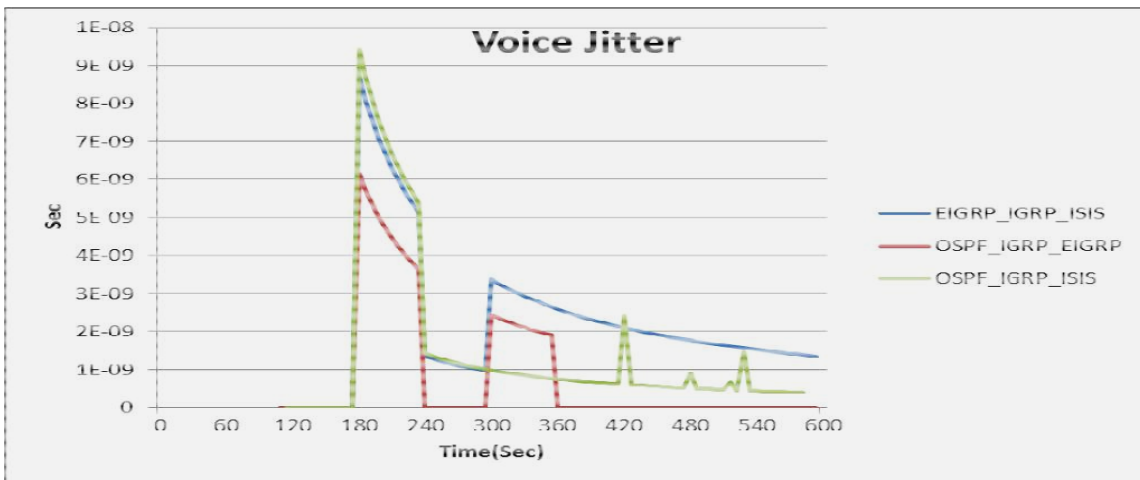


Figure 4.6: The voice jitter.

4.7. Voice Packet Delay Variation

Figure 4.7 shows the OSPF_IGRP_ISIS scenario is better slightly than the two other scenarios in terms of the voice packet delay variation. We notice from Figure 4. that the delay difference between the values in the three scenarios is around 0.1 msec at the beginning thereafter it goes to zero.

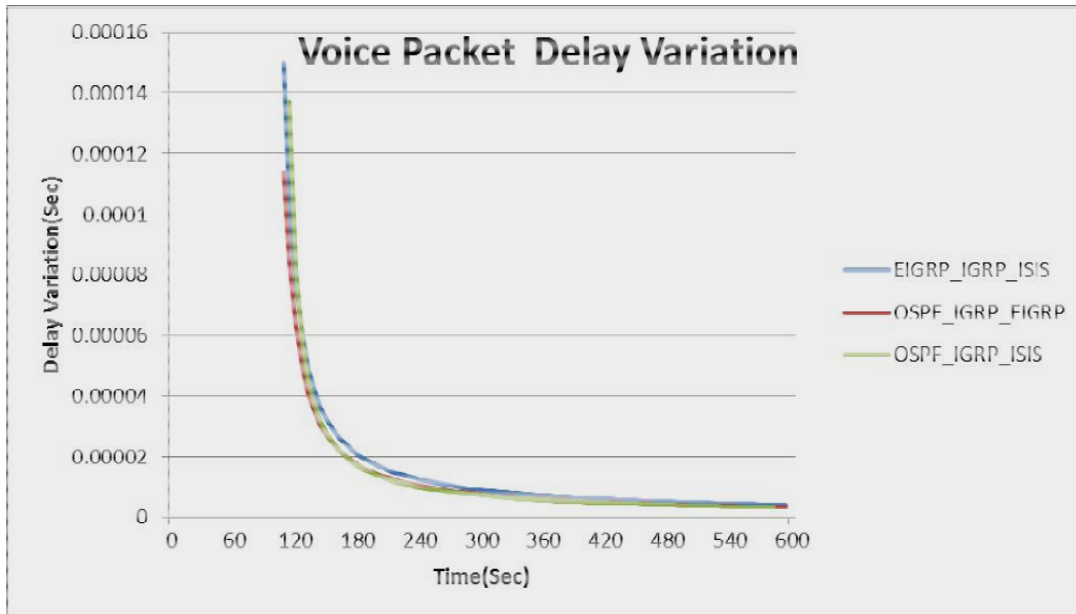


Figure 4.7: The voice packet delay variation.

4.8. Voice Packet End to End Delay

The OSPF_IGRP_ISIS scenario outperforms the two other scenarios in terms of the voice packet end to end delay as shown in Figure 4.8 therefore it is faster for sending a packet from source to destination over the network. We can see from Figure 4.6 to Figure 4.8 that the OSPF_IGRP_EIGRP scenario is better slightly than the OSPF_IGRP_ISIS scenario for voice service. Therefore, The OSPF_IGRP_ISIS scenario fits the real time applications such as voice and video conferencing.

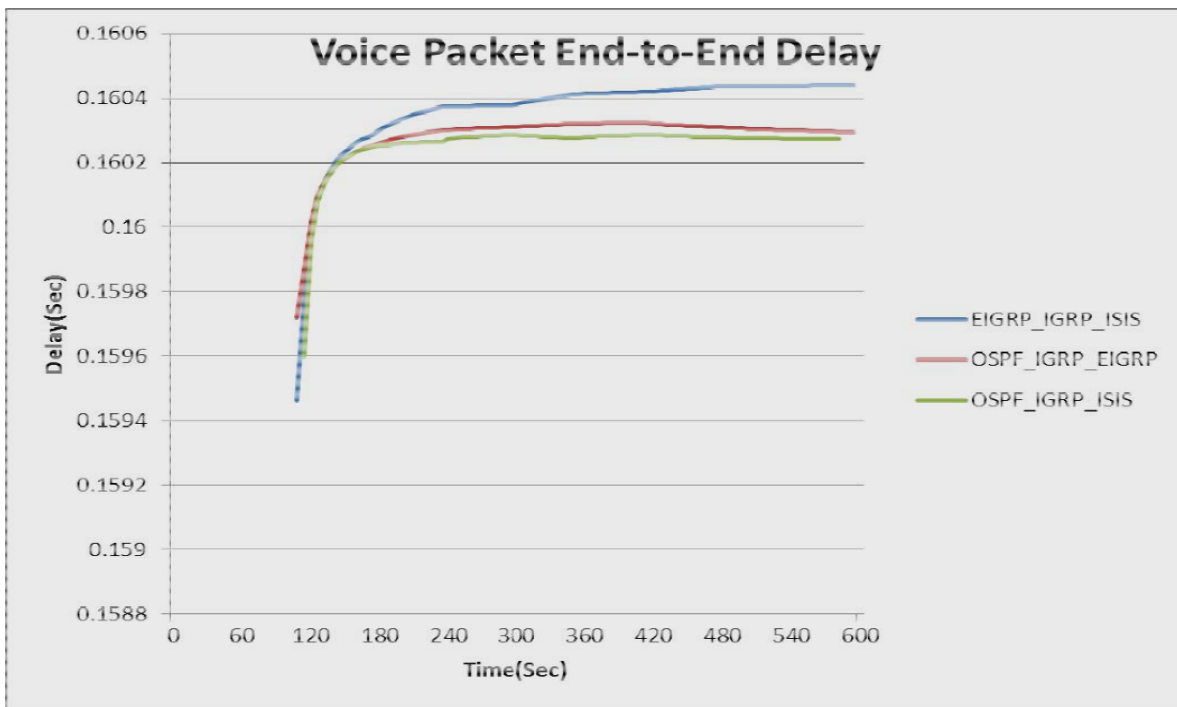


Figure 4.8: The voice packet end to end delay.

4.9. FTP Download Response Time

The response time of The EIGRP_IGRP_ISIS shows the best performance than the two other scenarios as shown in Figure 4.9 since it is the fastest one for the FTP downloading service.

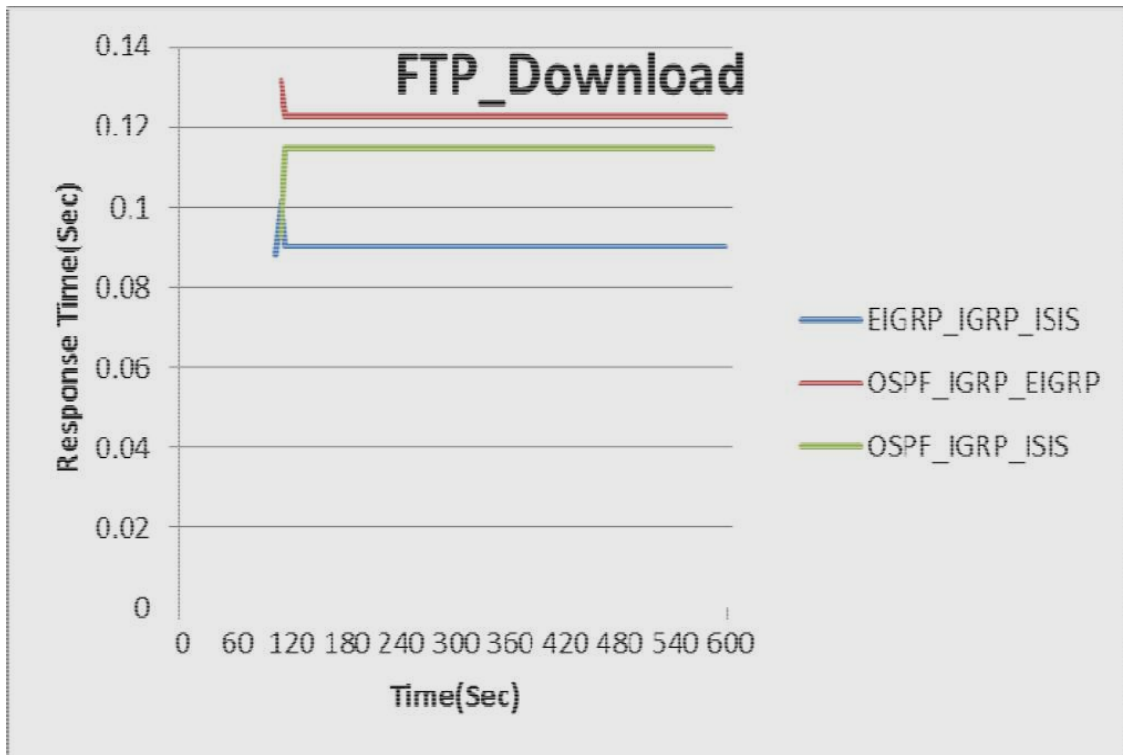


Figure 4.9: The FTP download response time.

4.10. FTP Upload Response Time

We can see from Figure 4.10 that the OSPF_IGRP_EIGRP scenario is faster the response time for the FTP uploading service before failure or recovery in the links are occurred whereas after failure or recovery occurred, it becomes higher slightly than the OSPF_IGRP_ISIS scenario. Therefore the OSPF_IGRP_EIGRP scenario has better slightly performance in terms of FTP uploading service. We can notice from Figure 4.9 and Figure 4.10 that the OSPF_IGRP_ISIS scenario fits FTP service in case of upload and download files are needed in the network.

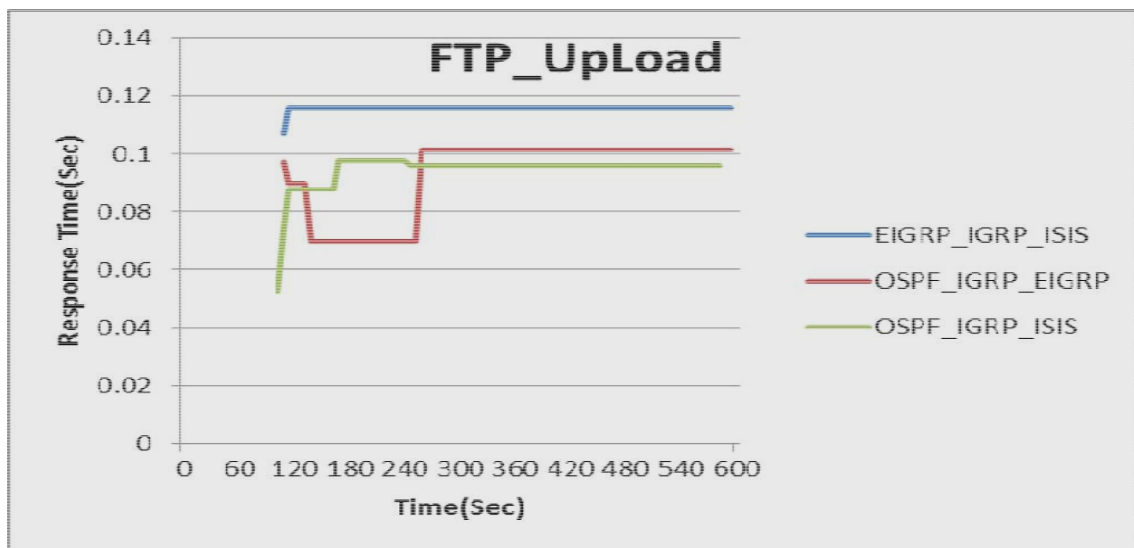


Figure 4.10: The FTP upload response time.

Finally, we present a quantitative comparison among the three proposed scenarios in terms of performance parameters in Table 2, where Table 2 shows the mean percentage performance value for each scenario in terms of convergence duration time, queuing delay, throughput, voice jitter, voice and video conferencing packet delay variations, voice and video conferencing packet end to end delays, FTP upload response time, and FTP download response time thereafter we rank each scenario into best, moderate, or worst according to its performance evaluation then we present the ranked results for the proposed scenarios in Table 3. We can notice from Table 2 and Table 3 that the OSPF_IGRP_ISIS scenario fits voice and video applications, on the other hand, the EIGRP_IGRP_ISIS scenario is a suitable for FTP download service, and in contrast, the OSPF_IGRP_EIGRP scenario is an appropriate for FTP upload service. We look deeply to the

percentages in Table 2 in order to make a decision about the best proposed scenario in this paper therefore the OSPF_IGRP_ISIS is a suitable for FTP and real application services.

Performance Para.(Mean) / Prop. Scenario	EIGRP_IGRP_ISIS	OSPF_IGRP_EIGRP	OSPF_IGRP_ISIS
Convergence time(sec)	100.00%	53.89%	54.38%
Queuing delay(sec)	64.36%	77.29%	100.00%
Throughput(bits/sec)	100.00%	88.62%	62.62%
Video conf. packet delay variation(sec)	100.00%	63.13%	4.23%
Video conf. packet end to end delay(sec)	98.62%	98.59%	100.00%
Voice jitter(sec)	37.77%	100.00%	57.30%
Voice packet delay variation(sec)	80.68%	98.88%	100.00%
Voice packet end to end delay(sec)	99.93%	99.99%	100.00%
FTP download response(sec)	100.00%	73.42%	78.77%
FTP upload response(sec)	80.32%	100.00%	98.27%

Table 4.1 The performance parameters comparisons among the proposed scenarios in terms of the percentage of mean value.

5. CONCLUSIONS

The route redistribution is an important issue in a boundary router configuration for a giant network such as an enterprise or university network that is used multiple routing protocols. We have created the three scenarios with diverse routing protocols configuration on the same network. The first scenario is configured from EIGRP, IGRP, and IS-IS, the route redistribution among OSPF, IGRP and EIGRP that is configured in the second scenario, and the third scenario is the combination of OSPF, IGRP, and IS-IS. The simulation showed the performance of the EIGRP_IGRP_ISIS scenario that is better in terms of FTP download response time, video packet delay variation, throughput, and network convergence time as compared with the other scenarios in this paper. On the other hand, the performance of the OSPF_IGRP_ISIS scenario outperforms the two other scenarios in terms of voice packet delay variation, voice and video conferencing packet end to end delay, and queuing delay. In contrast, the OSPF_IGRP_EIGRP scenario is better than the others in terms of FTP upload response time, and voice jitter. We notice from Table 3 that the OSPF_IGRP_ISIS scenario has strengths and slight weaknesses in terms of the performance parameters in our simulation. Therefore, we can conclude that the OSPF_IGRP_ISIS scenario withstands the links fluctuation between failure and recovery in the network; therefore it is a suitable for FTP service, and real time applications.

Performance Para. /Prop. Scenarios	EIGRP_IGRP_ISIS	OSPF_IGRP_EIGRP	OSPF_IGRP_ISIS
Convergence time	Best	Worst	Moderate
Queuing delay	Worst	Moderate	Best
Throughput	Best	Moderate	Worst
Video Con. packet delay variation	Best	Moderate	Worst
Video con. packet end to end delay	Moderate	Worst	Best
Voice jitter	Worst	Best	Moderate
Voice packet delay variation	Worst	Moderate	Best
Voice packet end to end delay	Worst	Moderate	Best
FTP download response	Best	Worst	Moderate
FTP upload response	Worst	Best	Moderate

Table 5.1 The performance parameters comparisons among the proposed scenarios.

Reference

- 1) G. Malkin, (Nov. 1998), "RIP version 2," RFC 2453.
- 2) Cisco, (Aug. 2005), "An Introduction to IGRP"
- 3) Cisco. (Jun. 2016). "Enhanced Interior Gateway Routing Protocol".
- 4) ParkHurst William R (1998) : "Cisco Router OSPF : Design and Implementation Guide Cisco Technical Expert", McGraw-Hill Professional.
- 5) J. T. Moy, (Apr. 1998), "OSPF version 2," RFC 2328.
- 6) Jose, San, (2006) . "Cisco IOS IP Configuration Guide". USA : Cisco System, Inc. CA 95134-1706.
- 7) D. Oran, (Feb. 1990), "OSI IS-IS intra-domain routing protocol," RFC 1142.
- 8) F. Le, G. G. Xie, and H. Zhang, (2007), "Understanding route redistribution", In Proc. International Conference on Network Protocols.
- 9) Xin Sun, Sanjay G. Rao, Geoffery G. Xie, (Dec. 2012), "Modeling Complexity of Enterprise Routing Design", Proceedings of the 8th international conference on Emerging networking experiments and technologies, pp. 85-96, Nice, France, December 10 - 13, 2012
- 10) D. Maltz, G. Xie, J. Zhan, H. Zhang, G. Hjalmtysson, and A. Greenberg, (2004), "Routing design in operational networks: A look from the inside", In Proc. ACM SIGCOMM, 2004.
- 11) Cisco, (Mar, 2012), Redistributing Routing Protocols.
- 12) Cisco, (Aug. 2005), "OSPF Design Guide".
- 13) Cisco, (2002), "Introduction to Intermediate System-to-Intermediate System Protocol".
- 14) S. Farhangi, A. Rostami and S. Golmohammadi, (2012), "Performance Comparison of Mixed Protocols Based on EIGRP, IS-IS and OSPF for Real-time Applications", Vol. 12 ,Issue 11, pp. 1502-1508, Middle-East Journal of Scientific Research.
- 15) Golap Kanti Dey et al, (2015), "Performance Analysis and Redistribution among RIPv2, EIGRP & OSPF Routing Protocol", 1st International Conference on Computer & Information Engineering (ICCI 2015), At Rajshahi University of Engineering & Technology (RUET), Rajshahi ,Bangladesh.
- 16) Chairul Mukmin, Darius Antoni and Edi Surya Negara, (February 2016), "Comparison Route Redistribution on Dynamic Routing Protocol (EIGRP into OSPF and EIGRP into IS-IS)", pp. 113-119, The 5th ICIBA 2016, International Conference on Information Technology and Engineering Application Palembang-Indonesia, 19-20 February 2016.

- 17) Mr.R. Jayaprakash and Ms.K. Saroja, (Jul. 2015), "RIP, OSPF, EIGRP Routing Protocols", *International Journal of Research in Computer Application and Robotics*, Vol. 3 Issue. 7, pp. 72-79.
- 18) Fatima A. Hamza and Amr M. Mohamed, (Oct. 2011), "Performance comparison of two dynamic routing protocols: RIP and OSPF", *Journal of Emerging Trends in Computing and Information Sciences*, Vol. 2, No. 10, pp.509-513.
- 19) Vishal Nigam, Md. Samil Farouqui and Gunjan Gandhi, (Feb. 2014), "Enhanced Comparative Study of Networking Routing Protocols", *International Journal of Advanced Research in Computer Science and Software Engineering*, Vol. 4, Issue 4.
- 20) N. Nazumudeen and C. Mahendran, (Feb. 2014), "Performance Analysis of Dynamic Routing Protocol Using Packet Tracer", *International Journal of Innovative research in Science, Engineering and Technology*, Vol. 3, Issue 1, p.570-574.
- 21) Amrah Baba Ali and et al., (2016), "A Comparative Study of IGP and EGP Routing Protocols, Performance Evaluation along Load Balancing and Redundancy across Different AS", *IMECS*, March 16-18, 2016, Hong Kong.
- 22) Archana C, (Mar. 2015), "Analysis of RIPv2, OSPF, EIGRP Configuration on router Using CISCO Packet tracer", Vol. 2, Issue 2, p. 215-222, *IJESIT*.
- 23) Sandra Sendra and et al., (2010), "Study and Performance of Interior Gateway IP Routing Protocols", Vol. 2, No. 4, p. 88-117, *Network Protocols and Algorithms*.
- 24) Abhishek Verma and Neha Bhardwaj, (2016), "A Review on Routing Information Protocol (RIP) and Open Shortest Path First (OSPF) Routing Protocol", Vol. 9, No. 4, pp. 161-170, *International Journal of Future Generation Communication and Networking*.
- 25) V.Vetriselvan, Pravin R.Patil and M.Mahendran, (2014), "Survey on the RIP, OSPF, EIGRP Routing Protocols", Vol. 5(2), pp. 1058-1065, (*IJCSIT*) *International Journal of Computer Science and Information Technologies*.
- 26) JASWINDER KUMAR, SAMIKSHA, SUSIL BHAGAT and KARANJIT KAUR, (Feb. 2015), "ROUTE REDISTRIBUTION BETWEEN EIGRP AND OSPF ROUTING PROTOCOL IN COMPUTER NETWORK USING GNS3 SOFTWARE", Vol. 5, Issue 1, pp.27-34, *International Journal of Computer Networking, Wireless and Mobile Communications (IJCNWMC)*.
- 27) Chaganti B N Lakshmi and Dr. S.K.Mohan Rao, (Jan. – Mar. 2016) "Routing Layer Design issues and Protocols for Wired and Wireless Networks", Vol. 7, Issue 1, pp.9-13, *International Journal of Computer Science And Technology*.

- 28) Vasudha and Dr.G.K.Jindal, (May 2011), "Investigations and Performance Evaluation of Dynamic Routing Protocol with New Proposed Protocol for WAN",Vol. 3 No. 5 , pp. 1970-1979, *International Journal on Computer Science and Engineering (IJCSE)*.
- 29) Mustafa Abdulkadhim, (March 2015), "Routing Protocols Convergence Activity and Protocols Related Traffic Simulation With Its Impact on the Network",Vol 5, Issue 3, pp. 40-43,*International Journal of Computer Science Engineering and Technology(IJCSET)*.
- 30) Priya Asher, (2015), "Comprehensive Analysis of Dynamic Routing Protocols in Computer Networks", Vol. 6, Issue 5, pp. 4450-4455, *International Journal of Computer Science and Information Technologies (IJCSIT)*.
- 31) Bhavna Rathi and Er. Farminder Singh, (Jul-Aug 2015),"Performance Analysis of Distance Vector and Link State Routing Protocols", Vol. 3, Issue 4, pp.23-32, *International Journal of Computer Science Trends and Technology (IJCST)*.
- 32) Paramjeet Singh Sandhu, Kamaljit Singh Bhatia, and Harsimrat Kaur, (2013), "Comparative Study of Various Router Protocols",pp. 13-15,*International Conference on Innovations in Engineering and Technology (ICIET'2013) Dec. 25-26, 2013 Bangkok (Thailand)*.
- 33) Neha Grang et al, (March-May, 2013), "Compare OSPF Routing Protocol with other Interior Gateway Routing Protocols",*International Journal of Engineering, Business and Enterprise Applications*, 4(2), pp. 166-170.
- 34) Shubhi and Prashant Shukla, (October 2015), "Comparative Analysis of Distance Vector Routing & Link State Protocols",Vol. 3, Issue 10,pp.9533-9539,*International Journal of Innovative Research in Computer and Communication Engineering*.
- 35) Sonam, Rajan Vohra and Dr. Ravinder Singh Sawhney, (June 2014), "Dynamic Routing Protocols Analysis based on Dissimilar Number of Packets",Vol. 2, No. 4,pp.50-55,*The SIJ Transactions on Computer Networks & Communication Engineering (CNCE)*.
- 36) Hamed Jelodar and Pouya Nikravesh, (March 2014), "ASSESSMENT OF RIP-V1 AND OSPF-V2 PROTOCOL WITH CONSIDERATION OF CONVERGENCE CRITERIA AND SENDING PROTOCOLS TRAFFIC", Vol. 8, No. 21,pp.1-4,*Advances in Science and Technology Research Journal*.
- 37) D.VENKATAVARA PRASAD, SURESH JAGANATHAN and G.P SAIKALYAN, (2016), "Study and Analysis of Dynamic Routing Protocols in real time for Optimal Resource Utilization",vol. 1,pp.21-29,*International Journal of Communications*.
- 38) ARSALAN IQBAL and SAMEER LIAQAT ALI KHAN, (JANUARY 2015), "Performance Evaluation of Real Time Applications for RIP, OSPF and EIGRP for flapping links using OPNET

- Modeler", VOL. 3, NO. 1, pp.16–26, International Journal of Computer Networks and Communications Security.*
- 39) *Jaswinder Kumar, Samiksha, Amandeep Kaur and Harsukhpreet singh, (Jan-Feb 2015), "Performance Analysis of RIPv2 protocol in Wired Network Using Cisco Packet Tracer", Vol 6, no.1, pp.1-6, Int.J.Computer Technology & Applications, IJCTA.*
- 40) *Haresh N. Patel, Prof.Rashmi Pandey, (Sept-Oct 2014), "Enhanced Analysis on Route Summarization and Route Redistribution with OSPF vs. EIGRP Protocols Using GNS-3 Simulation", Vol 5 (5), 1682-1689, Int.J.Computer Technology & Applications(IJCTA).*
- 41) *Mabubur Syed and Isaac Yerima Ambore, (November 2016), "PERFORMANCE EVALUATION OF OSPF AND RIP ON IPV4 & IPV6 TECHNOLOGY USING G.711 CODEC", Vol.8, No.6, pp. 1-15, International Journal of Computer Networks & Communications (IJCNC).*
- 42) *Chandra Wijaya ,(2011), "Performance Analysis of Dynamic Routing Protocol EIGRP and OSPF in IPv4 and IPv6 Network", ICI '11 Proceedings of the 2011 First International Conference on Informatics and Computational Intelligence ,Pages 355-360 December 12 - 14, 2011, IEEE Computer Society Washington, DC, USA ©2011.*
- 43) *D.Gurupandi , K.kumarra tamizh parithi, R.parthiban and M. gajendiran, (2015), "INTERCONNECTING ROUTING PROTOCOLS", 3rd International Conference on Advanced Research in Biology, Engineering, Science and Technology (ICARBEST'16), pp. 41-45.*