Performance Evaluation of Dynamic Routing Protocols

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Abstract:

Routing protocols are an essential component while performing routing. Majority of the researches put stress on the analysis of the security of IPv6 routing protocols as a future research work. In case of DB query response time, EIGRPv6 did not perform well as compare to other two routing protocols. While for voice and video, jitter, packet end-to-end delay, EIGRPv6 performed best among other routing protocols. Their evaluation involved four pairs of scenarios and each pair dedicated to respective routing protocols to be analyzed. Finally, their results also predicted that communication between ISIS and OSPF routing protocols is quite noticeable. The major purpose of their research was to figure out the best possible combined solution of routing protocols in a complex scenario to provide a seamless flow of communication. While, in the combined network, RIP-OSPF combination had a low CPU utilization in comparison to EIGRP-OSPF combination. This paper will conduct a performance evaluation and analysis of routing protocols, RIP, OSPF, EIGRP and IGRP using different performance metrics. In a situation where there are frequent network topological changes, RIP and IGRP are the least suited routing protocols. While EIGRP and OSPF are the best suited routing protocols in a changing network environment. OSPF can be a better choice than EIGRP considering transmission cost and router overhead, while EIGRP performed best in terms of convergence, utilization, delay and throughput. Hence it becomes really difficult to select among OSPF and EIGRP. Future research can be based on selecting a routing protocol among OSPF and EIGRP based on their performance in a large network using different performance metrics.

Keywords: Network Designing, Network Performance, Dynamic Routing Protocols, RIP-OSPF-EIGRP-IGRP

1. INTRODUCTION

Most important and key aspect of communication is routing, and this is performed by routing protocols [1]. It has been a challenge for network communication researchers to select a best suited routing protocol based on the network size and frequent network changes [2]. Major objective of setting up routing protocols is to carry forward the Internet Protocol (IP) packets [3]. Routing protocols are uncompressed with various algorithms, and based on these algorithms they adopt to the network changes. These protocols can be referred as, Routing information protocol (RIP), Internet Gateway Routing Protocol (IGRP),

enhanced internet gateway routing protocol (EIGRP) and Open Shortest Path First (OSPF) [4].

Transferring packets from source to destination is based on routing tables. IGRP and RIP works on distance vector algorithm [5]. OSPF routing protocol is based on link-state algorithm while EIGRP works according to hybrid Algorithm of link-state and distance vector [6]. RIP takes path that has the lesser hops (lesser cost) in a situation where there are various paths available. Cisco systems created IGRP routing protocol for medium scale networks. EIGRP was also created by cisco systems, and it is more advanced than IGRP as it works based on both distance vector and link-state algorithms [7]. Internet engineering task

force created OSPF for small and large networks. OSPF is useful in situations where RIP has scalability problems. Overall, EIGRP is very efficient and effective in networks that encounter frequent changes [8].

Various simulators are available for simulating a designed network. These simulators act as an alternate source instead of performing direct measurement. Direct measurement can be very costly and abrupt in nature. Hence majority of researchers and company's use simulators to predict and analyze performance of various networking aspects [9]. NS-3, Omnet++, cisco packet tracer, Qual net and Riverbed modeler are different simulators available for simulating and analyzing a given situation in a network [10]. This study reviews recent works of various authors and their contribution towards highlighting the issues and challenges of choosing the suitable protocols for various network scenarios and their performance evaluation based on different metrics. This paper will conduct a performance evaluation and analysis of routing protocols, RIP, OSPF, EIGRP and IGRP using different performance metrics. Riverbed modeler will be used for simulating the designed network. Based on the simulation results, performance of the routing protocols will be analyzed. Furthermore, Anchor paper for this research is [11], based on their topology and parameters, the simulation would be conducted using Riverbed Modeler in the later phase of the research. Results would be analyzed and compared with their research once the designed network is simulated based on the respective parameters. This paper [12], will be used as a secondary reference source for further evaluation and analysis of the metrics and routing protocols

2. LITERATURE REVIEW

Researcher in [22] Performed a network simulation of routing protocols RIP, EIGRP, IGRP, and OSPF. The Network was simulated using OPNET to analyze the performance of routing protocols. They designed four network scenarios, scenario1 for OSPF protocol which is the baseline model, Scenario2 for RIP protocol, Scenario3 was modeled for IGRP protocol and Scenario4 for EIGRP. Network convergence was used to analyze the performance of protocols based on two different situations, situation 1 was simulated for 15 minutes and situation 2 for 6 minutes. Based on their

simulation results, they concluded that for a specific network with around 1000 hosts, OSPF and EIGRP is the best-suited combination of routing protocols. Also, it was noted that combination of RIPv2 and EIGRP would be best suited to a smaller network. Researchers [11] also supports the above conclusion, that EIGRP and OSPF are the best suited combination of routing protocols. EIGRP and OSPF performed best in situations where there are frequent network changes.

Researchers [13] presented a comparative analysis of OSPF, RIP and EIGRP protocols. They created and analyzed the network using Cisco packet tracer, and analysis was performed based on simulation of three different scenarios. Scenario 1 involved EIGRP protocol for services like EMAIL, 3G SERVER, DNS and NTP, the Scenario2 analysis was done using OSPF with the same services and Scenario3 was simulated using RIPv2 protocol. From the findings of simulation, they concluded that EIGRP protocol is efficient for the medium scale to large scale networks as it involves an algorithm that is less complicated as compared to OSPF. Based on their analysis, RIP would be the last option for the similar networks as it is not time efficient and network encounter delays.

Furthermore, they concluded that there is a difference between the routing protocols and that is due to the algorithms used that can generate delays in some services execution.

The research in [14] demonstrates a comparative analysis of EIGRP and OSPF routing protocols. They analyzed the performance of protocols using OPNET simulator with respect to CPU utilization. The Network was designed with different scenarios based on the topology of spoke-to-hub to analyze the effect of CPU utilization for the respective routing protocols. Topology was created with Cisco 26000, switches and 7500 routers. The Scenario includes once central hub and five-spoke sites for the site's connection and all routers are deployed with respective routing protocols. Numerous LANs in every spoke site which is attached with routers and every spoke site has various switches and routers. While the central router is linked with all the routers using a switch, every spoke site has the same network skeleton and every spoke site has various nodes and 10 LANs. Based on their simulation graph, OSPF showed constant behavior while EIGRP depicted different behavior. Hence, it was concluded that OSPF is better than EIGRP as

OSPF deals with less routing information such as update, delete and add. Overall their results showed that EIGRP is less intelligent than OSPF as EIGRP misuse resources such as CPU. Furthermore, Researchers [15] highlighted that sometimes it becomes very difficult to select between OSPF and EIGRP in a specific network situation.

The researchers in [16] presented the comparative performance evaluation of RIP and OSPF with respect to recovery cases and network link failure. OPNET is used for the evaluation and simulation of the real campus network as according to them, it is widely used for the related work and has all the required features. Their design includes three major areas of the University of Salford network and every area represents LAN. Every LAN has its own dedicated router which acts as a medium of external connection. Routing protocols RIP and OSPF are deployed on the respective routers in the typical network as the best fit size of LANs as compare to IGRP and EIGRP which are best suited for WANs. Their evaluation involved four pairs of scenarios and each pair dedicated to respective routing protocols to be analyzed. Three Pair were dedicated for the purpose of comparative evaluation of the respective protocols with respect to failure and recovery conditions. While one pair is for the verification and validation of the design as to see whether the design works and makes sense. There were certain parameters that were used to simulate the network such as Hop counts, router convergence activity, metric cost and routing traffic sent. Based on their findings from the simulation, OSPF converges late than RIP during every case in the initial stage of the network. While during the later stage of the network OSPF converges quicker than RIP based on average link failure/recovery for multiple links. Hence, it was concluded according to the performance evaluation that OSPF should be used for a network that has more frequent link failure while RIP would be used for networks with fewer failure links.

The research in [17], performed the analysis of routing protocols using services like voice, FTP and video conferencing. Riverbed modeler was used for the performance analysis of the designed network. Different scenarios were used for the purpose using ppp_wkstn_adv, ethernet_adv, ppp_DS1 link, and 10BaseT link and profile, application definition and failure recovery specifications were deployed for the

respective services linked with routing protocols. 12 scenarios were created with failure recovery specification and one without it. For three situations network was simulated for 1400 seconds. The Analysis was conducted based on packet end-to-end delay, convergence and jitter. The simulation was performed based on IP traffic dropped, packet end-to-end delay, and voice, traffic of video conferencing and convergence time of the network. It was noted that choice of best-suited routing protocol for real-time application is of great importance as some parameters can lead to packets loss for received video. Their study involved packet drop and convergence time of the network for all four routing protocols with respect to the traffic based on FTP, video, and voice. Based on their simulation findings, OSPF took greater time of convergence as compare to other three routing protocols for the traffic of voice and video also EIGRP has the greatest amount of dropped packets in IP network. While RIP and OSPF resulted in better performance as far as video conferencing packet delay variation is concerned. For flapping links, EIGRP and RIP showed adequate performance for the voice traffic and overall for both situations, EIGRP resulted in better performance than other three routing protocols.

The researchers in [18] demonstrated performance comparison evaluation of EIGRP and OSPF routing protocols for real-time applications in the scope of the enterprise network. The Major purpose of this paper was to check through experiment the effect on network performance while using single routing protocol in real topology. The Researcher used the case of an enterprise stated as STIC situated in Casablanca. Enterprise has opened a new department in some other location and they want one of their department in Casablanca to be linked with the new department so that both departments can communicate, considering that the network is provided by the service provider. The Problem that enterprise encountered was to choose the right routing algorithm for the communication of their sites to exchange data and reach a satisfactory level of Quality of service, for this purpose researcher has carried out his work. OPNET modeler 14.5 was used to simulate the real case scenario to conduct a comparative analysis of the two routing protocols. The network topology is based on EIGRP and OSPF protocols with every required combination experimented using suitable

quantitative metrics. Based on the Simulation result, it was concluded that use of one single routing protocol is always a good option in real time applications rather than a combination of both. As there is always a chance of metric loss while transmitting from one routing protocol to another. Furthermore, EIGRP gave them best output among routing protocols for all network components.

This paper [19] presented a comparative analysis of EIGRP, OSPF, BGP, IS-IS routing protocols with respect to convergence times in a network. Two main objectives of this paper were to estimate convergence time for respective routing protocols in a particular topology and performance comparison of these routing protocols. Based on their research, convergence time is one of the most important aspects of routing protocols and it estimates the time routers take to adapt to their respecting routing algorithm/tables to the changes in the topology. Graphical Network Simulator (GNS3) was chosen for the simulation of the network, as based on their research, GNS3 has a simple and easy to use user interface. Results were analyzed based on three major parts, firstly the data of convergence time of routing protocols with failure link close to the source were gathered, secondly, the convergence time with respect to failure link near to the traffic destination was collected and for the third part convergence time for topological changes was collected. Based on their simulation result, EIGRP performance was better among all four routing protocols. EIGRP takes less bandwidth as the traffic generated is quite less as compared to other routing protocols this gives sufficient bandwidth for the data transmission. They concluded that EIGRP performed well in all parts of the network including the topological changes, as it converges much quicker and utilization of bandwidth is much better than other three routing protocol.

The article [20] presented a comparative performance evaluation of EIGRP and IGRP routing protocols. The major purpose of their research was to figure out the best possible combined solution of routing protocols in a complex scenario to provide a seamless flow of communication. GNS3 was used to simulate the network with a network analyzer tool Wireshark. Four scenarios were created, senario1 based upon EIGRP and RIPv2, senario2 consists of EIGRP and OSPF routing protocols, senario 3 includes ISIS and OSPF

while the last scene was for BGP. Based on their simulation findings, it was concluded that a combination of EIGRP and OSPF gives the best performance for a specified network with approximately 1000hosts. Missing segmented areas made EIGRP and RIPv2 combination as best suited for a small network. Finally, their results also predicted that communication between ISIS and OSPF routing protocols is quite noticeable.

The Researchers in [21], demonstrated a comparative performance analysis of dynamic routing protocols, RIP, EIGRP, and OSPF. OPNET was used to simulate the network for the comparative analysis of the protocols with respect to convergence activity in a network with topological changes. Six scenarios were created based on two experiments, RIP, OSPF, AND EIGRP were individually configured in the first three scenarios and the combination of these three routing protocols (two protocols per scenario) was configured in the last three scenarios. Redistribution process was invoked in the network as it is used where routing protocols of two different nature are used in the same network. First 3 scenarios were used in experiment 1 while last 3 scenarios were grouped together for the 2nd experiment. NSFnet topology was used for the network design and both experiments results were analyzed. Based on the research and simulation findings research concluded that OSPF detects topology changes in a better way and updates routing tables of routers, comparatively quicker. Based on the later stages of the experiment, OSPF does not perform well and for CPU utilization OSPF is not best suited as it has a significantly high CPU utilization in comparison to EIGRP and RIP. While, in the combined network, RIP-OSPF combination had a low CPU utilization in comparison to EIGRP-OSPF combination. RIP was chosen as the best choice in the case of CPU utilization as it has a very low CPU utilization as compared to other two routing protocols. Upon further findings, EIGRP was declared as a least ideal choice with a network with frequent topological changes. Overall, within a network where there are frequent occurring topological changes, OSPF was stated as the best option with OSPF/RIP network can be used for decreasing CPU utilization.

This paper [22] presented a performance analysis of diverse dynamic routing protocols. OPNET simulator was used for route

redistribution and the respective topology. They used route distribution to ensure the connection among the routers in a large-scale business network. Four scenarios were created respectively, the first scenario includes a group of EIGRP, OSPF, AND ISIS, the second scenario was configured using a group of EIGRP, OSPF, AND RIPv2, the third scenario was created using RIPv2, EIGRP AND ISIS and the final scenario was set up using a group of RIPv2, OSPF, AND ISIS. Based on the simulation findings, group of EIGRP, OSPF AND ISIS performed best in terms of response time of email, web browsing and database query. While, a group of RIPv2, EIGRP AND ISIS outperformed other groups for real-time applications.

The article [23], conducted a performance evaluation of routing protocols with respect to IPv6. The major purpose of their paper was to investigate and estimate the performance of IPv6 routing protocols in an application which runs in real time. A number of criterions were considered including, convergence time, DB query response time, traffic dropped, video packet end to end delay, Http response time and etc. OPNET 17.5 simulator was used for the simulation of the respective IPv6 WAN network. According to the author, choice of best routing protocol is a critical task and requires a lot of testing. The simulation was based on evaluating the comparative analysis of IPv6 routing protocols with real-time applications. EIGRPv6 performed better than RIPng and OSPFv3 in case of failure/recovery and convergence time, so it is the quickest of all. EIGRPv6 was also chosen as the best choice for Http page response time metric. In case of DB query response time, EIGRPv6 did not perform well as compare to other two routing protocols. While for voice and video, jitter, packet end-to-end delay, EIGRPv6 performed best among other routing protocols. The researcher also put stress on the analysis of the security of IPv6 routing protocols as a future research work.

Table 1: Literature Summary

Research Article	Simulation Tool	Area Covered
[19]	Graphical network simulator (GNS3)	Comparative analysis of OSPF, BGP, IS-IS
[23]	OPNET 17.5	Performance evaluation of routing protocols.
[12]	OPNET simulator	Comparative performance evaluation of dynamic routing protocols (EIGRP, IGRP, RIP, and OSPF).
[13]	Cisco packet tracer	Comparative analysis of OSPF, RIP, and EIGRP
[14]	OPNET simulator	Comparative performance evaluation of EIGRP and OSPF.
[16]	OPNET simulator	Performance evaluation of RIP and OSPF

[17]	Riverbed modeler	Performed the performance analysis of routing protocols (EIGRP, OSPF, and RIP) using services like voice, FTP and video conferencing
[18]	OPNET modeler 14.5	Performance comparison evaluation of EIGRP and OSPF routing protocols for real-time applications in the scope of enterprise network
[22]	OPNET simulator	Performance analysis of diverse dynamic routing protocols in the case of route redistribution
[20]	GNS3	Comparative performance evaluation of EIGRP and IGRP routing protocols
[21]	OPNET simulator	Comparative performance analysis of dynamic routing protocols like RIP, EIGRP and OSPF

Based on the literature review, it can be seen that each routing protocol has its own suited network and based on the network configuration and topology, a best-suited routing protocol or a combination of routing protocols can be chosen. Dynamic routing protocols have their own set of properties and characteristics (Algorithm) based on which they perform in every metric. According to the study based on the related works, EIGRP performed considerably well in a network which involves topological changes. EIGRP protocol takes lesser bandwidth and quicker time to converge as compare to RIP, OSPF and IGRP this makes it best suited for similar networks. It is also noted that RIP is an ideal choice for a network in the case of CPU utilization as it has very low CPU utilization among other routing protocols. OSPF is better than EIGRP in the case of CPU utilization, as OSPF takes lesser routing information and is more intelligent than EIGRP.

EIGRP is best suited for the medium scale to large scale networks while RIP would be the last option for the similar networks. Combination of EIGRP and RIPv2 is best suited for smaller networks, while the combination of EIGRP and OSPF can be used for a network with around 1000 hosts. OSPF and RIP combination can be used for decreasing CPU utilization. Furthermore, in case of IPv6 routing protocols, EIGRPv6 outperformed OSPF, RIP, and IGRP in real-time applications.

This section refers to the various important factors discovered and discussed in the research part of this paper. Different methods of conducting the research is available, each method is compared, relevant and most suitable method will be chosen in this part of the paper with proper justification. Computerized simulation, analytical evaluation and mathematical analysis are different methods available for the research for conducting performance evaluation of routing protocols in a given network, based on various metrics.

Computerized simulation and mathematical evaluation are the most suitable method, keeping in view all the limitations and parameters involved in the research work. Simulation is an alternate to direct measurement, as simulation can be cheaper in cost and time efficient as well [24]. Mathematical analysis has various benefits for conducting the research, such as it can be efficient in terms of cost and time, while it is very much suitable for results that involve predictive analysis [12]. Furthermore, direct analysis and measurement involves real time operational network, which has a varying and dynamic environment and can be very costly in terms of setting up the configurations of the network. Despite of that, direct measurement can lead to results that are quite accurate.

NS-3, Omnet++, cisco packet tracer, Qual net and Riverbed modeler are different simulators available for simulating and analyzing a given situation. Riverbed modeler (academic edition) was chosen as the most suitable simulator for this research work. This modeler is based on DES (Discrete event system) and is object oriented in nature, it is the most practiced tool for simulating a network due to its reliability, user-friendly interface and fast performance [25].

3. RESEARCH METHODOLOGY

This section refers to the various important factors discovered and discussed in the research part of this paper. Different methods of conducting the research is available, each method is compared, relevant and most suitable method will be chosen in this part of the paper with proper justification. Computerized simulation, analytical evaluation and mathematical analysis are different methods available for the research for conducting performance evaluation of routing protocols in a given network, based on various metrics. Computerized simulation and mathematical evaluation are the most suitable method, keeping in view all the limitations and parameters involved in the research work. Simulation is an alternate to direct measurement, as simulation can be cheaper in cost and time efficient as well [24]. Mathematical analysis has various benefits for conducting the research, such as it can be efficient in terms of cost and time, while it is very much suitable for results that involve predictive

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4. SIMULATION OF THE CHOSEN NETWORK

This section will include the network model including the four scenarios based on RIP, OSPF, EIGRP and IGRP routing protocols. In the sub section, all scenarios will be configured by defining and using certain parameters. All of this will be performed on Riverbed modeler, followed by setting up simulation environment, time and results in the next section.

- Network model and scenario

Riverbed modeler is used for simulating the network and analyzing the constructed situations. First phase of the simulation involves, developing the network based on the RIP, OSPF, EIGRP AND IGRP routing protocols. Designed network scenarios include four different scenarios, first scenario is labelled and modelled as the baseline of RIP protocol. Second scenario is modelled for base lining OSPF protocol. While, third and fourth scenarios are modelled for base lining EIGRP and IGRP routing protocols. Family model cisco 7000 is used for modeling the network, and modeling of network involves, 2 work stations, five routers (Cisco 7000), link failure component, and profile and application config.

Baseline network for all four scenarios is modeled by linking five routers with each other through ppp_ds3 links and 2 ethernet work stations. Two workstations (PCs) in the network are configured for video conferencing. Furthermore, performance evaluation and

analysis of the routing protocols would be conducted based on few metrics, like convergence time, point to point throughput (bits/sec), point to point queuing delay (sec) and point to point utilization. The four different scenarios and their network models are shown below.

Figure 1: Configured Network model (RIP)

Figure 1 above represents the RIP network model that is configured based on the two situations that will be highlighted and listed in the next phase of this paper.

Figure 2: Configured network model (OSPF)

Figure 2 above represents that network model for OSPF routing protocol, this network is configured based on the two situations that will be shown in the next phase.

Figure 3: Configured network model (EIGRP)

Figure 3 above shows the network model configured for EIGRP routing protocol based on the two situations for the simulation that will be shown in the next phase.

Figure 4: Configured network model (IGRP)

Figure 4 above represents the network model for IGRP routing protocol. This network is configured based on the two situations for the simulation.

- Simulation Configurations and parameters

Figure 5: Application config (Video conferencing)

Figure 5 above represents the configuration of application config node. In the application definition, number of rows is set at 1, name is Video and, in the description, video conferencing is set ON with high resolution video.

Figure 6: profile definition config

Profile definition is configured by setting up profile configuration rows 1, profile name is VI and Video is selected which was pre-set in the application definition node. Start time offset (seconds) is set uniform (5,10) and remaining statistics can be seen in the figure 6.

Situation 1		Situation2	
Status	Time (secs)	Status	Time (secs)
Fail	240	Fail	30
Recover	420	Recover	60
Fail	520	Fail	90
Recover	580	Recover	120
Fail	610	Fail	150
Recover	620	Recover	180
Fail	625	Fail	210
Recover	626	Recover	240
Fail	726	Fail	270
Recover	826	Recover	300
		Fail	330
		Recover	360

Figure 7: Link failure and recover (Situation1&2)

Figure 7 above represents the two situations for link and failure recover. All four networks above are configured under these two situations to analyze and check the convergence time for all four routing protocols.

Figure 8: Link failure and recover (Situation 1 configuration)

Figure 8 above represents the configuration setup of link failure/recover node as an example for situation 1 and it will be configured the same way for situation 2 based on the link status and time (sec). For situation 1, link failure/recovery specification is set by making 10 rows with logical network as R2-R1, status and time based on the situation one parameters.

Figure 9: Individual DES statistics (Configuration)

Choosing individual DES statistics for the simulation is represented in figure 9 above. It can be seen that IP network convergence

duration (sec) is checked and its description box shows that it has been achieved. While for link statistics (point to point), queuing delay (sec), throughput (bits/sec) and utilization is selected.

Figure 10: Configuration for simulation results

Figure 10 above represents the configuration of simulation results. Presentation is selected as overlaid statistics and average. All 4 scenarios are selected and for global statistics IP network convergence is checked. In object statistics, point to point metrics are selected for further performance evaluation.

5. SIMULATION RESULTS: DISCUSSION AND ANALYSIS

This paper evaluated and analyzed the performance of routing protocols under two different situations, while the network was simulated for 15 minutes in the case of situation 1 and situation 2 was simulated for 6 minutes. Performance of routing protocols was evaluated

and analyzed using network convergence (sec).

Figure 11: Convergence time (situation 1 and situation 2)

Results for convergence time (sec) of all 4 scenarios of RIP, OSPF, EIGRP and IGRP respectively are shown above. Results in case of situation 1 and situation 2 are shown in the figure 10 respectively. How efficient the group of routers are in convergence is evaluated in convergence time, this is the basic and most key performance metrics for identifying which routing protocol is the most reliable and efficient in convergence. This is subjective, as convergence time might vary due to the size of the network, small network takes less time to converge while larger network would take more time to converge.

It can be seen that distance vector algorithms such as IGRP and RIP converges very slow and are not suitable where there are frequent network topological changes. Before the router's convergence, there is a change in the network, this may cause loss of packets/data and errors in routing. EIGRP and OSPF (Link-State Algorithms) are seen to have a more efficient and quicker convergence as compare to RIP and IGRP. Also, IGRP takes lesser bandwidth as compare to RIP, despite of that, RIP still converges faster than IGRP. OSPF and EIGRP are much quicker and efficient in terms of convergence and frequent network topological changes. This is because in OSPF scenario every router has a backup of the routing table and database to detect any changes in the route to find an alternate route, as compare to IGRP and RIP which uses distance vector algorithm. Furthermore, EIGRP works on DUAL

algorithm, which is executed once router identifies any changes in the route.

Figure 12: Point to point throughput (Bits/sec)

Figure 13: Point to Point utilization

Figure 14: Point to Point delay (sec)

Performance metrics like point to point throughput, utilization and delay are also conducted for enhanced performance evaluation of the four routing protocols. Figure12, figure13 and figure 14 shows the results of throughput, utilization and delay respectively. Based on the evaluation from the results, it can be analyzed that EIGRP throughput is maximum, while OSPF is the second best in terms of point to point throughput (bits/sec). IGRP and RIP showed the least throughput in the results. In figure 15, it can be seen that link utilization is greatest for EIGRP, second best was OSPF followed by RIP and IGRP. In figure14, it can be seen that EIGRP delayed for the least amount of time (sec) followed by OSPF, RIP AND IGRP. Hence, it can be concluded that EIGRP was the best suited routing protocol according to the performance evaluation and analysis.

- Results comparison with the Anchor paper

Figure 15: Convergence Time (Anchor paper) [11], [26] and Derwesh, 2014)

Figure 16: Three parameters of performance [11]

In figure 15, convergence time of four different scenarios based on routing protocols RIP, OSPF, EIGRP and IGRP is shown based on the anchor paper. Results of researchers [11], [26] for convergence time are quite similar to this paper. For convergence time of situation 1 the results of this paper vary a bit, as the simulation environment was different it caused some delay in the simulation results. For situation 2, the results of anchor paper and this paper are quite similar. In the results of both papers, IGRP and RIP converged slower than EIGRP and OSPF routing protocols.

In figure 16, results of anchor paper for point to point throughput, utilization and delay is shown. It can be seen that results of this paper and anchor paper for the three performance parameters are quite similar, hence similar evaluation is achieved. In both papers, EIGRP performed well than other three routing protocols, and it can also be evaluated based on the results evaluation of both papers, that OSPF performed second best based on the similar performance metrics. While, RIP and OSPF are the last resort and option in the scenario where there are frequent network topological changes.

6. CONCLUSION

Based on the results of the simulation performed on various routing protocols such as RIP, OSPF, EIGRP and IGRP, using different performance metrics, it can be concluded that EIGRP outperformed all other routing protocols. In a situation where there are frequent network topological changes, RIP and IGRP are the least suited routing protocols. While EIGRP and OSPF are the best suited routing protocols in a changing network environment. OSPF can be a better choice than EIGRP considering transmission cost and router overhead, while EIGRP performed best in terms of convergence, utilization, delay and throughput. Hence it becomes really difficult to select among OSPF and EIGRP. Future research can be based on selecting a routing protocol among OSPF and EIGRP based on their performance in a large network using different performance metrics.

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