A comprehensive study of Routing Protocols Performance with Topological Changes in the Networks

Mohsin Masood
Electronics & Electrical Engineering Department
University of Strathclyde
Glasgow, Scotland, UK
mohsin.masood
@strath.ac.uk

Mohamed Abuhelala
Electronics & Electrical Engineering Department
University of Strathclyde
Glasgow, Scotland, UK
mohamed.abuhelala
@strath.ac.uk

Prof. Ivan Glesk
Electronics & Electrical Engineering Department
University of Strathclyde
Glasgow, Scotland, UK
ivan.glesk
@strath.ac.uk

ABSTRACT

In the modern communication networks, where increasing user demands and advance applications become a challenging task for handling user traffic. Routing protocols have got a significant role not only to route user data across the network but also to reduce congestion with less complexity. Dynamic routing protocols such as OSPF, RIP and EIGRP were introduced to handle different networks with various traffic environments. Each of these protocols has its own routing process which makes it different and versatile from the other. The paper will focus on presenting the routing process of each protocol and will compare its performance with the other. Experiments are conducted, using network topology with topological changes in order to analyze the protocols convergence activity and how it affects the overall performance of the network. The simulated results are analyzed to understand the function of the routing protocols in various network scenarios.

Keywords

Dynamic Routing Protocols, OSPF, RIP, EIGRP, OPNET, Routing Process

1. INTRODUCTION

Routing protocols play a significant role for forwarding or to route the user data to its right destination. The job of routing protocols is very critical in terms of choosing the right route for user traffic and to forward it by having various networks limitations. There are number of routing protocols that have developed such as OSPF (Open Shortest Path First), RIP (Routing Information Protocol) and EIGRP (Enhanced Interior Gateway Routing Protocol) [1], [2], [3]. All these mentioned protocols are based on their own routing process and thus does convergence with any topological change in the network. According to [1], [3], [4], [6] routing process can be defined as to select the best path among multiple paths from where the user data can be forwarded towards its destination. Thus, each routing protocol has different routing process from the other. Therefore, the performance of each routing protocol differs when applying to the network having some real type of network limitations. Different approaches of defining and making comparison of these three routing protocols are in process by the researchers and number of research papers are published. In [1], [4], [5], [6] and [7], the authors designed different topologies and compare routing protocols, but no work has been considered about the changing functionality of these routing protocols with the topology with real-time network limitations. such as topological change, network congestions, and so on. Hence without considering the topology with different network scenarios one cannot fully understand and make right comparison among any routing protocols.

This paper will give a comprehensive literature review of each routing protocol. Such as how each protocol (OSPF, RIP or EIGRP) does convergence activity with any change in the network. Two experiments are conducted that are based on six scenarios. In the first three scenarios (first experiment), OSPF, RIP and EIGRP routing protocols are individually configured in the network. While the later three scenarios (second experiment) are based on OSPF/ EIGRP, OSPF/ RIP and RIP/ EIGRP configured three networks (such as two protocols are configured in the same network). In each network, for using two different protocols, redistribution process is used. Redistribution process is used in a scenario where IP network is configured with two different routing protocols [14], [15], [16]. For both experiments, OPNET tool is used and simulated results will explain that how each routing protocol with topological changes.

2. ROUTING PROCESS OF ROUTING PROTOCOLS

For network optimization, routing protocols have got an important role of moving the user traffic in the network. For this purpose, routing process is performed by the routers in the network which uses any of the mentioned routing protocols. It should be noted here that OSPF, RIP and EIGRP use their own routing process which is different from each other [1], [6], [16]. This differentiation makes each routing protocol special and significant from the other and so each perform differently in various situations in the networks. The section below will explain the convergence activity performed by each routing protocol in the network.

2.1 Open Shortest Path First (OSPF) Routing Protocol

For IP networks, Internet Engineering Task force introduced a link state routing protocol in mid-80`s named Open Shortest Path First (OSPF) routing protocol. OSPF widely uses in large enterprise networks because of its efficient convergence in the network [8]. Using OSPF routing protocol, routers distribute network topology information across the network [6], [7], 15]. As OSPF is a dynamic routing protocol, so all routers that are configured with OSPF routing protocol will exchange the link state routing information to all the connected routers and thus build their own routing table. The routing table in each router is based on information it received from the other routers. Having routing table in each router, the Dijkstra algorithm is used to find the shortest route from the current router to all the connected routers [8]. When any link fails/ set in the network, then all the routers in the network become active and therefore do convergence activity. During this convergence activity, each router exchanges this topological change (link fails/ set) information across the network. And once each router is updated with the latest change in the network, it again updates its routing table [1], [2], [5], [6], [8].

2.2 Routing Information Routing Protocol (RIP)

RIP (Routing Information Protocol) is considered as one of the major distance vector routing protocol which offers hop count as a routing metric. It is an interior gateway routing protocol which works within an autonomous network system [7], [9]. RIP first version was published as RFC 1058 in 1988 [9]. Later RIPv2 was published as RFC 2453 in 1998 [10]. Typical RIP routing protocol offers a maximum of 15 hops count from sources towards the destination and therefore provide loop-free routing. Limitation of 15 hops count makes RIP routing protocol for the limited size network. Thus, offering more than 15 hops count destination as unreachable from source in RIP configured routing protocol [9], [10], [17]. In RIP configured network, routers send and receive Request Message and Response Message from other RIP configured routers in the network with regular interval of time. This protocol uses set of timers as an important part for its convergence activity. These timers are named as update timer, invalid timer, flush timer and hold-down timer [9], [10]. Therefore, when the network is configured with RIP, this protocol is considered as a routing protocol that has slow convergence activity with limited hop counts but has less CPU utilization in the network [18]. However, RIP can behave differently in terms of topological change from other two (OSPF and EIGRP) routing protocols as it converges in a different process [1], [6], [18].

2.3 Enhanced Interior Gateway Routing Protocol (EIGRP)

An enhanced version of Interior Gateway Routing Protocol (IGRP) was introduced by Cisco in 1993 named as Enhanced Interior Gateway Routing Protocol (EIGRP) [11]. Later in 2013 this protocol was published in 2016 as RFC 7868 [3], [11]. It is a distance vector routing protocol that uses an algorithm called as DUAL (Diffusion Update Algorithm). However, it is considered as hybrid routing protocol because it has also got the properties of link state protocols [1], [6]. Means, this routing protocol contains the features of both link state and distance vector routing protocols. EIGRP protocol is mostly used for large networks [6]. Any router in the network which uses EIGRP protocol it keeps all routes in its routing table. This routing protocol also does convergence when there is any topological change occur in the network [2]. EIGRP protocol operation is based on four components such as Neighbor Discovery/ Recovery, Reliable Transport Protocol (RTP), DUAL and Protocol dependent module [11], [19]. Neighbor discovery is one of the process of EIGRP protocol in which a router discovers its neighbor routers by sending HELLO packets with regular interval of time. RTP ensures the reliable transmission of unicast or multicast packets of EIGRP protocol in the network [11], [20]. DUAL plays a significant role as a loop avoidance mechanism which is used for the topological change in the network. This algorithm is based on further four components which are used to detect the change in topology and therefore helps to build the new routing table. These four tools are named as [11], [19], [20];

1). FD (Feasible Distance): the lowest distance towards the destination, 2). RD (Reported Successor): A router calculated the cost for reaching the destination, 3). Successor: An adjacent router that can be used as the least cost route towards the destination, 4). FS (Feasible Successor): A router that fulfills the conditions of FC (feasible condition) and acts as an adjacent router which offers loop-free backup path towards destination, and 5). FC (Feasible Condition): It is used to select the successor after fulfilling the conditions of FD. When any link fails/ set in the network means a topological change occurs then DUAL is get activated by EIGRP protocol as convergent activity. In result of DUAL, routers in update their routing table. EIGRP protocol offers loop free routes and hence easy to configure in large network [6], [20]. With the help of DUAL mechanism (using Feasible Successor) this protocol can also keep the backup loop free path towards the destination. Protocol Dependent Modules helps to build the topology table which is based on DUAL mechanism. EIGRP supports only cisco router and thus other vendor routers cannot utilize EIGRP protocol [3], [6], [11], [20].

3. DESINGNED NETWORKS & SIMULATIONS

To evaluate the performance of each of the mentioned routing protocols, experiments are performed with different scenarios. The purpose of these experiments is not only to study the individual characteristics of routing protocols under various scenarios in the network but also to analyze their functions when they are configured together in the same network. OPNET modeler is used as a networking tool for simulations. This tool provides a networking environment that fulfills the programmer requirements to design the communication networking model. The software helps to understand the network model at its any stage with its embedded features such as designing the network models, data collection and analyses along with simulations of various parameters of networking. We used OPNET [12], [13] for our experiments.

Total six scenarios are undertaken in these experiments and will be described below in details. While first three scenarios are grouped as 1st experiment and the last three scenarios are grouped as 2nd experiment. Later in the paper, the results of both experiments will be analyzed. In order to design the network, NSFnet topology is used for all the experiments, which is based on 14 nodes. These 14 nodes represent the LANs (local area networks which are connected to WAN (wide area network). LANs are connected to WAN using Ethernet links. While for WAN optical networking is used.

Figure 1.1: NSFnet Topology

The first three scenarios are designed is such a way that each routing protocol is configured individually in three separate networks. Such as, in 1st scenario, OSPF routing protocol is configured, in 2nd scenario RIP protocol is configured while for the 3rd scenario EIGRP protocol is configured across the network. In all three mentioned scenarios a topological change is monitored. When the link (between any two nodes in the network) fails or set up, such changes are named as topological change in the experiments. A table has been developed which shows that every 5mins there is a link failure or setup across the network. The simulation has been run for total of one hour. The topological change table is given in figure 1.2.


(Link Failure/Recovery Specification) Table

	Name	Time (seconds)	Status
...r <-> Salt Lake City	Ann Arbor <-> Salt Lake City	300	Fail
Boulder <-> Lincoln	Boulder <-> Lincoln	600	Fail
...aign <-> Pittsburgh	Champaign <-> Pittsburgh	900	Fail
...r <-> Salt Lake City	Ann Arbor <-> Salt Lake City	1,200	Recover
Boulder <-> Lincoln	Boulder <-> Lincoln	1,500	Recover
...aign <-> Pittsburgh	Champaign <-> Pittsburgh	1,800	Recover
... <-> Salt Lake City	Palo_Alto <-> Salt Lake City	2,100	Fail
...ton <-> College PK	Princeton <-> College PK	2,400	Fail
... <-> Salt Lake City	Palo_Alto <-> Salt Lake City	2,700	Recover
...ton <-> College PK	Princeton <-> College PK	3,000	Recover

10 Rows Delete Insert Duplicate Move Up Move Down
Details Promote Show row labels OK Cancel

Figure 1.2: Network Topological Change Table

The topological change scenario is designed in such a way that links are failed and recovered with the mentioned simulation time (given in figure 1.2). For example, the link between Ann Arbor and Salt Lake City is failed at 300sec (5min) of simulation time and then recovered at 1200sec (20mins). The other links fail/set table can be seen in figure 1.2.

3.1 First Experiment

In 1st scenario, OSPF routing protocol is configured to the network. At the start, each routing protocol that is configured to the network normally does the convergence activity and after that, each router builds its own updated routing table [7], [8]. When routing protocol does convergence in the network, it affects the overall performance of the network and hence based on various parameters the routing protocols can be analyzed. The parameters which are monitored in the experiments are convergence activity, convergence activity duration and CPU utilization of the network. In 2nd scenario RIP protocol is configured while in 3rd scenario EIGRP protocol is configured across the network. The simulated results are given.

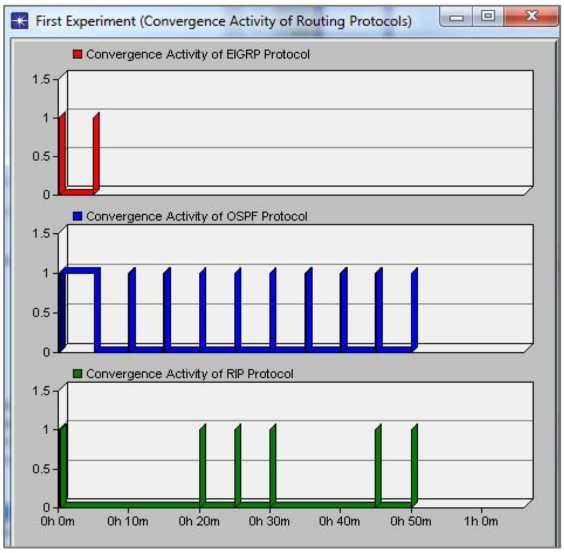

Figure 1.3: Convergence Activity of OSPF, RIP and EIGRP Protocols

Figure 1.3 depicts the convergence activity performed by OSPF, RIP and EIGRP configured networks of the first experiment. According to the topological change table in figure 1.2, where links fail and set after every 5mins between different of the network. Every routing protocol monitors this topological change with efficiency. In figure 1.3, at vertical line, 0 shows no convergence activity and 1 represents the presence of convergence activity performed by each protocol. Figure 1.3 shows that OSPF protocol (represented in blue lines) detect the topological change after each 5mins in the network and does convergence activity. While RIP protocol (green lines) converges on 1st minute, 20th, 25th, 30th, 45th and 50th minute across the network. Whereas EIGRP protocol only converges two times such as on 1st and 5th minute. The result clearly shows that how quick and accurate response of topological change can be monitored by OSPF routing protocol.

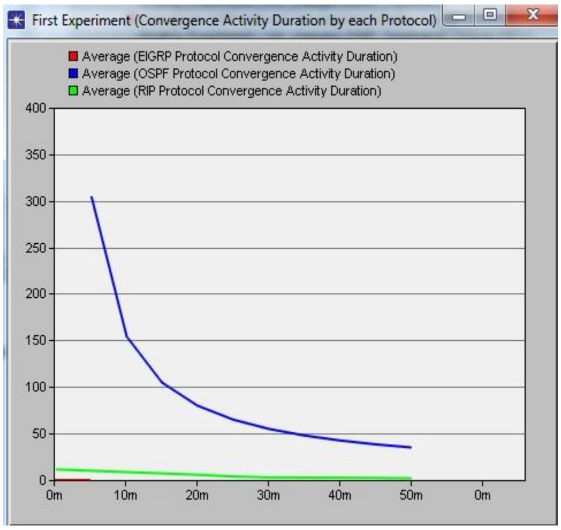

Figure 1.4: Convergence Activity Duration (sec) by OSPF, RIP and EIGRP Protocol

Figure 1.4 represent the convergence duration by each routing protocol during its convergence activity. Fig.1.4 shows that OSPF protocol at the start of the simulation takes very high convergence duration time but later it takes very low time to converge for further topological change. On the other side, RIP and EIGRP protocols take a very low convergence duration time as compared to OSPF protocol.

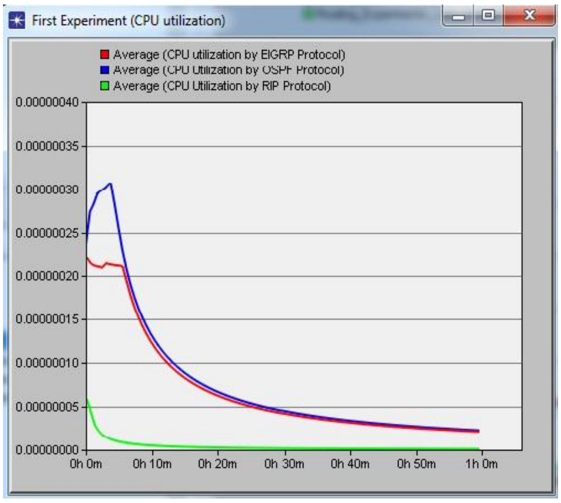

Figure 1.5: Network CPU Utilization (%) by OSPF, RIP and EIGRP Routing Protocols

Figure 1.5 represent the CPU utilization (in percentage) by each routing protocol. It can easily be seen that OSPF protocol (blue curve) CPU utilization is highest than other two routing protocol. While RIP CPU utilization is far lower than EIGRP protocol.

3.2 Second Experiment

The second experiment consists of three scenarios. In the first scenario, OSPF and EIGRP protocols are on the same network. Such as some nodes are configured with OSPF protocol while the remaining are with EIGRP protocol (called as EIGRP/OSPF network). In the 2nd scenario, EIRGP and RIP are configured, named as EIGRP/RIP network. While in 3rd scenario OSPF are RIP are configured together (OSPF/RIP network). The simulated results of three mentioned scenarios are given.

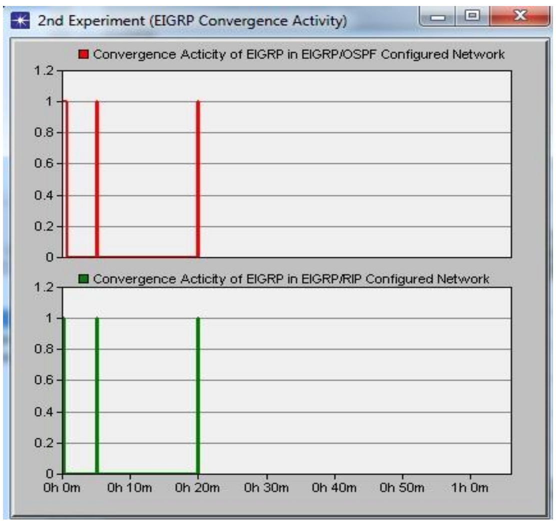

Figure 2.1: EIGRP Protocol Convergence Activity in EIGRP/OSPF and EIGRP/RIP Configured Networks

Figure 2.1 represents the convergence activity response of EIGRP protocol in two scenarios (EIGRP/OSPF and EIGRP/RIP configured networks). This result shows that EIGRP converges at 1st, 5th and 20th minute in EIGRP/OSPF and EIGRP/RIP networks. This shows that EIGRP protocol convergence response is same for both networks.

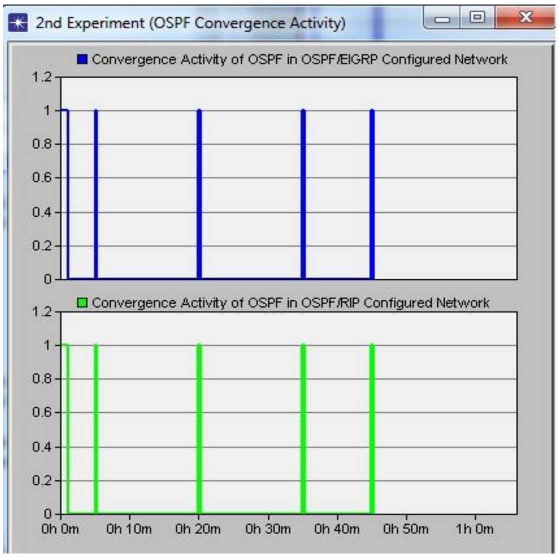

Figure 2.2: OSPF Protocol Convergence Activity in EIGRP/OSPF and OSPF/RIP Configured Networks

Figure 2.2 shows the convergence activity response of OSPF protocol in OSPF/EIGRP and OSPF/RIP configured networks. OSPF protocol converges a 1st, 5th, 20th, 35th and 45th minute. It can be seen that convergence activity response by OSPF protocol with both networks (OSPF/RIP and OSPF/EIGRP) is same.

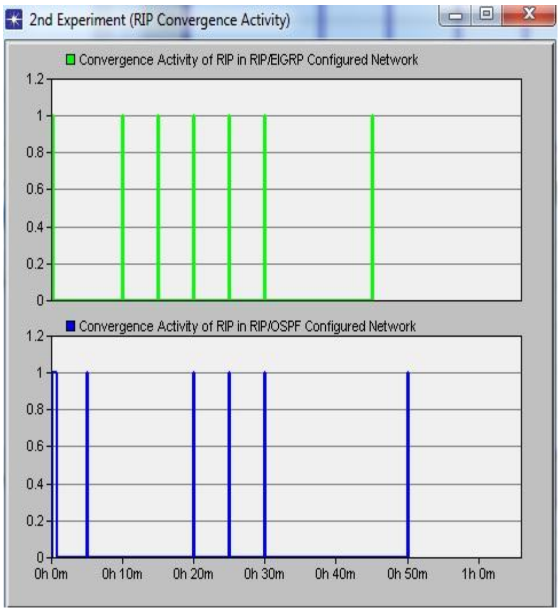

Figure 2.3: RIP Protocol Convergence Activity in RIP/OSPF and OSPF/RIP Configured Networks

Figure 2.3 depicts the RIP convergence activity response in RIP/EIGRP and RIP/OSPF networks. The results show that RIP protocol does convergence activity in RIP/EIGRP network at 1st, 10th, 15th, 20th, 25th, 30th and 45th minute of the simulation time. But in RIP/OSPF network, RIP converges at 1st, 5th, 20th, 25th, 30th and 50th minute. The results clearly show that RIP protocol convergence activity different in both networks.

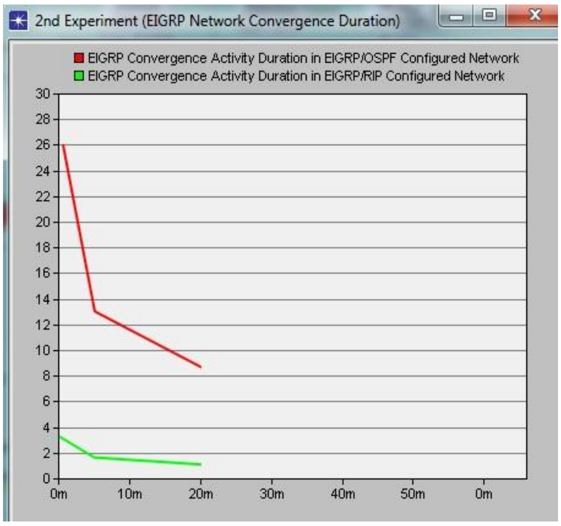

Figure 2.4: EIGRP Protocol Convergence Activity Duration in EIGRP/OSPF and EIGRP/RIP Configured Networks

Figure 2.4 represents the convergence duration by EIGRP convergence activities in EIGRP/OSPF and EIGRP/RIP configured networks. The figure shows that the EIGRP protocol convergence duration is much higher in EIGRP/OSPF network than the EIGRP/RIP network.

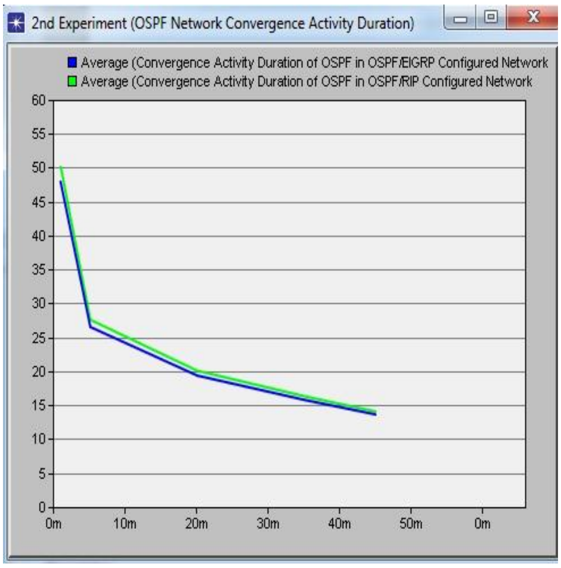

Figure 2.5: OSPF Protocol Convergence Activity Duration in EIGRP/OSPF and OSPF/RIP Configured Networks

Figure 2.5 represents the OSPF convergence activity duration in OSPF/EIGRP and OSPF/RIP configured networks. The result shows that there is no major convergence activity duration change of OSPF protocol while working with any of the two routing protocol such as RIP or EIGRP. As OSPF protocol takes same convergence activity duration time while configured in OSPF/EIGRP and OSPF/RIP networks.

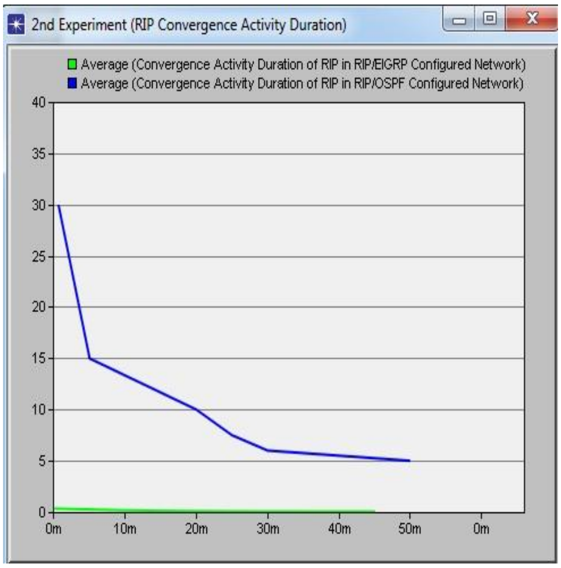

Figure 2.6: RIP Protocol Convergence Activity Duration in RIP/OSPF and EIGRP/RIP Configured Networks

RIP convergence activity duration (in RIP/OSPF and RIP/EIGRP configured networks) results are represented in figure 2.6. The results show that when RIP is configured with OSPF protocol, it takes much higher convergence duration as compared to working with EIGRP protocol (where the convergence activity duration is very low).

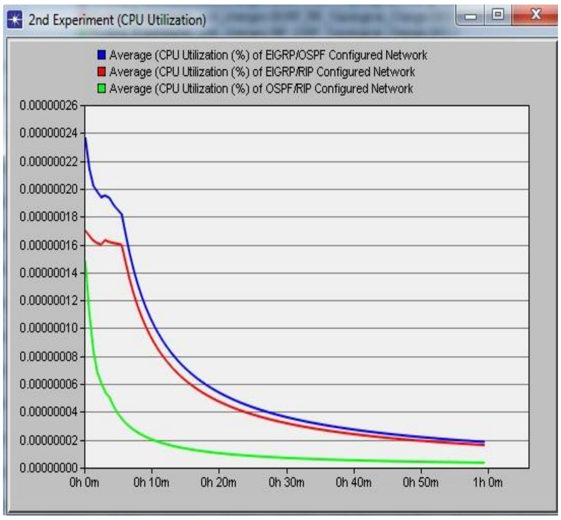

Figure 2.7: Network CPU utilization (%) in EIGRP/ OSPF, OSPF/RIP and EIGRP/RIP Configured Network

Figure 2.7 represent the CPU utilization (in percentage) of overall network in three different scenarios of the second experiment. The result shows that OSPF/EIGRP configured network has the highest CPU utilization. While EIGRP/RIP network utilizes more CPU utilization than OSPF/RIP configured network. Hence, the result shows that OSPF/RIP configured network is the most efficient combination of routing protocols in terms of CPU utilization.

4. DISCUSSION

Two experiment are conducted based on six scenarios, simulated on OPNET tool to analyze the dynamic routing protocols (OSPF, RIP and EIGRP) in response of network topology change. The simulated graphs give some interesting results regarding routing protocols in terms of convergence activity, convergence activity duration and network CPU utilization. Convergence activity performed by each protocol give different output in both experiments (including all scenarios). The performance of each routing protocol can be analyzed by understanding the figures given in the simulation section.

According to figure 1.3 and figure 2.2, it can be observed that OSPF is being very active regarding its convergence activity when it is configured alone in the network. While it becomes less effective in terms of convergence activity when it is being configured with other two routing protocols. The reason is that part of the network is configured with either RIP or EIGRP rather than OSPF protocol. Therefore, other routing protocols (RIP or EIGRP) detect the topological change in the network. Convergence activity duration of OSPF is high in figure 1.4 as compared to fig. 1.5 (in EIGRP/OSPF and RIP/OSPF networks). While CPU utilization of OSPF network is high as compared to the OSPF/EIGRP and OSPF/ RIP networks.

EIGRP network performance shows as the least effective routing protocol in terms of convergence activity. The reason of low active convergence activity of EIGRP could be the presence of FS (Feasible Successor) in each router in the network, however this argument cannot always be right. Describing the convergence activity of EIGRP protocol from the results, it can be analyzed that this protocol convergence activity become more active while configured with EIGRP/RIP and EIGRP/OSPF networks. The convergence activity duration is very high in EIGRP/OSPF and EIGRP/RIP networks. CPU utilization of EIGRP protocol is more effective in EIGRP/OSPF and EIGRP/RIP networks as compared to EIGRP configured network.

RIP configured network convergence activity results are different from RIP /OSPF and RIP/EIGRP networks (as given in figure 1.3 and figure 2.3). From the figure 1.4 and figure 2.6, it can be analyzed that RIP configured network, RIP protocol spent very less convergence duration time as compared to RIP/OSPF and RIP/EIGRP networks. Whereas in RIP/OSPF network, RIP convergence duration is much higher than RIP/EIGRP networks. RIP CPU utilization is very low either it is configured in the network or in RIP/OSPF and RIP/EIGRP networks.

4.1 Analyzing The Collected Data

From the simulated results, the data is collected in order to analyze the performance of each routing protocol during its each convergence activity. Figure 2.8 explains the convergence activity duration and CPU utilization that has been spent by the routing protocol.

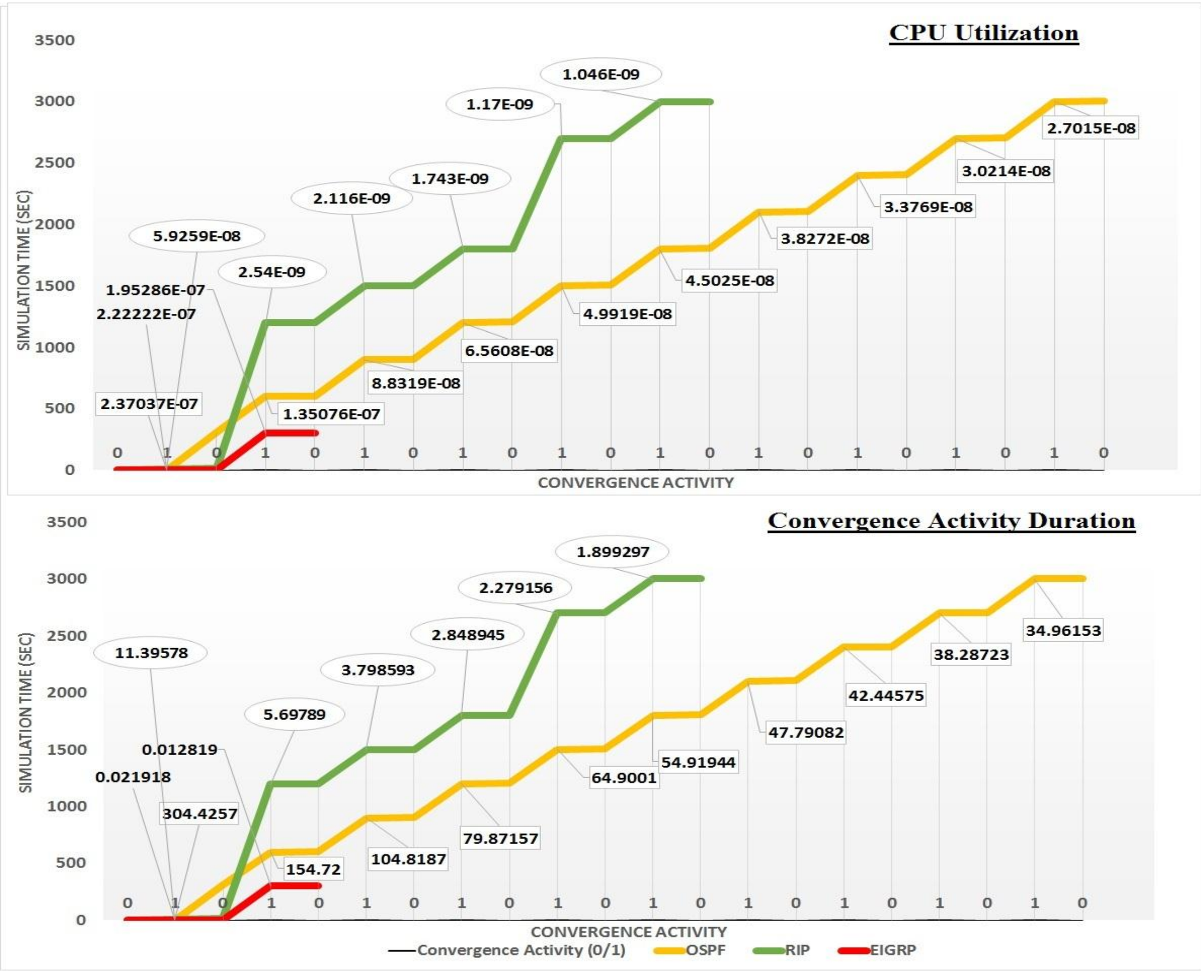

Figure 2.8: Collected data of OSPF, RIP and EIGRP Protocols

Figure 2.8 consists of two graphs; the lower graph describes the convergence duration for routing protocols (OSPF, EIGRP and RIP). While the upper graph depicts CPU utilization by each protocol`s convergence activity. In the figure; x-axis represents the convergence activity (by the protocol), that is either 0 or 1. 0 means no convergence activity and 1 shows the convergence activity performed by the protocol. While the simulation time (in seconds) is represented in y-axis. The values of convergence duration and CPU utilization during each convergence activity (performed by protocols) are plotted in figure 2.8.

From the figure, it is noted that the convergence duration of OSPF protocol is gradually going down with every convergence activity. Such as, during first convergence activity, the duration was 304.4257 secs while in the second convergence activity, OSPF convergence duration reduced to 154.72 secs. And the last convergence activity duration of OSPF jumped down to 34.96153 secs. From the upper graph, when we monitor the CPU utilization of OSPF, the readings show the decreasing values of CPU utilization by OSPF protocol with each convergence activity. For the case of RIP from figure 2.8, it can be seen that the values of both parameters (CPU utilization and convergence duration) is high at the start and then gradually jumps down. Similarly, for EIGRP protocol, there are two convergence activities. At first convergence activity, the convergence duration and CPU utilization is high while during the second convergence activity both parameters values decreased.

5. CONCLUSION

OSPF, RIP and EIGRP are three most popular dynamic routing protocols that are designed to face present and future networking challenges and to fulfill the networking requirements. In the paper, the mentioned routing protocol are analyzed in terms of literature review and with the simulated results that are the outcome of two experiments. Then, from the simulated results, the data was collected to deeply understand the performance of each protocol. Convergence activity, convergence activity duration, and CPU utilization parameters are used in OPNET tool in order to understand the performance of these mentioned routing protocols. From the results obtained and the outcome of the discussion, there are some facts that can be concluded.

OSPF is the most active routing protocol that detects topological change with quick response and thus updates the routers routing table. While at the start, it takes longer time for convergence (as convergence duration) but for later topological changing cases its convergence duration decreases. In a case of CPU utilization, OSPF network could not prove as ideal protocol. As it spends very high CPU utilization as compared to RIP and EIGRP protocols. While in OSPF/RIP and OSPF/EIGRP networks, OSPF/RIP network spent very low CPU utilization as compared to OSPF/EIGRP network.

RIP is a distance vector dynamic routing protocol based on hop count based metric. RIP network convergence activity is better than EIGRP network presented in fig. 1.3. While in 2nd experiment results show that RIP convergence activity changes. Convergence activity duration of RIP for both experiments is lower than OSPF protocol networks but relatively higher than EIGRP protocol. For CPU utilization, RIP protocol proved as ideal choice for the network programmers among three discussed routing protocols, as it has the least CPU utilization from other two protocols (OSPF and EIGRP).

EIGRP is the only routing protocol that has got characteristics of both link state and distance vector routing Protocols. In the first experiment, EIGRP presented as routing protocol that has got least convergence activity and convergence activity duration among three presented protocols. Furthermore, EIGRP has higher CPU utilization than RIP protocol. This shows EIGRP as not an ideal routing protocol while configuring it alone in the network when there is a scenario of quick topological changes. On the other side, EIGRP/ OSPF and EIGRP/RIP results are quite different as EIGRP protocol become more active in terms of convergence activity and its duration. While CPU utilization in the first experiment is not so low and thus, it is higher than RIP protocol. In the 2nd experiment (EIGRP/OSPF and EIGRP/RIP networks), the CPU utilization of EIGRP/OSPF is higher than OSPF/RIP network.

For the network, where random and quick topological changes are possible, for such scenarios OSPF looks better choice for network programmers as compared to RIP and EIGRP protocol. It gives quick response for any topological changing networks but network will also experience high CPU utilization. However, the CPU utilization can be decreased in OSPF/RIP network.

REREFENCES

[1] Sheela, G. (2010). Dynamic Routing Protocol implementation decision between EIGRP, OSPF and RIP based on Technical Background Using OPNET Modeller. *Second International Conference on Computer and Network Technology*.

[2] Noman, A. and Chowdhury, A. (2014). Performance Analysis of EIGRP and OSPF for Different Applications using OPNET. *Australasian J. of Computer Science*, 1(1), pp.1-8.

[3] Bright, A., Adamou, M., Franklin, A. and Asante, M. (2016). Performance Analysis of Enhanced Interior Gateway Routing Protocol (EIGRP) Over Open Shortest Path First (OSPF) Protocol with Opnet.*International Journal of Advanced Computer Science and Applications*, 7(5).

[4] Farhangi, S. and Golmohammadi, S. (2012). A comparative study of IS-IS and IGRP Protocols for Real Time Application Based on OPNET. *Advances in Electrical Engineering Systems*.

[5] Kudtarkar, A., Sonkusare, R. and Ambawade, D. (2014). Performance Analysis of Routing Protocols for Real Time Application. *International journal of Advanced Research in Computer and Communication Engineering*.

[6] Rakheja, P., kaur, P., gupta, A. and Sharma, A. (2012). Performance Analysis of RIP, OSPF, IGRP and EIGRP Routing Protocols in a Network. *International Journal of Computer Applications*, 48(18), pp.6-11.

[7] Shah, A. and Waqas, J. (2013). Performance Analysis of RIP and OSPF in Network Using OPNET.*International Journal of Computer Science*.

[8] Ietf.org. (n.d.). *OSPF Version 2*. [online] Available: https://www.ietf.org/rfc/rfc2328.txt.

[9] Ietf.org. (n.d.). *Routing Information Protocol*. [online] Available: https://tools.ietf.org/html/rfc1058

[10] Ietf.org. (n.d.). *RIP Version 2*. [online] Available: https://tools.ietf.org/html/rfc2453

[11] Ietf.org. (n.d.). *Cisco's Enhanced Interior Gateway Routing Protocol (EIGRP)*. [online] Available: https://tools.ietf.org/html/rfc7868

[12] Lu, Z. and Yang, H. (2012). *Unlocking the power of*

OPNET modeler. New York: Cambridge University Press.
[13] Modeling and simulation of communications systems in opnet. (2012). [Place of publication not identified]: Not Avail.
[14] Hanmin, Y., Qianting, S. and Zihang, S. (2014). IEEE Workshop on Advanced Research and Technology in Industry Applications (WARTIA). *Research of two-way route redistribution based on multi-protocol*.
[15] Le, F., G. Xie, G. and Zhang, H. (2016). *Understanding Route Redistribution*.
[16] Kanti Dey, G., Mobasher Ahmed, M. and Tanvir Ahmmed, K. (2015). 1st International Conference on Computer & Information Engineering, 26-27 November, 2015 Organizer: Dept. of CSE, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh. *Performance Analysis and Redistribution among RIPv2, EIGRP & OSPF Routing Protocol*.
[17] Fiţigău, I. and Toderean, G. (2016). *Network Performance Evaluation for RIP, OSPF and EIGRP Routing Protocols*.
[18] Yang1, S. and Zhi Yong2, Z. (2016). 2012 International Conference on Industrial Control and Electronics Engineering. *RIP Internet Protocol Failure Analysis and Research*.
[19] Expósito, J., Trujillo, V. and Gamess, E. (2010). 2010 Sixth International Conference on Networking and Services. *Easy-EIGRP: A Didactic Application for Teaching and Learning of the Enhanced Interior Gateway Routing Protocol*.
[20] M. Jaafar, T., F.Riley, G., Reddy, D. and Blair, D. (2006). Proceedings of the 2006 Winter Simulation Conference L. F. Perrone, F. P. Wieland, J. Liu, B. G. Lawson, D. M. Nicol, and R. M. Fujimoto, eds. *SIMULATION-BASED ROUTING PROTOCOL PERFORMANCE ANALYSIS – A CASE STUDY*.