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SIMULATION BASED APPRAISAL STUDY OF OSPF AND EIGRP FOR EFFECTIVE COMMUNICATION NETWORK

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ABSTRACT:
Today, internet is playing a vital role in communication networks and this computer communication networks are based on technology that provides technical infrastructure, where routing protocols are used to transmit packets across the network. The Open Systems Interconnection (OSI) reference model was created, to determine the compatibility of various connected devices for communication. The routing protocols are implemented in the network layer of the model, providing the set of rules for devices to route data packets towards the destination. This paper focuses on two (2) routing protocols: Open Shortest Path First (OSPF) and Enhanced Interior Gateway Routing Protocol (EIGRP) which is a member of Interior Gateway Protocol (IGP). Different protocols use different algorithms to route its packets and this affects the overall performance of the network. OSPF and EIGRP were used to distribute routing information between routers in the same autonomous system. Extensive experiments have been conducted to analyze and compare a set of characteristics of OSPF and EIGRP on an application like video Conferencing by using OPNET Modeler in an enterprise partial mesh network topology to determine the best protocol for a fast network convergence. Hence, this research simulates three network topologies and the results clearly show that EIGRP converges faster than OSPF and also EIGRP has the least Point to Point Queuing Delay than OSPF.

Keywords: *OSPF, EIGRP, OPNET Modeler, Simulation, Routing Protocols*

INTRODUCTION

In recent time, computer communication networks are growing rapidly day by day. Routing protocols facilitates provision of services such as file transfer, file sharing, and video streaming and voice conferencing. Today's technology is based on IP routing, (Todd, 2005); Routing protocols play important role in data communication network and determine how network communications flows. There are commonly used routing protocols like Routing Information Protocol (RIP), Open Shortest Path First (OSPF) and Enhanced Interior Gateway Routing Protocol (EIGRP), Interior Gateway Routing Protocol (IGRP), Intermediate System to Intermediate System (IS-IS). Routing Protocols specifies how the information about the links such as bandwidth, link failure and error rate are communicated between the routers. It includes the process of selecting the best route in a network, based on various routing metrics used by different protocols. According to Nikolaidis (2002), the various metrics are: reliability of the link, length of the path, available Bandwidth, delays in a network, System load, Cost of communication.

Some protocols use multiple metrics and others combine the routing metrics to form a single hybrid metric. These metrics are used to calculate the optimum path for transfer of data from one network to the other. Routing protocols are essentially separated into two categories. First type is the interior gateway routing protocols which are distance vector, link state and hybrid routing protocol. Routing Information Protocol (RIP), Open Shortest Path First (OSPF), Interior Gateway Routing Protocol (IGRP) and Enhanced Interior Gateway Routing Protocol (EIGRP) are the cases of interior gateway routing protocols. Second type is the Exterior Gateway Routing Protocols (EGRP). Boarder Gateway Protocol (BGP) is an example of Exterior Gateway Routing Protocols. The basic routing protocols move traffic across the networks, (Thorenoor, 2010) and the corresponding routers should be aware of where they forward the data in order to reach the correct destination node. Thus, for effective network performance, routing protocols play a crucial role.
Protocols use different algorithm to route the packets and this may vary the route processing delay as well as the network efficiency. As a consequence, the impact of different algorithm can affect the overall performance of the network for better traffic flow. A consideration is made on two routing protocols OSPF and EIGRP with real time applications to determine the best routing protocol between them and thus implement that on an enterprise network for better traffic flow.
Looking at the important place the implementation of OSPF and EIGRP occupy in an enterprise network, there is the need to give network programmers the best possible analysis that will enable them choose the best protocol to implement when designing a network and to also help them to overcome challenges ahead in the implementation of such network.
The study will equally assist the clients or the organization to know the actual reasons behind the preferred routing protocol chosen in the design and implementation of their network topology.
Hence, the rest section is focused on comparative analysis of OSPF and EIGRP routing protocols on a computer communication network using OPNET modeler 17.5 and the series of steps involved in the design and simulation of the appraisal study.

LITERATURE REVIEW

Chris (2006) observes an approach for tuning dynamic routing systems using link metrics and focusing on the EIGRP dynamic routing protocol in order to get consistent and expected failover of dynamically routed links in complex networks. It examines: architectural issues for designing enterprise network backbones with redundant links; operational routing issues associated with configuring "hot spare" routers and contingency backbone sites; and finally a metrics system for tuning the routing system where multiply redundant links (redundant groups of redundant links) are used. He observed that to be able to route packets, a router must know, at a minimum, the following: destination address, neighbor routers from which it can learn about remote networks, possible routes to all remote networks, the best route to each remote network, how to maintain and verify routing information

Over the past two decades, a lot of research has been published on the comparative performances of IGPs. BGP is advisable when multi-homing to multiple ISP's or when trying to communicate with an alternate Autonomous System (Kurose and Ross, 2010). Mirzahossein et al (2013) opined that OSPF has the best detection mechanism but is practically more suitable for limited networks because of the higher possibility for packets to drop from different areas while EIGRP is better suited for scalable networks. Waqas (2009) Suggests that EIGRP is more suitable for topologies with few routers while IS-IS is ideal for complex topologies because of its higher scalability feature. Sendra et al (2010) studied their implementation with varying sizes of topologies and suggested that EIGRP is better suited for networks with the critical delivery that cannot tolerate errors while OSPF is more suitable for networks with bandwidth constraints. George et al (2006) evaluates the Enhanced Interior Gateway Routing Protocol (EIGRP) via packets simulation. EIGRP, an intra-domain routing protocols developed by Cisco, is mainly based on the Diffusing Update Algorithm (DUAL) which computes shortest paths distributed without creating routing-table loops or incurring counting-to-infinity problem. Previous studies showed EIGRP's ability to adapt quickly to routing changes in medium-scale networks. Farhangi et al (2012) opined that implementation of multiple IGPS within a single topology, so as to be able to use the best of all the protocols for higher throughput and lower bandwidth utilization, would be a more effective approach to gain higher throughput while minimizing bandwidth utilization. Labovitz et al (2000) Proved that the routing system will converge to a stable path when service providers can set rankings and filters autonomously. Large scale IP networks are impossible to provide the appropriate site to site paths without routing protocols. Interior Gateway (Routing) Protocols (IGPs) are used within a domain for routing i.e. a network that is within the control of an organization.

Shortest Path First (OSPF) and Enhanced Interior Gateway Protocol (EIGRP) are routing protocols which are member of Interior Gateway Protocol (IGP). OSPF and EIGRP will distribute routing information between routers in the same autonomous system. This research studies how the OSPF and EIGRP routing protocols work and compare these dynamic routing protocols. It also simulates the recovery rate of the algorithms on some network topology and show the various output of the analysis from the OSPF and EIGRP from the different network topologies

ROUTING PROTOCOLS OVERVIEW

Routing protocol is the language used for communication between routers about the state of the links within the networks. It works with different algorithms and is usually classified into two groups: namely static routing and dynamic routing. This is shown in Figure 1. Static routing is a manual routing process while dynamic routing is a non-manual process. This research is focused on dynamic routing protocols namely: OSPF and EIRGP.

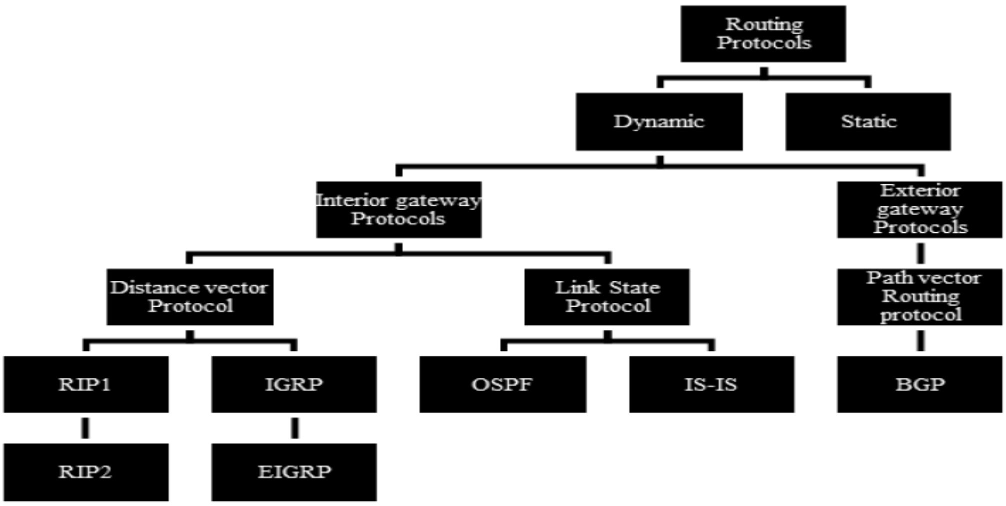

Figure 1: Classification of Routing Protocols (Source: Mirza & Sanjay, 2016)

Routing protocols can also be classified into two based on algorithms: distance vector and link state. Distance vector protocols use Bellman-Ford algorithm and Ford-Fulkerson algorithm in path calculation. Link state searches for optimal path from built topology and it requires more system resources. Chandra (2011) opined that Link-state routing protocol is also known as shortest path routing protocol, as it compute the finest path in the network which is the shortest path available from the source network to the destination network. OSPF is based on link state methodology, thus, OSPF works by using the Dijkstra algorithm (Todd, 2007).

Chandra (2011) stated that Distance vector routing protocol present routes as function of distance and direction vectors where the distance is represented as hop count and direction is represented as interface. In the distance vector routing protocol, Bellman-Ford algorithm is used for the path calculation where router take the position of the vertices and the links.

EIGRP uses a complex equation to find the Route Metric Value. EIGRP considers the following network performance related attributes to calculate the EIGRP metric value:

i) Bandwidth
ii) Delay

iii) Reliability
iv) Load
v) Maximum Transmission Unit (MTU)

i. Bandwidth
Bandwidth is defined as 10^7 Kbps divided by the slowest link along the path. Because routing protocols select the lowest metric, inverting the bandwidth (using it as the divisor) makes faster paths have lower costs.

ii. Load and reliability
Load and reliability are 8-bit calculated values based on the performance of the link. Both are multiplied by a zero K-value, so neither is used. Hence, it is dynamically computed as a rolling weighted average over five seconds.

iii. Delay
Delay is a constant value on every interface type, and is stored in terms of microseconds. For example, serial links have a delay of 20,000 microseconds and Ethernet lines have a delay of 1000 microseconds. EIGRP uses the sum of all delays along the path, in tens of microseconds.

Hence, EIGRP $\text{Metric} = 256 * [\text{K1} * \text{Bandwidth} + \frac{\text{K2}*\text{Bandwidth}}{256-\text{Load}} + \text{K3} * \text{Delay}] * \frac{\text{K5}}{\text{Reliability}+\text{K4}}$
By default, the values of K1 and K3 are set to 1, and K2, K4 and K5 are set to 0. Hence, the above equation is deduced to:
EIGRP Metric $= 256 * (Bandwidth + Delay)$
When K5 is equal to 0 then [K5 / (reliability + K4)] is defined to be 1
Substituting the earlier description of variables, the equation becomes 10,000,000 divided by the chokepoint bandwidth plus the sum of the delays:

$$\text{Metric} = 256 * \left[\frac{10^7}{\min(bandwidth)} + \sum \frac{delay}{10}\right]$$

NETWORK SIMULATION METHODOLOGY
Three methods are available for comparative analysis of OSPF and EIGRP routing protocols in a network which include: Mathematical or analytical method, Direct measurement and Computer simulation. Computer simulation method was chosen after due considerations among the three methods. The simulation software chosen for this work is OPNET Modeler. The work flow methodology of OPNET modeler is as shown in figure 2.

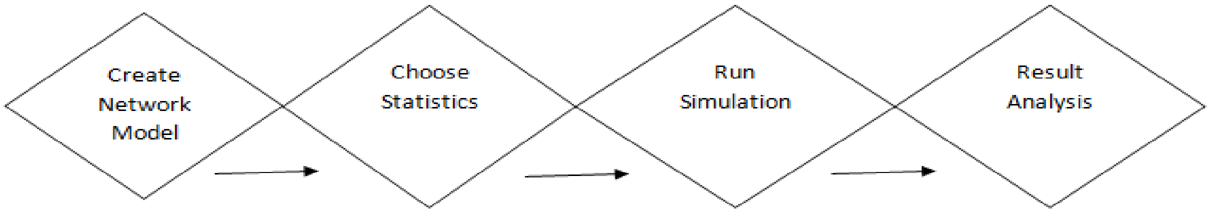

Figure 2: Design Steps

OPNET's structure
OPNET is a C and C++ built high level UI (User Interface) that comes with a very wide library for its functions and has a hierarchical structure that is divided in 3 domains: namely network domain, node domain and process domain.

a) **Network domain:** In the network model configuration, physical connection and interconnection can be included and it represents the overall system such as geographical map, network and sub network to be simulated.

b) **Node Domain:** Node domain is the network's domain internal infrastructure and can be workstations, switches, routers, satellite etc.

c) **Process Domain:** The process domain specifies the processor's attribute model by using C++ source code that is inside the nodes. In more detail, process domain includes all modules which are programmable by the user and executes tasks or processes.

NETWORK TOPOLOGY DESIGN
Network topology is the arrangement of different component of a computer network such as devices and cabling. Network topology can be either physical or logical. The arrangement of devices and cables is referred to as physical topology while logical topology deals with network data. The topology of the network used in this research is as shown in Figure 3. This topology is applied to the three scenarios used in this simulation.

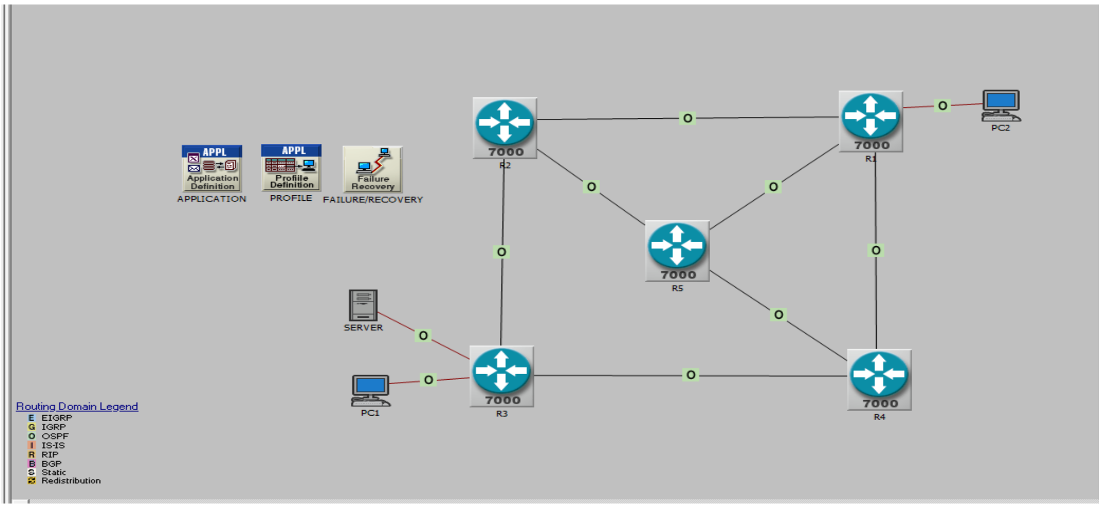

Figure 3: Model Configuration Network Topology

The network scenario consists of 5 Cisco routers connected in a partial mesh network topology; the routers are connected using Point-to-Point Digital Signal 3 (PPP_DS3) links with bandwidth of 44.736Mbps. A connection of 100BaseT link runs through the routers to the server and the personal computer (PC). The data in the network is provided by the server connected through router 3. In the network, the application configuration and profile configuration is set up particularly for video conferencing applications. A failure recovery is setup in the link between the router 2 and router 1 in the first topology (scenario), router 1 and router 4 in the second topology (scenario), and router 5 and router 4 in the third topology (scenario).

The Figure 3 shows OSPF protocol being implemented throughout the designed network, the same model network has been used while engaging and testing the other routing protocol which is EIGRP.

CONFIGURATIONS APPLIED TO THE NETWORKS

Application Configuration

Figure 4 to Figure 5 shows the set up for application configuration and profile configuration respectively, the main application in consideration is video conferencing.

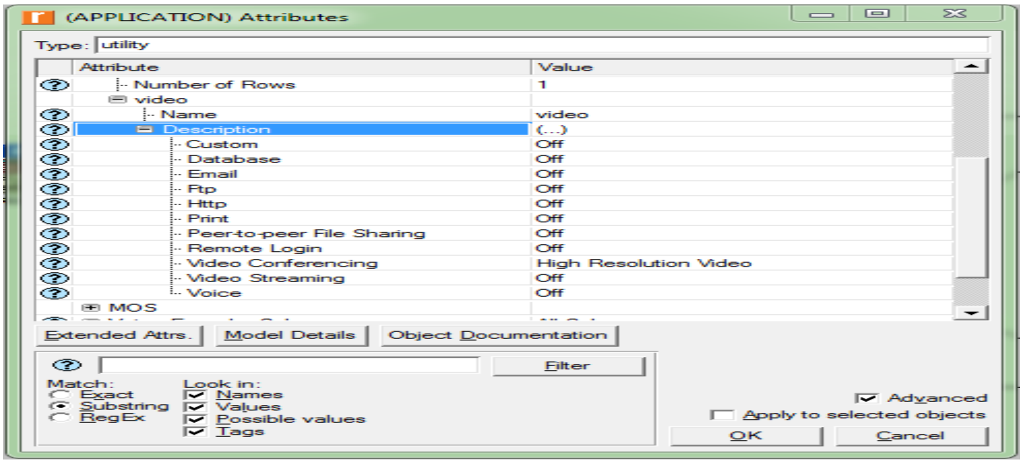

Figure 4: Application Configuration (Video Conferencing)

Profile Configuration

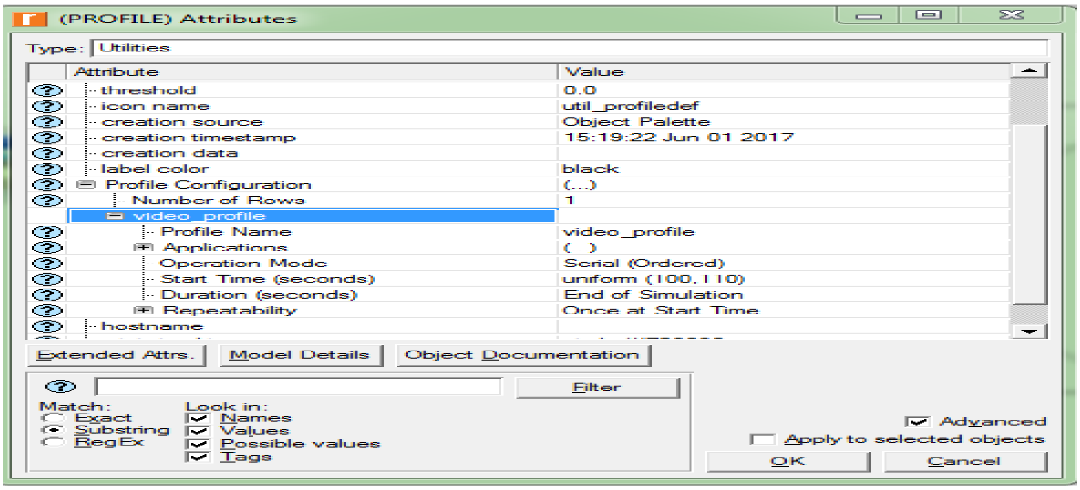

Figure 5: Profile Configuration

Failure/Recovery

Figure 6 to Figure 8 show the set up for failure recovery for the three scenarios. The simulation is set for 15 minutes while the failure and recovery time is set for different intervals of time respectively for the three scenarios.

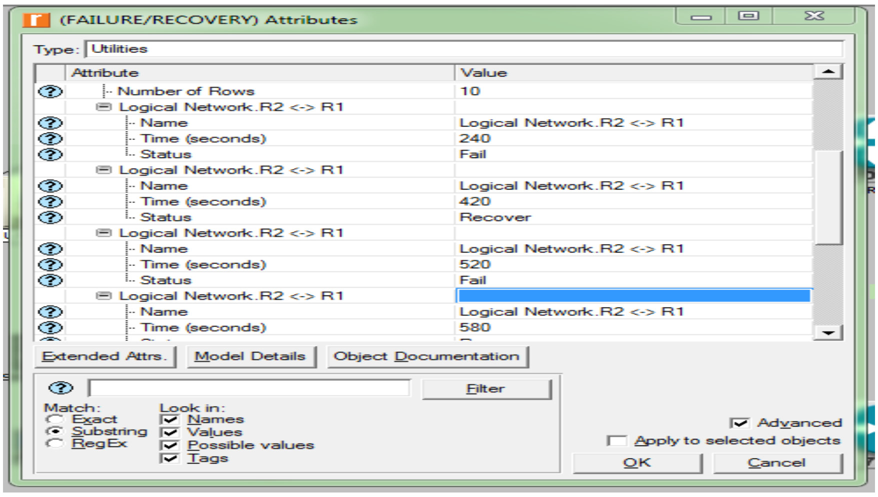

Figure 6: Failure/Recovery Attributes (Scenario 1)

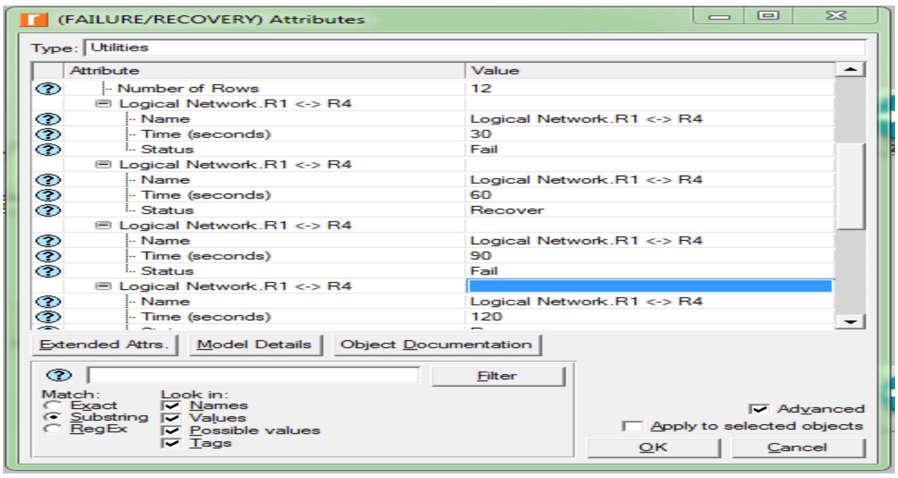

Figure 7: Failure/Recovery Attributes (Scenario 2)

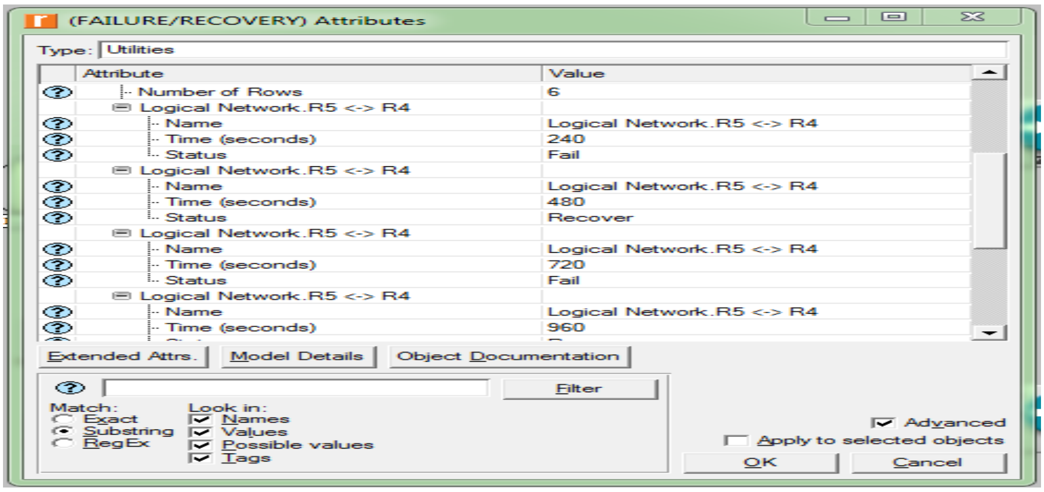

Figure 8: Failure/Recovery Attributes (Scenario 3)

Server

The server is set up to support the application running on the network and hence the operational speed is determined by the connected links data rate. The figure 9 below illustrates the setup of the attributes.

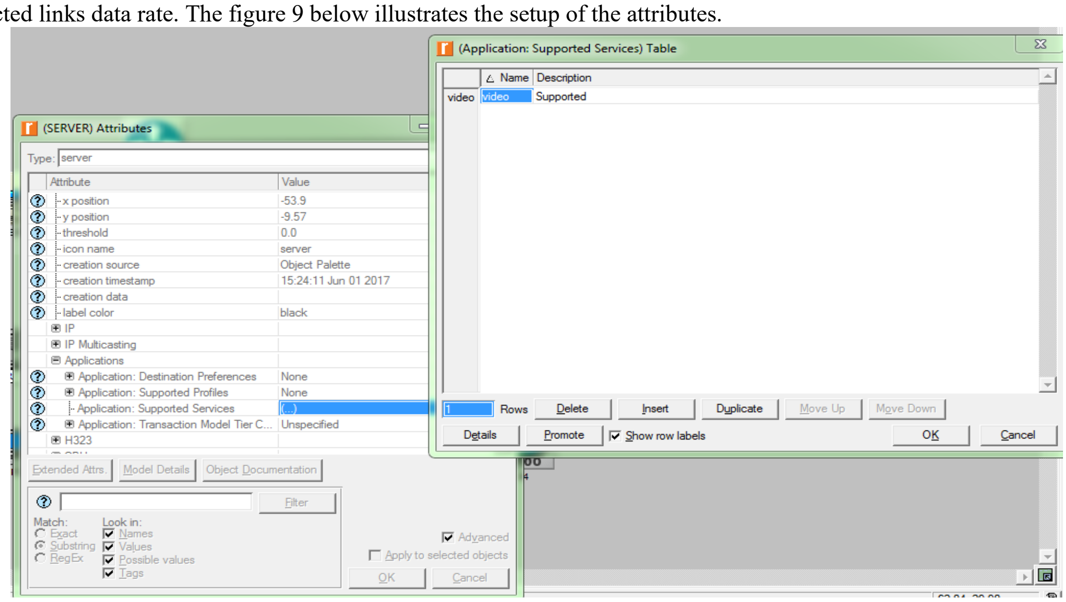

Figure 9: Server Configuration

SIMULATION RESULTS

i) OSPF and EIGRP Convergence Duration (Scenario1)

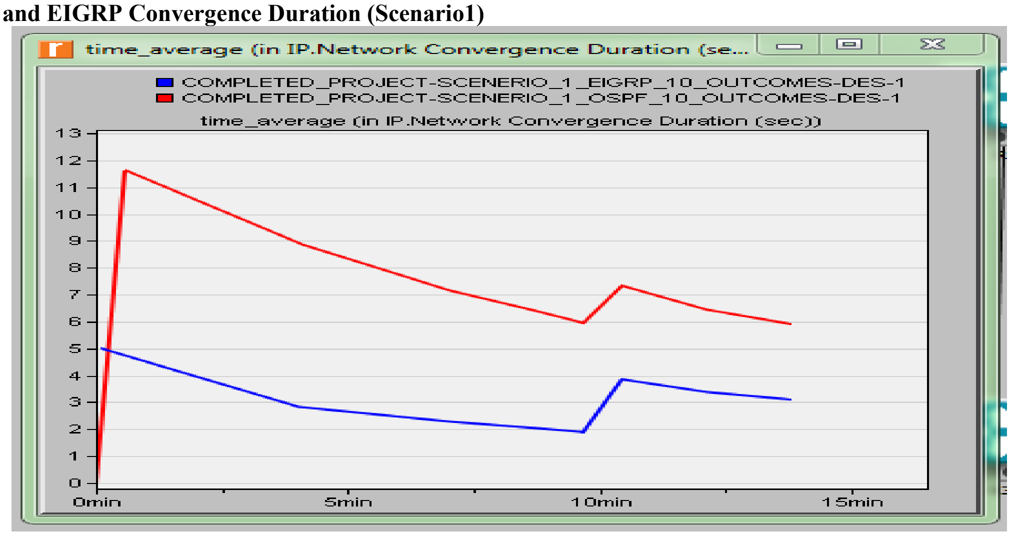

Figure 9: OSPF and EIGRP Convergence duration (Scenario1)

In Figure 9, it is observed that the convergence duration of OSPF took approximately 11.5 (seconds) before it attains its convergence at 6 (seconds) while EIGRP took 5 (seconds) before it attains its convergence at approximately 3 (seconds). Hence, EIGRP took less time to converge on the first network topology (scenario1) compared to OSPF that took more time.

ii) OSPF and EIGRP Convergence Duration (Scenario2)

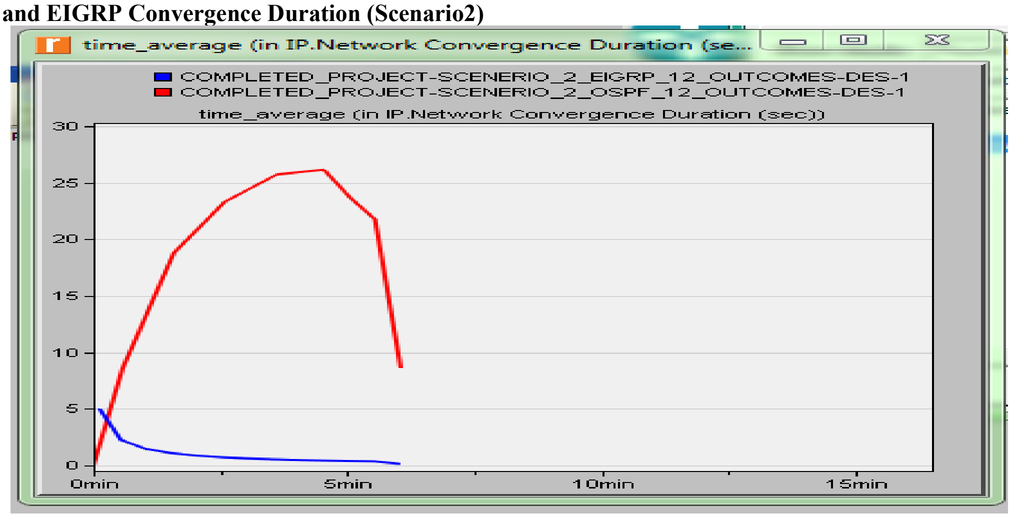

Figure 10: OSPF and EIGRP Convergence duration (Scenario2)

In Figure 10, it is observed that the convergence duration of OSPF took approximately 26 (seconds) before it attains its convergence at 9 (seconds) while EIGRP took 5 (seconds) before it attains its convergence at approximately 0.1 (seconds). Hence, EIGRP took just a micro-seconds to converge on the second network topology (scenario2) compared to OSPF with about 5 (seconds).

iii) OSPF and EIGRP Convergence Duration (Scenario3)

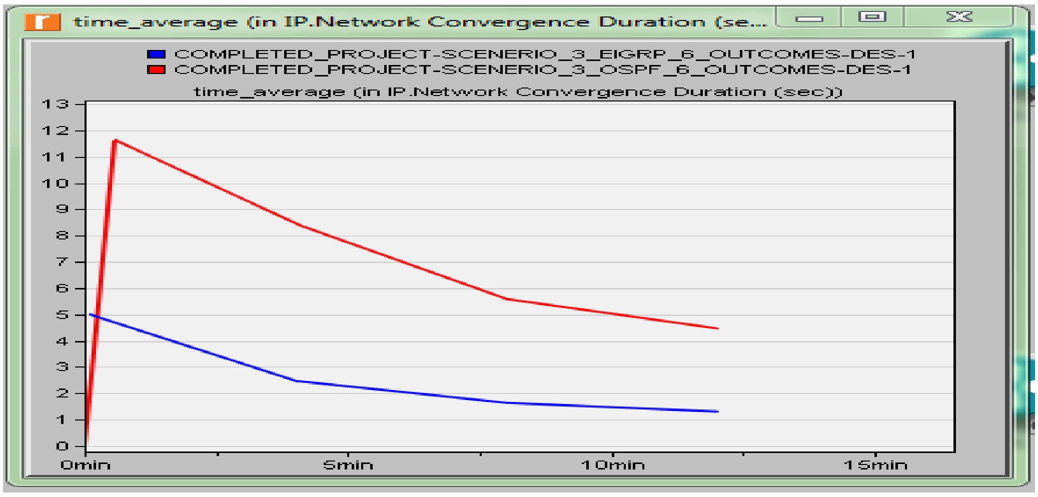

Figure 11: OSPF and EIGRP Convergence duration (Scenario3)

In Figure 11, it is observed that the convergence duration of OSPF took approximately 11.6 (seconds) before it attains its convergence at 4.5 (seconds) while EIGRP took 5 (seconds) before it attains its convergence at approximately 1.4 (seconds). Hence, EIGRP took just a few seconds to converge on the third network topology (scenario3) compared to OSPF with about 4.5 (seconds).

iv) OSPF and EIGRP Point to Point Queuing Delay (Scenario1)

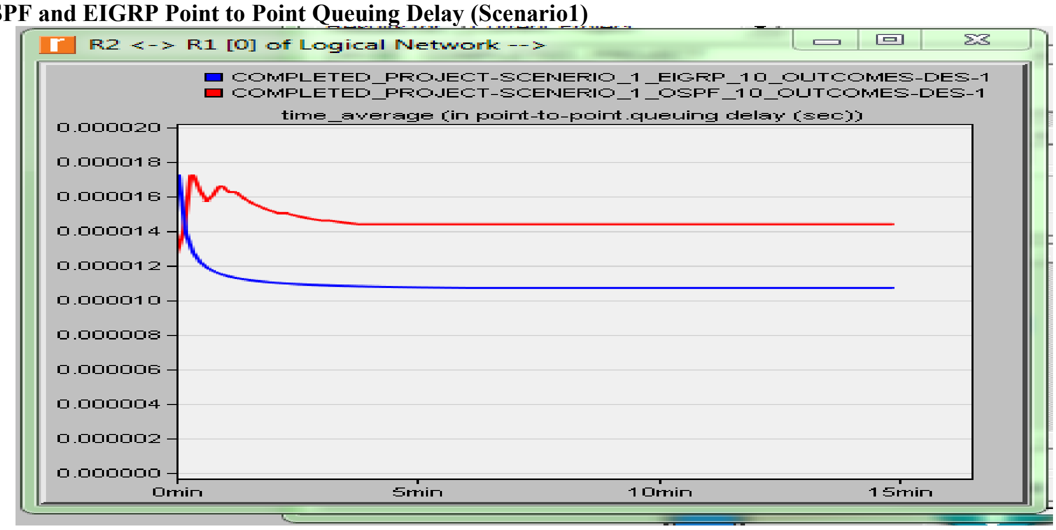

Figure 12: OSPF and EIGRP Point to Point Queuing Delay (Scenario1)

In Figure 12, it is observed that the Point to Point Queuing Delay of OSPF is approximately 0.0000142 (seconds) for every minutes compared to EIGRP which is approximately 0.000011 (seconds).

v) OSPF and EIGRP Point to Point Queuing Delay (Scenario2)

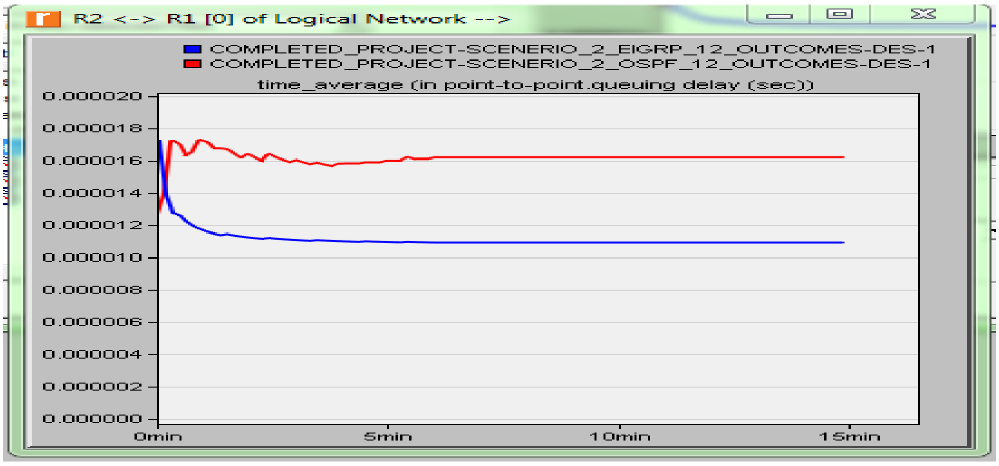

Figure 13: OSPF and EIGRP Point to Point Queuing Delay (Scenario2)

In Figure 13, it is observed that the Point to Point Queuing Delay of OSPF is approximately 0.000016 (seconds) for every minutes compared to EIGRP which is approximately 0.000011 (seconds).

vi) OSPF and EIGRP Point to Point Queuing Delay (Scenario3)

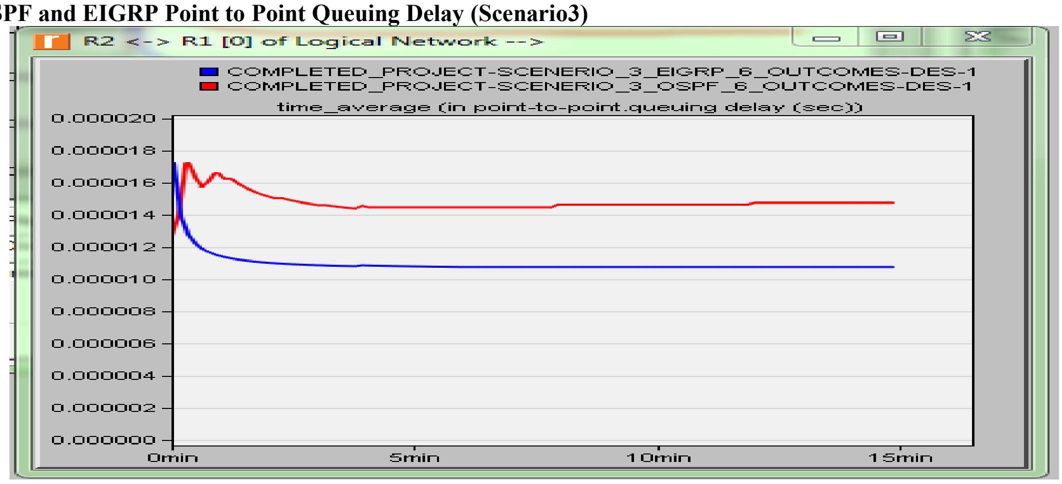

Figure 14: OSPF and EIGRP Point to Point Queuing Delay (Scenario3)

In Figure 14, it is observed that the Point to Point Queuing Delay of OSPF is approximately 0.0000143 (seconds) for every minutes compared to EIGRP which is approximately 0.000011 (seconds).

RESULT DISCUSSION

It is obvious that EIGRP converges faster compared to OSPF and it is also clear that EIGRP has the least Point to Point Queuing Delay compared to OSPF. EIGRP makes efficient use of the bandwidth. This is because EIGRP uses metrics like bandwidth, delay, reliability and load when calculating optimal routes whereas OSPF only takes bandwidth into consideration when calculating optimal routes. Hence, EIGRP will be more viable commercially provided that it is a full end to end Cisco implementation.

CONCLUSSIONS

It was demonstrated that OPNET Modeler 17.5 can be employed by network designers to select the most suitable routing protocol for various networks and to design an optimal routing topology. An analysis was performed using two (2) major types of routing protocols: Open Shortest Path First (OSPF) and Enhanced Interior Gateway Routing Protocol (EIGRP). Three different network topologies had been built and the simulation of each routing protocol in all three topologies had been performed. Convergence time and Point to Point Queuing Delay were carried out on the three network topologies implemented with OSPF and EIGRP respectively and also different outcomes has been set for the three network topologies to ascertain the failure recovery of the two routing protocol. According to the convergence activity results, it is obvious that EIGRP converges faster compared to OSPF. Also, it is clear that EIGRP has the least Point to Point Queuing Delay compared to OSPF. Reference to the analysis of all simulation results, a conclusion can be drawn that EIGRP is the best choice since it has the fastest convergence duration as well as least Point to Point Queuing Delay and EIGRP uses the bandwidth efficiently. For instance, EIGRP uses bandwidth, delay, reliability and load when calculating optimal routes whereas OSPF only takes bandwidth into consideration when calculating optimal routes. Hence, EIGRP will be more viable commercially provided that it is a full end to end Cisco implementation.

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