Comparison of EIGRP, OSPF, and RIP Routing Protocols using OPNET Simulator

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الملخص:

تعتبر بروتوكولات التوجيه من أهم الركائز التي تعتمد عليها الشبكات في عملية الاتصال والتحديث وتبادل المعلومات فيما بينها. تتمثل الوظيفة الأساسية لبروتوكولات التوجيه في اختيار المسار الأمثل للحزم للانتقال إلى وجهتها النهائية. جميع بروتوكولات التوجيه المستخدمة حاليًا في الشبكات الحديثة هي بروتوكولات التوجيه الديناميكي، والتي تنقسم بدورها إلى بروتوكولات البوابة الداخلية IGPs وبروتوكولات البوابة الخارجية EGPs.

تستخدم IGPs خوارزمية متجه المسافة أو خوارزمية حالة الارتباط، بينما تستخدم EGPs خوارزمية متجه المسار لاختيار المسار الأمثل. في هذه الورقة البحثية، تمت مقارنة أداء IGPs، وهي RIP وEIGRP وOSPF، باستخدام أداة محاكاة OPNET أظهرت النتائج أن بروتوكول EIGRP يستغرق أقل وقت للتقارب بين الشبكات، بينما يستغرق بروتوكول OSPF وقتًا أطول للتقارب. ومع ذلك، يستغرق بروتوكول RIP وقتًا أطول للعمل في التقارب.

Abstract

Routing protocols are considered to be one of the most important pillars on which networks depend in the process of communicating, updating, and exchanging information between them. The primary function of routing protocols is to choose the optimum route for packets to travel to their final destination. All routing protocols currently used in modern networks are Dynamic Routing Protocols, which in turn are divided into Interior Gateway Protocols (IGPs) and Exterior Gateway protocols

(EGPs). IGPs use the Distance vector algorithm or Link state algorithm, while EGPs use the Path vector algorithm to choose the optimal route. In this research paper, the performance of IGPs, namely RIP, EIGRP, and OSPF, was compared using the OPNET simulation tool. The results show that EIGRP protocol took the least time to converge between networks, while OSPF takes a longer time to converge. However, RIP protocol takes the longest time to work in convergence.

Keywords: RIP, EIGRP, OSPF, OPNET

1. Introduction

The primary function of a router is to forward packets from one network to another. The routing process takes place by choosing a specific path through which packets pass.

This process is performed by routing protocols, where routing protocols use specific algorithms to choose the route where packets can pass through.

There are several criteria can be used to classify routing protocols. Routing protocols can be classified into: Interior and Exterior routing protocols, Dynamic and Static routing protocols, and routing protocols that use Distance vector algorithm and others that use the Link state algorithm. Figure (1) shows the classification of routing protocols.

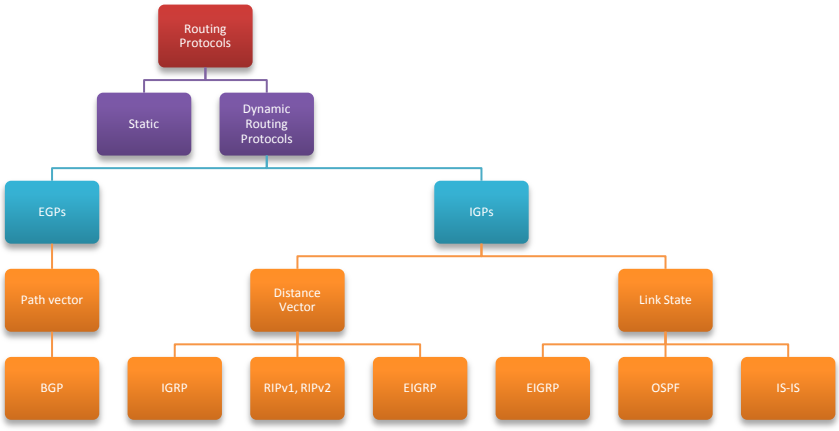


Figure (1): Classification of Routing Protocols [1]

The following subsections explain the classification of routing protocols:

1.1 Interior and Exterior Routing Protocols

This classification depends mainly on the Autonomous System (AS), AS can be defined as a group of routers, which use a specific protocol to exchange routing information inside and outside the AS. Routing protocols are divided under this classification into:

Interior Gateway Routing protocols

The IGPs work within the autonomous control system (AS), as shown in Figure (2). The most IGPs are:

- Routing Information Protocol (RIP)
- Enhanced Interior Gateway Routing Protocols (EIGRP)

- Open Shortest Path First (OSPF)

Exterior Gateway Routing Protocols

The EGPs work to exchange routing information between different Autonomous Systems as shown in Figure (2). The main function of EGPs is to connect different ASs. One of the most famous EGPs is the Border Gateway Protocol (BGP).

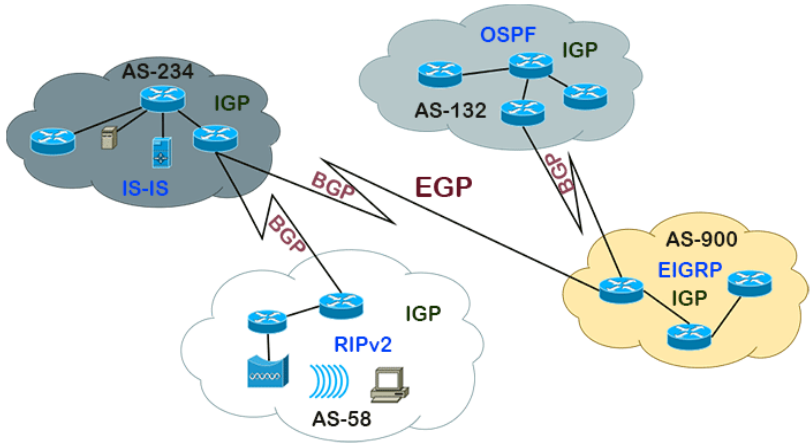


Figure (2): Interior & Exterior Routing Protocols [2]

1.2 Dynamic and Static Routing Protocols

The routing protocols in this criteria are divided into dynamic routing and static route. The network engineer sets the static route, and the router directs packets through this path without taking into account any other criteria. It is not recommended to use static routes in routing operations because they require direct monitoring by the network engineer.

Dynamic Routing Protocols choose the optimum path based on certain algorithms, either choosing the shortest path or the best path. Dynamic protocols also update routing information to determine the path through which packets will pass. The updating process takes place periodically, in order to add new networks, or find the failure of existing networks.

1.3 Routing Protocols Algorithms

Routing protocols are classified into protocols that use the Distance Vector algorithm, protocols that use the Link State algorithm, and protocols that use the Path Vector algorithm.

Protocols that use the distance vector algorithm calculate the best path based on the shortest distance through which packets can pass. The algorithm calculates the number of routers between the sending and receiving nodes, and based on the smallest number, the packet routing path is chosen. The most well-known protocols that use the Distance vector algorithm are RIPv1, RIPv2, and IGRP.

Protocols that use the Link State algorithm calculate the best path based on a set of criteria, including bandwidth and delay coefficient, depending on the type of protocol. The most famous protocols that use the Link State algorithm are OSPF and IS-IS.

Protocols that use the path vector algorithm calculate the path based on the vector distance and available path information. The Path vector algorithm is used in (EGPs). The most famous EGP is BGP.

In this research paper, the focus will be on the comparison between the performance of RIP, OSPF, and EIGRP in terms of their capability for network convergence.

2. Routing Protocols

This section explains in some detail the IGPs: RIP, EIGRP, and OSPF, as the aim of this paper is to compare the performance of these protocols.

2.1 Routing Information Protocol

This protocol is considered to be one of the interior dynamic routing protocols that uses the Bellman-Ford routing algorithm, which is one of the algorithms that relies on calculating the shortest path to direct packets.

This protocol employs a counter to avoid the problem of counting to infinity by defining a maximum number of permissible distances, which is 15 routers, which limits the size of the network supported by this protocol, and is suitable for small networks.

RIP works at the network layer, and it uses one table, which is the Routing Table, in which network addresses and routes are recorded, and it calculates the best path through the least number of routers.

RIP sends routing table updates every 30 seconds to routers that work with it. RIP has two versions, RIPv1 and RIPv2. [1]

2.2 Open Shortest Path First

OSPF is classified as a link state routing protocol and was developed by the Internet Engineering Task Force (IETF) to be an alternative to the RIP protocol. [3]
The OSPF protocol creates three tables:

- Neighbor table: it includes all information about neighboring routers. • Topology table: it contains a complete map of the network, including available OSPF routes and alternative routes to the best route if it is not available.

• Routing Table: it includes the best path under the current situations, which will be used to direct traffic between neighboring routers.

2.3 Enhanced Interior Gateway Routing Protocol

The EIGRP was developed by Cisco and it is an improvement to the IGRP protocol. EIGRP is a hybrid protocol that has characteristics of protocols that use the Distance vector algorithm and protocols that use the Link state algorithm. EIGRP uses the Diffusing Update Algorithm (DUAL), which uses metrics such as bandwidth and delay to calculate the optimal path.

EIGRP has fast convergence and updates using specific information about available routes. The number of hops in the EIGRP protocol reaches 255 hops. The EIGRP protocol has three tables containing information about available routes. These tables are:

• Neighbor Table: This table includes information about the routers that are directly connected to the router that has the EIGRP protocol enabled.
• Topology Table: This table contains all information about the networks associated with neighboring routers
• Routing Table: It contains all the routes available for networks associated with routers that have the EIGRP protocol enabled.

Figure (3) shows the process of building relationships with neighbors and how to build an EIGRP protocol table

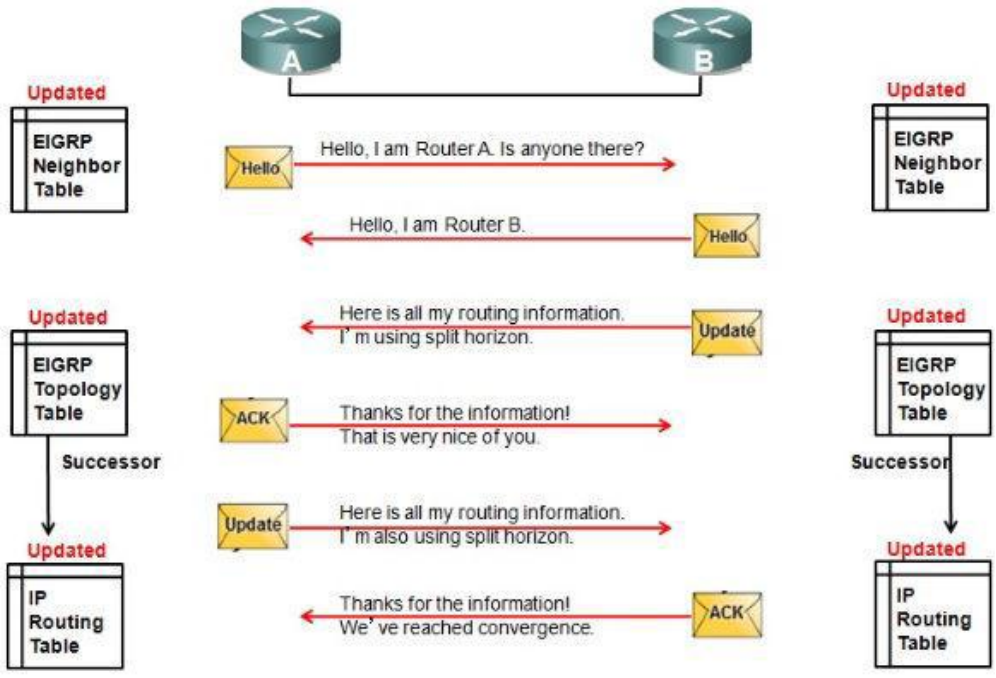


Figure (3): The process of building EIGRP tables [3]

3. Related works

There are many previous studies that have been conducted regarding comparing the performance of interior routing protocols RIP, OSPF, and EIGRP. For example: Researchers in [3] compared routing protocols RIP, OSPF, and EIGRP in terms of quality of service on physical (real) networks.

On the other hand, in 2014, researcher Gehlot and others in [4] evaluated the performance of the RIP, OSPF, and EIGRP protocol using several criteria, including the delay coefficient and the rate of sending and receiving packets.

In 2012, S. Farhangi and others in [5] analyzed and compared networks using routing protocols OSPF, IS-IS, and EIGRP. The comparison was analyzed using voice and video packets, and the results showed that the convergence coefficient for IS-IS, OSPF is lower than the convergence coefficient for EIGRP.

In this paper, the comparison of routing protocols RIP, OSPF, and EIGRP will be carried out using OPNET.

4. Research methodology

In this research paper, we compared the performance of routing protocols RIP, OSPF, and EIGRP using the network simulation tool OPNET. A deductive research approach was employed using experiments to compare and evaluate the performance of the aforementioned routing protocols. The next sections provide an explanation of the OPNET simulation tool and network topology.

4.1 OPNET Simulation Tool

OPNET stands for Optimized Network Engineering Tool, which is a computer network simulation program provided by OPNET Inc. It supports communications in wired and wireless networks. [6]

OPNET has licensed version, which is OPNET Modeler, and a free version, OPNET IT Guru, which is used for academic purposes and scientific research purposes, with limited capabilities. OPNET can be downloaded directly from the company's website for free. OPNET has many features which can be summarized as follows:

1. Provides a graphical user interface GUI.
2. Easy to use compared to other simulation tool such as NS-2.
3. Compatible with wireless networks.

4. It does not require programming skills when using it.
5. There is a free version of OPNET.
6. High degree of accuracy of simulation results.
7. Linking with Excel to analyze the results and draw them according to the user's needs.

4.2 Experimental Procedure

In this paper, the network was simulated using the OPNET program, which contains 5 subnetworks connected to each other with 3 scenarios as follows: in the first scenario, RIP protocol was activated, in the second scenario, OSPF protocol was activated, and in the third scenario, EIGRP was activated. The simulation period took about 900 seconds. The application sent during the simulation period was video. Figure (4) shows the simulated network.

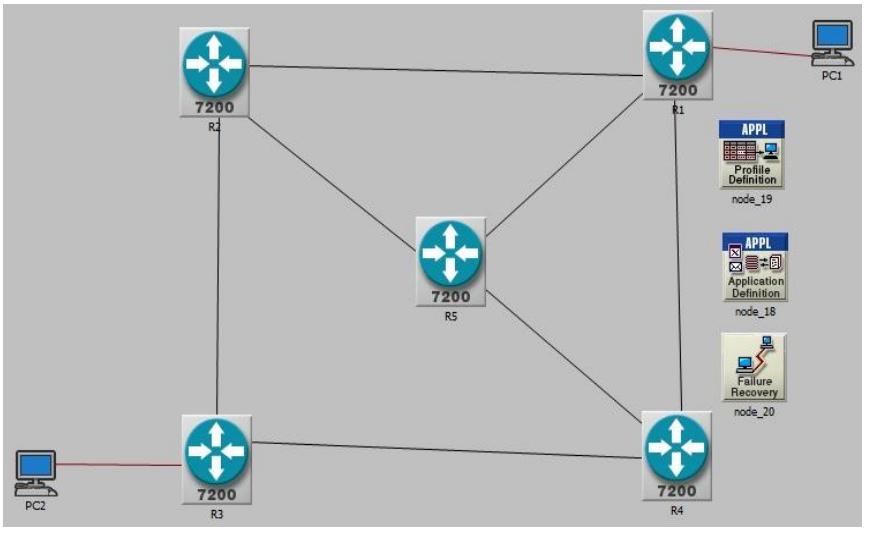


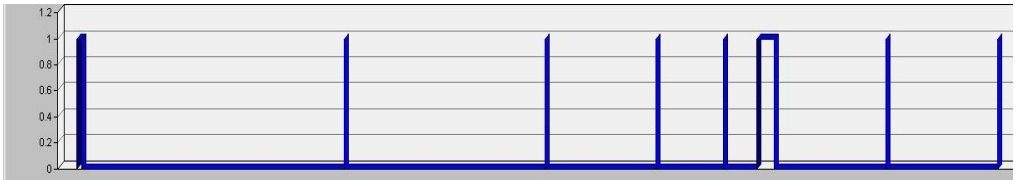
Figure (4): Network Topology

During the simulation period, network malfunctions occurred from time to another through the Failure recovery tool. The following table shows the time periods during which network malfunctions occurred and the periods during which the network returned to operating normally.

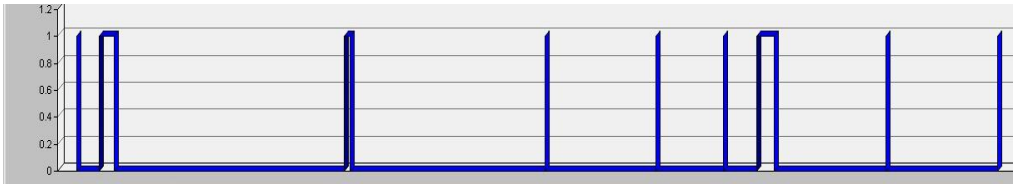
Status	Fail	Recover	Fail	Recover	Fail	Recover	Fail	Recover	Fail	Recover
Time (seconds)	240	420	520	580	610	620	625	626	726	826

5. Results and Discussion

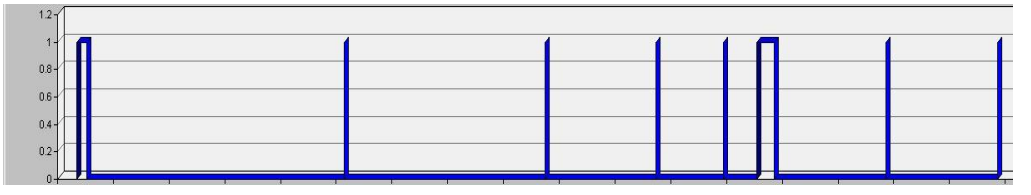
In this paper, several criteria were used to compare the performance of routing protocols RIP, OSPF, and EIGRP. However, one of the most important parameter that considered in this paper is Network convergence. Network convergence tests how fast the routing protocol gather, update, and broadcast the routing information. Network convergence was measured according to network activity which fluctuated between failure & recovery as shown in Figure (5)



Network Convergence Activity - EIGRP



Network Convergence Activity - OSPF



Network Convergence Activity - RIP

Figure (5): network activity: (a) EIGRP, (b) OSPF, (c) RIP

Figure (6) shows the comparison between RIP, EIGRP, and OSPF in terms of network convergence. From the figure, it is noticeable that EIGRP took the least time to converge between networks, while OSPF took the longest to converge, whereas RIP protocol took the longest to converge.

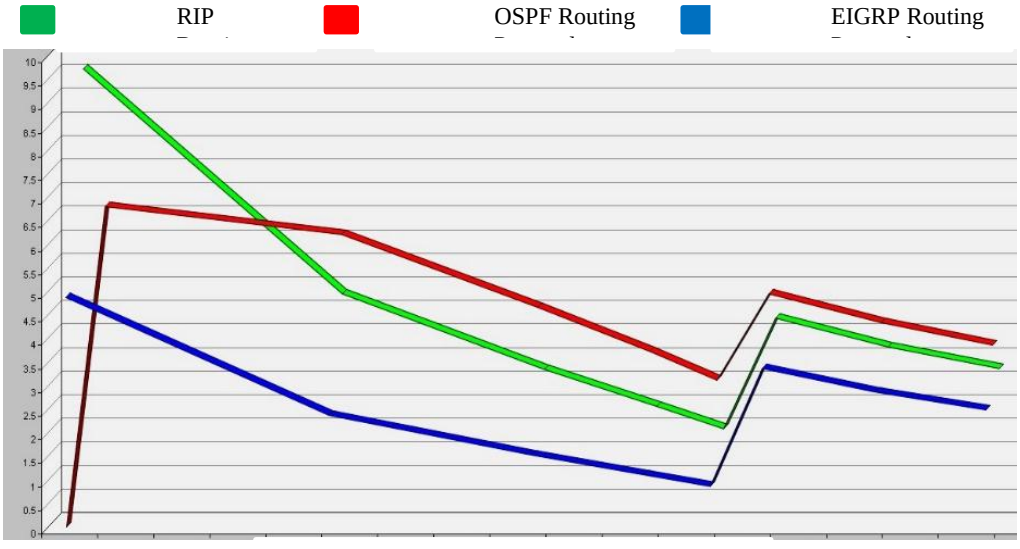
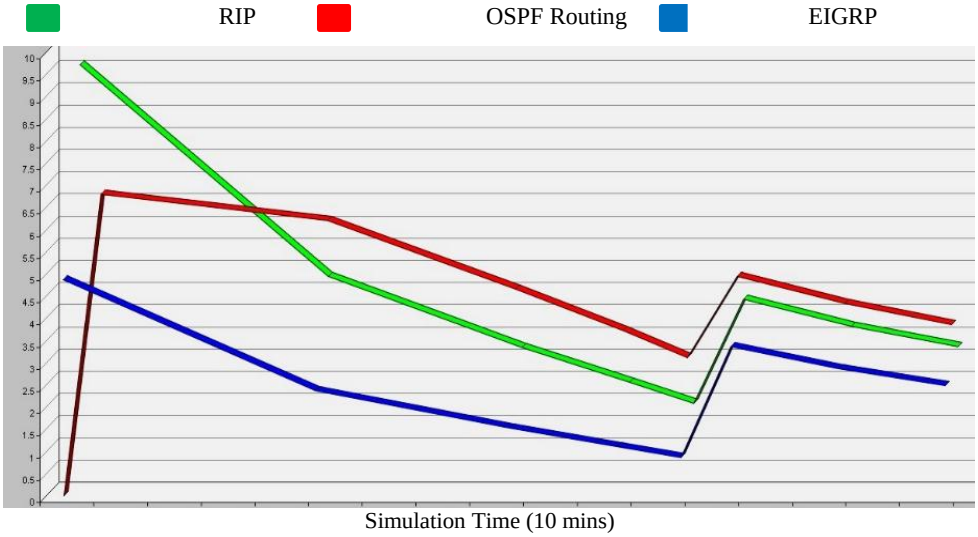


Figure (6): network convergence scenarios for RIP, OSPF, and EIGRP

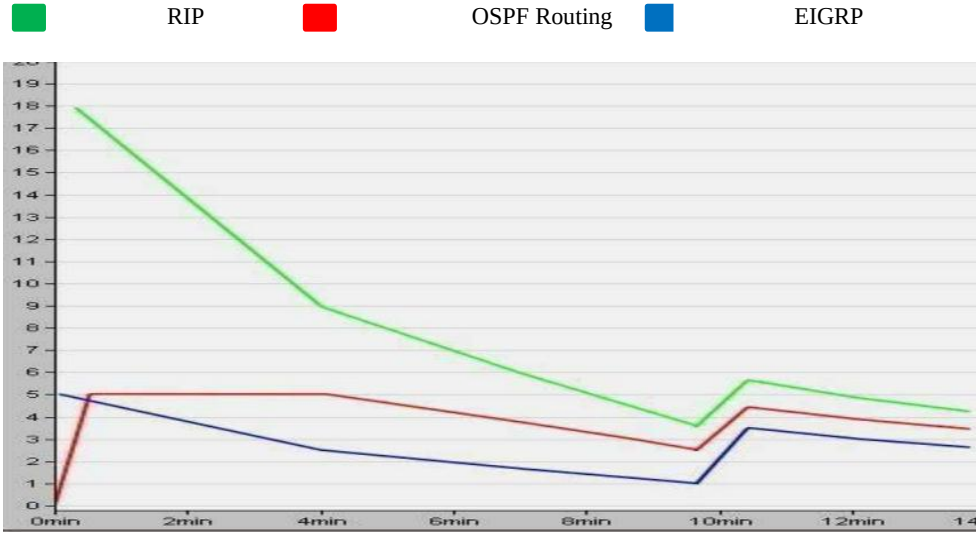
These results are consistent with the results obtained by researchers in [7] who used the convergence coefficient and data transmission rate to compare the performance of routing protocols.

The results obtained were also compared with the results obtained by [1] who used the convergence coefficient, channel utilization coefficient, and delay coefficient to compare EIGRP, RIP, and OSPF. From the comparison, it is clear that the obtained results are consistent, and relatively convergent as shown in Figure (7).

The other comparison was made with results obtained by researchers in [8] The comparison clarifies that both results are similar and comparable as shown in Figure (8).

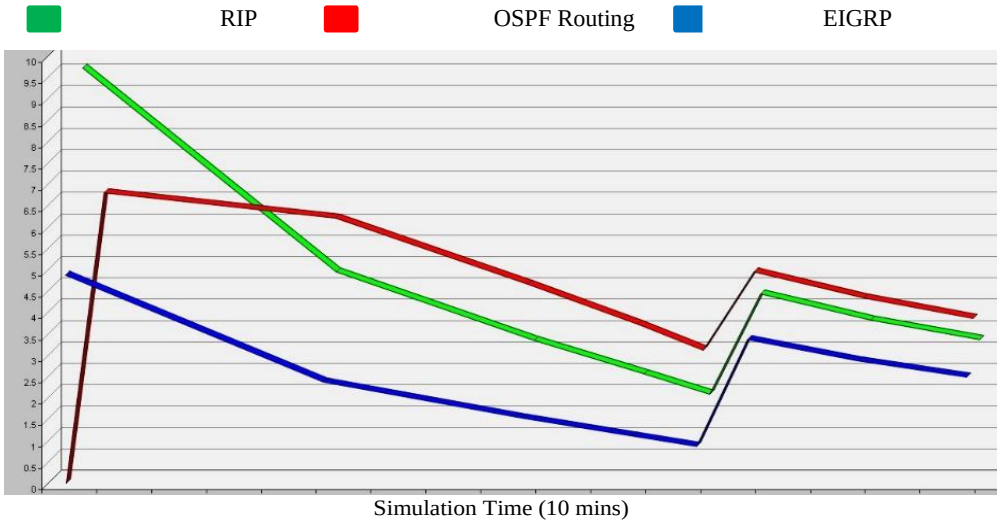


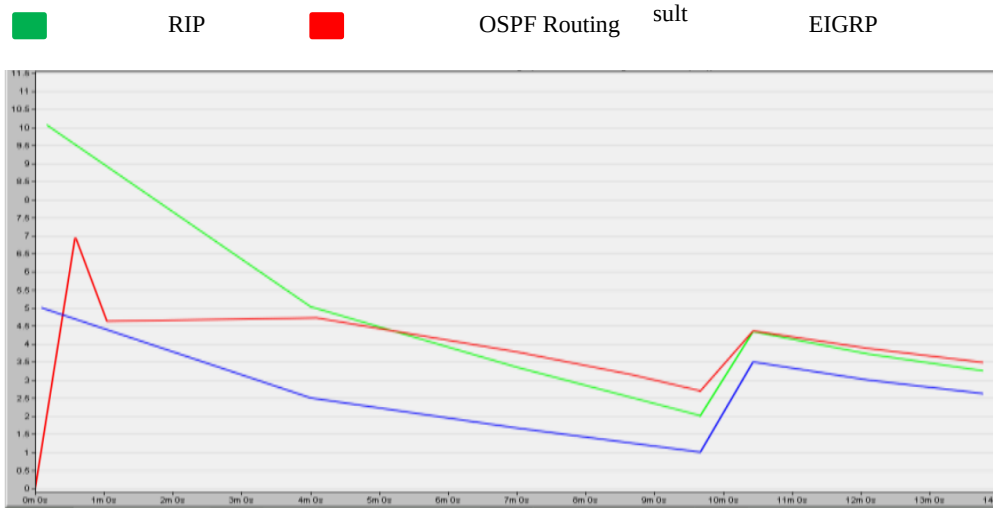
(a) Network Convergence results obtained



(b) Network Convergence results

Figure (7): comparison of (a) obtained results with (b) results obtained by [1]





(b) Network Convergence results

Figure (8): comparison of results with results obtained by [8]

As shown in Figures (7) and (8), it is clear that the researchers used network convergence to compare routing protocols. The results in Figures (7) and (8) prove that EIGRP protocol does not take longer to converge between networks, while OSPF takes a longer time to converge. However, RIP protocol takes the longest time to work in convergence.

6. Conclusion

In this paper, the performance of the most famous internal protocols, namely RIP, EIGRP, and OSPF, was compared by relying on the results of previous studies, which in turn used the OPNET simulation program for comparison. The results showed that the EIGRP protocol does not take longer to converge between networks, while OSPF takes a longer time to converge. However, RIP protocol takes the longest time to work in convergence.

7. References

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