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Analysis and Performance Evaluation of OSPF and RIP Routing Protocols Using QualNet

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Abstract: Undoubtedly, the human life tasks rely more and more on computers. Especially after the internet and communication technologies leaded to the E (electronic) to be includes in almost everything from governments to trading and banking system, etc. Hence, the quality of the services can be provided by such systems became a matter of interest. Since the routing protocols are the fundamental procedures controlling the network work. They became the most interest field to be researched. In this paper, we simulate two of the widest used routing protocols, RIP and OSPF performs in different scenarios and network configurations, then we analyze the performance (total data sent and received, total throughput and average end to end delay) of each scenario in different conditions. The result of simulation show that OSPF performs better than RIP especially when it comes to the reliability of connection and the convergence time to cope the network failure. QualNet simulation tool had been used to design the network; analysis of the results was examine using standard tools.

Keywords: RIP, OSPF, QualNet

1. Introduction

Nowadays, the Quality of Services (QoS) which can give an indication about the whole network performance becomes a big issue and an important parameter need to be achieved and enhanced as much as possible.

The past few years have witnessed an ever-growing reliance on computer networks for business transactions. With the free flow of data and the high availability of computer resources, and with the expansion of the existing networks and the emergence of new applications that require a real- time communication. A variety of factors can affect the whole network system performance and the Quality of Service [1].

Routing protocols become one of the most important decisions in the design of these networks. The first question we should make ourselves is why routing protocols are so important? Routing is the act of sending Information from a source to a destination. Usually, this information passes through some intermediate devices. The purpose of routing protocols is to provide these intermediate devices the necessary information to send the packet correctly. So, the importance of routing protocols is such that without them the different devices that make up a network are not able to communicate with each other [1,2].

By using QUALNET, which is a communications simulation platform, can planning, testing and training tool that "mimics" the behavior of a real communications network, two types of routing protocols (link state and distance vector) will be testified and evaluated by using same network topology under different conditions. Then analysis on the performance of these two protocols will be done from a comparative point of view. Where some of the important parameters as the throughput, delay and convergence time will be taken in consideration [3].

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2. PROTOCOLS

variety type of routing protocol exists and each type of these protocols using different algorithms built on different criteria. In this work, a network system with specific topology will be built and two fundamental types of these protocols will be used which they:

- Distance Vector Routing Protocols: which finds the best path on how far the destination is represented by (Routing Information Protocol version 2) RIPv2. It is an interior gateway protocol (IGP) created for use in homogeneous and small networks. However, they have poor improper and convergence scale, which has led to the development of more complex but more scalable link-state routing protocols for use in large networks [2]. RIPv2 uses broadcast User Datagram Protocol (UDP) data packets to exchange routing information. Since RIPv2 uses UDP as its delivery mechanism, the routing updates sent to the neighboring routers are not guaranteed [2,4].
- Open Shortest Path First (OSPFv2): which uses link-state technology in which routers send each other information about the direct connections and links to all routers in the network. Each OSPF router required to maintains an identical database to describe the autonomous system's topology. From this database, a routing table is calculated by constructing a shortest path tree. OSPF provides greater flexibility than the Distance Vector routing protocols and reduce overall broadcast traffic and make better decisions about routing by taking characteristics such as delay, bandwidth and reliability [5,6].

In general, these two protocols define the best way that packet might takes from the client to the server according to the cost of the path, but each one of them considers the cost of the path in a very different way. Where RIP takes the path with the less routers number as the lowest cost path, OSPF calculates the cost of the path according to that link bandwidth even if that path was not with the lowest routers number [1,7].

3. SIMULATION

To verify the differences between these two protocols and analyze their performance, a network with a topology below will be testifying in different scenarios and configurations using QUALNET. By setting the routers, links, access points, networks and terminals' configurations with RIP protocol from each element properties.

The topology has been designed to be simplistic and can give three transmitting options with a different routers number in each path, giving the ability of setting more than one link failure.

Since distance vector routing protocol (RIP) defines the best path as the path with the least number of router (the lowest hop counts' path) whatever the bandwidth of that path was, and then it will always choose that path unless a link failure happened. Moreover, to see that, at the beginning the simulation will be run with no link failure and then a link failure or more will be set from the link properties at specific period.

At the beginning, all elements in the network signaling the other to set the routing table, seeing which is the path with the less routing number and to inform the network about that path. Then it will start sending from the client to the server using that path as figure (1) shows, and whenever a link failure happens to that path as shown in figure (2), it will update the routing table for the network and start using the second less router numbers path as shown in figure (3).

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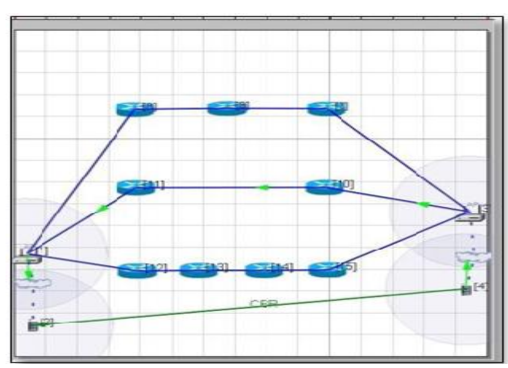

Figure 1. RIP 1st convergence at Sec 24

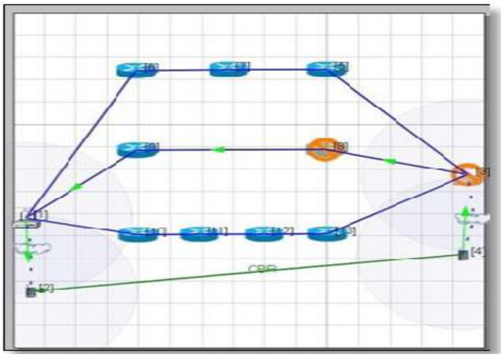

Figure 2. RIP 1st link failure at Sec 40

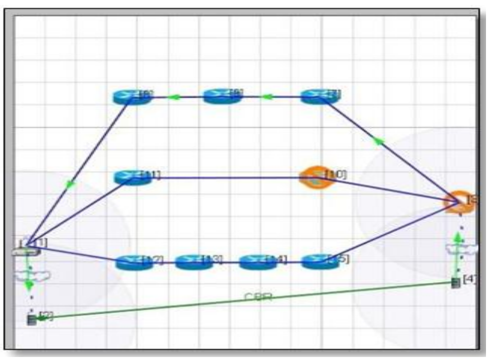

Figure 3. RIP 2nd convergence at Sec 72 after 1st link failure

If another link failure with the new path happened, then the network will update routing table again and fined another shortest path as shown in figures (4,5), respectively. Whenever all link failures are finished, the first used path will be used again after updating, that mean the signal will back to the first path as figure (6) shown below. That if both failures finished at the same time, but if not then, the signal will back to the path which was used before that link failure happens.

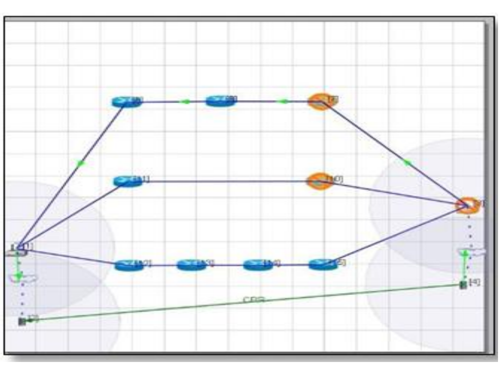

Figure 4. RIP 2nd link failure at Sec 72

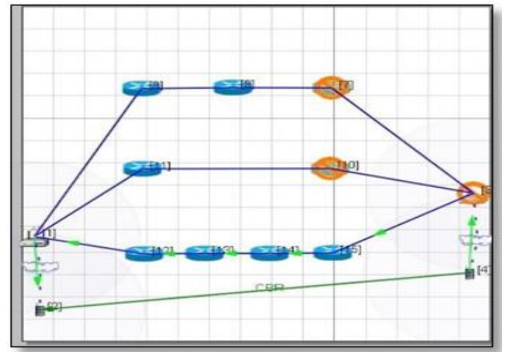

Figure 5. RIP 3rd. convergence at Sec 96 after 2nd link failure

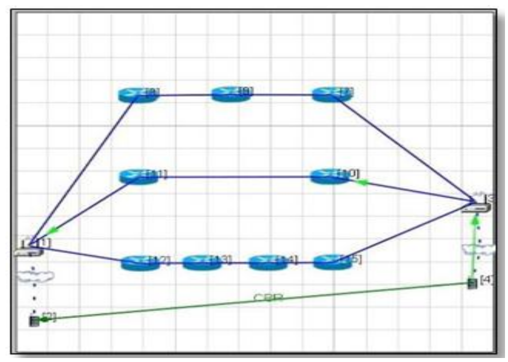

Figure 6. RIP 4th convergence at Sec 142

after the 2 links failure finish

On the other hand, Link State Routing Protocol (OSPF) works on a more complicated algorithm as what has been mentioned before, where links' costs been defined according to the bandwidth of that link, and the routing table for the entire network will be set regarding to each node with it is neighbors. One router will be the designated router that will be responsible for sending the link advertisement to the other routers. To illustrate that, the same topology will be deployed again and the configuration for the routing protocol will be set to work as OSPF and that is for all network's elements. At the beginning, a change for link bandwidth will be set from the configuration window to illustrate by QUALNET how the bandwidth plays as a fundamental role with OSPF.

Noticeably, as a figure (7) shows below, the path with a higher bandwidth will be chosen even if it was with a higher router number and there is no link failure, but since the aim of part one of this work is to know the best protocol's performance then exactly the same bandwidth, with the same links fail at the same time as what have been done with RIP protocol above, will be repeated in next steps with OSPF.

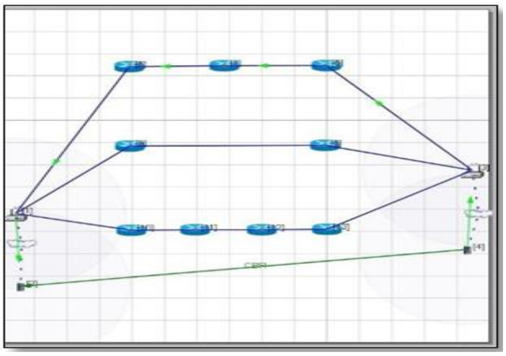

Figure 7. OSPF choosing the higher bandwidth path

Evidently, the signal will take the shortest open path if the all link bandwidths are same, and that means a network with the same topology and it's all links with the same bandwidth (10 Mbps by default in QUALNET) then OSPF will work as RIP regarding to which path will be chosen, and that is why when the same link failure happened, as what has been illustrated with RIP protocol above, then exactly the same paths will be chosen when OSPF protocol is in use, as figures (8,9,10,11) show, respectively.

It is necessary to notice the simulation time in these diagrams, where they look like exactly the same diagrams from RIP part, but the simulation times at each event, which will be depended later, are different.

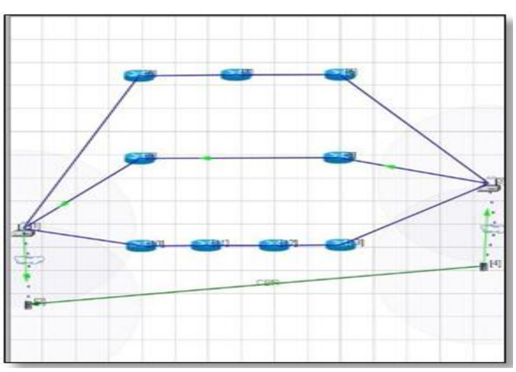

Figure 8. OSPF 1st convergence at Sec 28

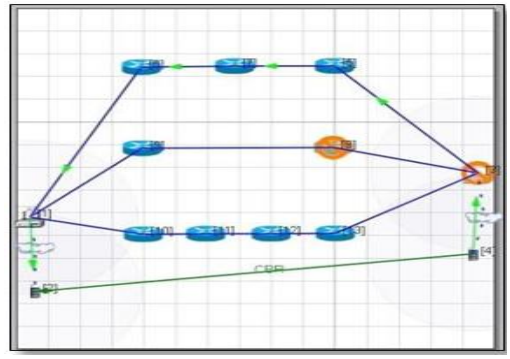

Figure 9. OSPF 2nd convergence at Sec 46

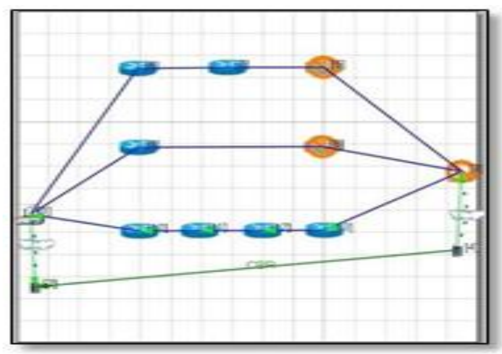

Figure 10.OSPF 3rd convergence at Sec 86

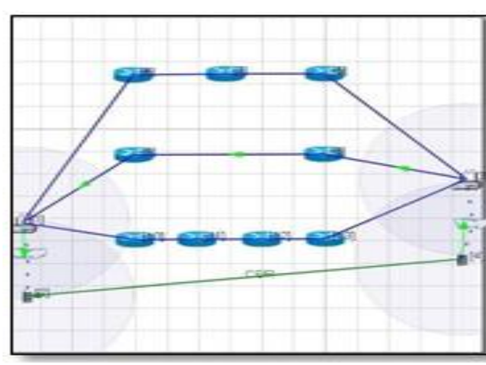

Figure 11.OSPF 4th convergence at Sec 110 after two links failure finish

4. Comparison and Analysis

Now, after having a brief view about both protocol's type and to know which one have better performance than the other and how networks and links different conditions can affect that performance, an analysis and comparison with specific values like total data sent and received, average end to end delay, total throughput, etc.., will be taken when there is no link failure and then with one and two link failures.

A. *Throughput and Data received*

Throughput refers to how much data can be transferred from one location to another in a given amount of time. The throughput and the total data receive are beneficial parameters to be used in the analysis of the performance of the network and the used protocol regarding to the speed and the reliability, where, whenever the total data received is not much lesser than the total data sent, that means no many of lost or dropped packets during the transmission. In addition, the higher the throughput the better the performance and Quality of Service of the network, and the smaller the delay.

Now, from QUALNET analysis bars and when total unicast data sent for both protocols is the same (152000 byte). For Distance Vector Routing Protocols (RIP), it is obvious that total unicast data received decreased from (143872 Byte) to (128000 Byte) when two link failures happened, through (134656 Byte) with one link failure, as well as the throughput which goes down from (4096.06 to 3644.19 bit /sec) with (3833.68 bit /sec) for one link failure.

On the opposite side. For Link State Routing Protocols (OSPF) the total data received has a slight change from (140800 Byte) with no and one link failure to (140288 Byte) when two link failures happened, as same as received throughput which goes from (4051.86 bit / Sec) for no and one link failure to (4037.12 bit /Sec) with two link failure.

From Figure (12), it is obvious that RIP performs better than OSPF at the beginning (first convergence), but whenever a link failure happens, longer transmission time or more complicated topology, OSPF offers a stability and reliability in the transmission that RIP cannot offer, where it can be seen from figure (13) the throughput with RIP plunged, and that because the limited number of hops, and the number of updates RIP usually takes and repeats (by default every 30 seconds), which will occupy the time and the path, leading to more dropped packets and decreasing in the throughput. In addition, because RIP uses the number of hops as a metric while OSPF uses the minimum cost, which might be the highest bandwidth path or the least delay, as a metric.

Besides, one of the OSPF better performance causes is that it used IP 89 to transmit its data while RIP uses UDP 520, and that will be detailed more later.

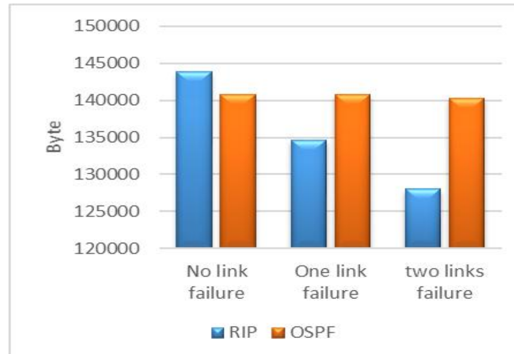

Figure 12. Total Unicast data received

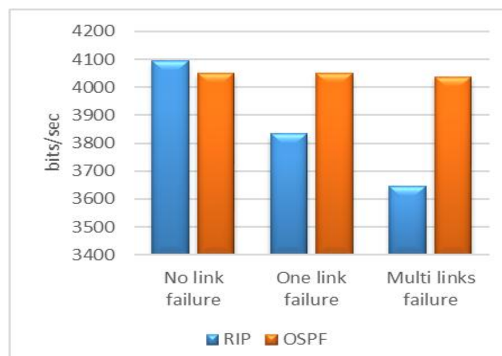

Figure 13. Unicast received throughput

B. *Average End-to-End Delay and Jitter*

Simply said, time difference in packets inter-arrival time to their destination can be called **End-to-end delay (E2ED)**. While **jitter** is the delay experienced by the packet inside the router queue. It is an undesirable effect caused by the inherent tendencies of TCP/IP networks and components. Jitter and delay are also two of the performance's affective parameters, which are good to analyze.

From the RIP side of work, it is obvious that the average end to end delay has an increment from (0.0126487 to 0.0131487 Sec then to 0.132373 Sec) with no, one and two link failures, respectively, as well as average jitter, which has slight increment from (0.002599 through 0.00274523 to 0.0028834 Sec).

While, with OSPF, a slight change can be seen for the average end-to-end delay and the average jitter, with (0.0126908 Sec) and (0.0026154 Sec) respectively, when there is no link failure, (0.0130918 Sec) and (0.00274548 Sec) respectively, when there is a link failure, and (0.013286 Sec) and (0.00287085 Sec) respectively, respectively, when two links fail.

Once more, as in Figures (14,15), jitter and delay for both protocols are approximately the same, but taking in consideration the better (higher) total data received with a network works on OSPF protocol.

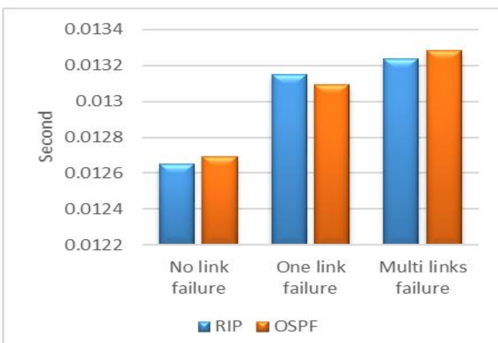

Figure 14. AE2ED

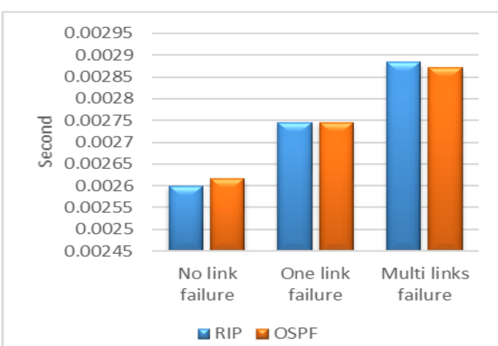

Figure 15. Average Jitter

The above results are for the receiver node, and if the whole nodes in the topology have been taken and evaluated, it can clearly be seen that in routers themselves, by exporting the founded results from QUALNET to a text file, results show that in case of same loaded conditions, the OSPF routing protocol records a remarkable minimum average delay and jitter. when compared with RIPv2 due to its link state properties, as figures (16, 17).

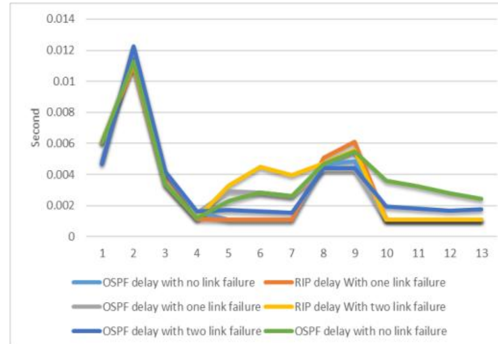

Figure 16. AE2ED for all node

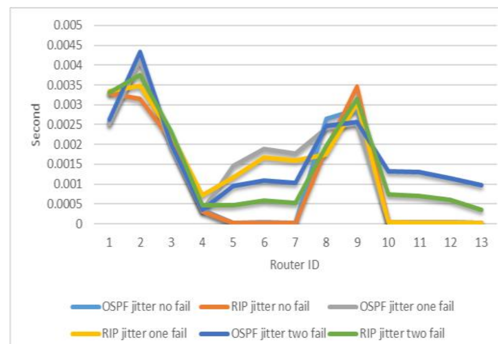

Figure 17. Average Jitter for all nodes

Convergence Time

One of the most important performance indicators to analyze is the convergence time, which is a measure of how fast a group of routers reach the state of convergence. In other words, it is the time that the network spent to find the suitable path at it is first work or after a link failure happened or finished, and start transmit.

With QUALNET, although, delay time, throughput and other factors can give in some way, what is the differences between RIP and OSPF protocols regarding to the convergence time, but since there is no exact parameter can show the exact convergence time for all conditions that have been tested above, therefore, the simulation time shown in all topology's figures above will be depended to clarify the differences.

From Figure (18) which illustrates all times from the related figures in the topology part, and with the same links fail at exactly the same time, which are at the second (40) to the second (102) for the first link failure and at second (72) to second (102) for the second link failure.

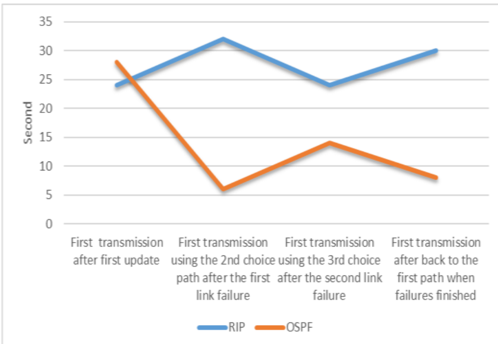

Figure 18. Convergence time

Clearly, OSPF takes longer than RIP at the first stage (first update) when a routing table being built, but after that and whenever a failure happen OSPF is faster than RIP as what can be seen in figure (16). Since, RIP update its routing table every 30 second by default and the routing table will be updated at each link failure or re-establishment, too, while OSPF set its routing table.

5. Conclusion

Regarding to the whole topology's possibilities at the first work. OSPF performs much better than RIP due to the convergence time. Another cause is that with OSPF, data transmit on IP protocol, while with RIP; data transmit over UDP, and that one of the main differences between these two protocols.

Where OSPF protocol runs directly over IP, using IP protocol 89. Moreover, it does not provide any explicit fragmentation / reassembly support. When fragmentation is necessary, IP fragmentation/reassembly is used. OSPF protocol packets have been designed so that large protocol packets can generally be split into several smaller protocol packets. This operation is recommended; IP fragmentation should be avoided whenever possible

While, RIP is a UDP-based protocol. So that each host that uses RIP has a routing process that sends and receives datagrams on UDP port number 520. All communications directed at another host's RIP processor are sent to port 520. All routing update messages was send from port 520. Unsolicited routing update messages have both the source and destination port equal to 520. Those sent in response to a request was send to the port from which the request came. Specific queries and debugging requests may be send from ports other than 520, but they are directed to port 520 on the target machine.

It is necessary to know that sometimes the first convergence for RIP take longer than OSPF's first convergence and that might rarely happen with some complex topologies having similar paths. As a final contrast for this part, Table (1) below shows the main differences between the two types illustrating the differences between these two protocols according to what have been mentioned before.

Table 1. Differences between RIP and OSPF

Feature	RIP	OSPF
Algorithm	Distance vector	Link state
Metric	Hop count	Depends on bandwidth, Delay, throughput
Maximum no of hops	15 - 16 hops is considered to be Infinity	Depends on the size of Routing tables
Subsystem Segmentation	Autonomous system is treated as single subsystem	Breaks the autonomous system in areas
Integrity	No authentication in RIP-1. Authentication is added to RIP-2	Supports authentication
Complexity	Simple	Relatively complex
Protocol / port	UDP 520	IP 89

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