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A COMPARATIVE STUDY BY SIMULATION OF OSPF AND EIGRP ROUTING PROTOCOLS

Tsochev G., Popova K., Stankov I. **A Comparative Study by Simulation of OSPF and EIGRP Routing Protocols.**

Abstract. Computer networks are based on technology that provides the technical infrastructure where routing protocols are used to transmit packets over the Internet. Routing protocols define how routers communicate with each other by distributing information. They are used to describe how routers communicate with each other, learn available routes, build routing tables, make routing decisions, and share information between neighbors. The main purpose of routing protocols is to determine the best route from source to destination. A particular case of a routing protocol operating within an autonomous system is called an internal routing protocol (IGP – Interior Gateway Protocol). The article analyzes the problem of correctly choosing a routing protocol. Open Shortest Path First (OSPF) and Enhanced Interior Gateway Routing Protocol (EIGRP) are considered leading routing protocols for real-time applications. For this they are chosen to be studied. The main objective of the study is to compare the proposed routing protocols and to evaluate them based on different performance indicators. This assessment is carried out theoretically – by analyzing their characteristics and action, and practically – through simulation experiments. After the study of the literature, the simulation scenarios and quantitative indicators by which the performance of the protocols is compared are defined. First, a network model with OSPF is designed and simulated using the OPNET Modeler simulator. Second, EIGRP is implemented in the same network scenario and a new simulation is done. The implementation of the scenarios shall collect the necessary results and analyze the operation of the two protocols. The data shall be derived and an assessment and conclusion shall be made against the defined quantitative indicators.

Keywords: routing protocols, convergence, bandwidth, computer networks, throughput, network topology, OSPF, EIGRP.

1. Introduction. In the modern age, computer communication networks develop and grow by the day. Computer networks are based on technology that provides the technical infrastructure, where routing protocols are used to transmit packages over the Internet. Routing protocols determine how routers communicate with each other by disseminating information. These protocols help routers find neighbors, monitor connections between them, study new routers, and recover quickly from sudden damage to connected or remote connections.

Among the various routing protocols, Open Shortest Path First (OSPF) and Enhanced Interior Gateway Routing Protocol (EIGRP) are considered the leading routing protocols for real-time applications. OSPF is a "link-state interior gateway" protocol based on a Dijkstra's algorithm – the shortest path algorithm (Dijkstra's Shortest Path First Algorithm – SPF). On the other hand, EIGRP is a 'distance-vector' Cisco protocol based on a Diffusing Update Algorithm (DUAL).

When selecting a routing protocol, factors such as network size, hierarchical structure, multiple equal or uneven paths to networks and bandwidth of connections must be taken into account. This makes it obvious that poor choice of a routing protocol can lead to reduced performance, route cycles, and low quality of service.

The main objective of the study is to compare the proposed routing protocols and to evaluate them based on different performance indicators. This assessment is carried out theoretically – by analyzing their characteristics and action, and practically – through simulation experiments.

In the first part, the OSPF and EIGRP protocols are presented, analyzed and explained on the basis of their operational and convergent behavior. Because they implement unique algorithms, namely SPF and DUAL, and use different metrics based on "value" (OSPF) and bandwidth, load and reliability (EIGRP), they work differently on topologies that, when scaled, present non-hierarchical forms or inefficient route summarization structures. [3] The impact of the inherent behavior of each protocol directly affects productivity in such cases, which has been demonstrated by simulation experiments.

To evaluate the performance of routing protocols, OSPF and EIGRP, the following tasks are assigned:

– Presentation of the different characteristics of the routing protocols;

– Implementation of the proposed routing protocols in IP networks;

– Selection of quantitative indicators – convergence activity, end-to-end delay, variation of package delay, flickering, loss of traffic and bandwidth;

– Analysis of the work of each protocol – theoretically and by simulation;

– Create a simulation environment that can be used for further research.

2. Methodology. The available scientific and technical literature has been used for the performance of the research. By reviewing and analyzing scientific papers and publications, an expanded study of the characteristics of the OSPF and EIGRP routing protocols has been done.

After the study of the literature, the simulation scenarios and quantitative indicators by which the performance of the protocols is compared are defined. First, a network model with OSPF is designed and simulated using the OPNET Modeler simulator. Second, EIGRP is implemented in the same network scenario and a new simulation is done. The implementation of the scenarios shall collect the necessary results and analyze the operation of the two protocols. The data shall be derived and an assessment and conclusion shall be made against the defined quantitative indicators.

3. Overview of OSPF and EIGRP

3.1. Definition and types. The network layer in the OSI reference model (Open Systems Interconnection Basic Reference Model) ensures that packages are transferred to the network. Routing protocols determine the path of each source package to the destination. To complete this task, routers use routing tables that contain information about possible destinations on the network and metrics (distance, "value", bandwidth, etc.) to these destinations [1].

Routing protocols are used to describe how routers communicate with each other, learn available routes, build routing tables, make routing decisions, and share information between neighbors. The main purpose of routing protocols is to determine the best route from source to destination. The routing algorithm uses different metrics based on one or more path properties to determine the best way to reach a network [2].

Routers are connected to multiple networks. When they receive a package on one of their interfaces, they check that the package is intended for the same network, to which that interface belongs. If so, they ignore the package. But if the package is intended for another network, then perform a search operation by searching their routing table, a local database, to find an output interface for forwarding the package. Therefore, the router performs two operations – a search process to find a route in their routing table, and a switching process to take a package from one interface and encapsulate it again to be sent to another interface [4].

To create a routing table, the router initially inserts into the table all the different networks that are directly connected to it and work. Then, it inserts all networks that are configured by the administrator by using static route commands. Finally, if a dynamic protocol is configured and running, the router inserts all routes learned through this protocol. If the steps described are completed, then the routing table is dynamic and changes every time there is an update in network topology [5].

Dynamic protocols are divided into different categories depending on whether they operate inside or outside an autonomous system (internal or external gateway protocols) or whether they implement a distance-vector protocol or a link-state protocol. Routing. Examples of internal gateway protocols are: RIPv1 and RIPv2, IGRP, EIGRP, OSPF and IS-IS, while the industry standard in the external gateway protocols is BGP [4] [5].

3.2. Distance vector routing. The term 'distance-vector routing' means that routing decisions are taken on the basis of route vectors (together with relevant distances) learned from directly connected adjacent routing devices. Routers that route with a vector at a distance do not know the entire topology of the network, but only have knowledge of the distance from the destination network and the direction in which traffic should be forwarded. The routing protocols that belong to this category are: RIPv1m RIPv2, IGRP and EIGRP.

One of the main features of distance vector routing is that updates are sent periodically to all interfaces. These updates may contain the entire routing table or part of it (partial updates). When a participating router receives such an update, it compares with what it already knows from its table, covers all new information, updates existing information and shares what it knows with its neighbors [6].

This type of routing has some inherent problems with creating route cycles in case there are multiple routes to the destination. This happens because routers do not have a clear idea of the entire topology of the network, but believe what their neighbors "tell" them. Different ways of dealing with this problem have been developed [7].

3.3. Connection status routing. The term "link-state routing" means that routing decisions are taken individually for each router based on a network graph that exists in its memory. This graph contains the connections of all nodes in the autonomous system. The topology information allows each router to calculate the best path or paths to all different networks in the system. Which are then placed in the marching table. The main feature of this process is that the router should not periodically update its neighbors, but only when an event occurs. The routing protocols that belong to this category are: OSPF and IS-IS [8].

Connection status routing starts with the neighbor discovery phase, in which each router exchanges "hello" packages to find neighbors on all operational connections. Then the router "fills" its connected connections, so that all routers in the autonomous system learn the connections and those that produce them. This ends in a topology table of the connection supported by each router. This table, along with the adjacent table, allows each router to form a full topological view of the network [9].

The final stage is the implementation of an algorithm that produces the shortest path to each connection on the network, based on the parameter – "value" (cost) of the connection. A network column is created and the router starts running an algorithm for the shortest path, placing itself as the root of the source tree. The end result of the algorithm, which works independently on each router, fills in the routing tables in the autonomous system. A characteristic feature is that changes in topology lead to a recalculation of the algorithm for the shortest path and, as a result, to CPU and memory usage. This type of routing takes precedence over vector distance routing, since all routers have knowledge of the entire topology [10].

3.4. OSPF. Open Shortest Path First is an internal protocol for routing the Internet Protocol (IP) network gateway. OSPF belongs to the family of connection status routing protocols and is used to distribute routing information within an autonomous system.

The name of the protocol depicts its two main characteristics. The first word "Open" refers to the fact that the protocol was developed using the open public RFC process (Request for Comments), and "Shortest Path First" refers to the Deakstra algorithm, in 1989, the first version of OSPF (OSPFv1) was created, drawn up in RFC 1131. In 1991, the second version (OSPFv2) was drafted and revised into RFC 1583, 2178 and 2328. In 1997, OSPFv3 was released in IPv6 RFC 2740 [11].

OSPF uses the Shortest Path Algorithm (SPF) to build and calculate the shortest path to all known destinations. Calculates using the Deakstra algorithm, which provides an optimal solution.

In a simplified way, the algorithm can be viewed in several steps:

– Each connection has a connected value and the goal is for each router to have a complete database of all connections that exist on the network;

– Link State Advertisements (LSA) ads are generated by the router when a change occurs on a connected network or during initialization;

– LSAs are exchanged through the procedure of "fill" between routers. Each router stores the resulting identical connection status update in its database and then distributes the update to other routers;

– When databases are created about the connection status in each router, the router running The Dijkstra algorithm creates a tree with the shortest paths to all destinations;

– If something changes on the network, the connection status protocol distributes it throughout the network, allowing all routers to keep up-to-date information [12].

The algorithm puts each router at the root of a tree and calculates the shortest path to each destination based on the cumulative costs required to reach that destination. Each router will have its own topology view, although all routers will build a tree with the shortest paths using the same connection status database [18].

The following lines summarize the main advantages and disadvantages of the OSPF protocol.

Advantages:

– The OSPF routing protocol is open unlike EIGRP, which is owned by Cisco;

– Cycle-free routes are always defined by OSPF;

– When changes occur, they spread quickly throughout the network.

– Use multicasting 224.0.0.5 to periodically send small hello packages checking connection performance without transferring the entire routing table, thus preserving the network bandwidth [13];

– Supports variable length subnet masks (VLSM) and CIDR by manual aggregation;

– Hierarchical protocol using Area 0 (Autonomous System) as the top of the hierarchy;

– "value" is used as an indicator;

– Suitable for large-scale networks;

– Uses low bandwidth;

– Supports multiple routes;

– Route exchanges are kept to a minimum and the size of the routing table is shortened by the architecture of the area;

– There are no limits on the number of jumps (hop);

– The OSPF package is indicated by IP header 89;

– Packages are routed based on their type of service.

– Disadvantages:

– OSPF configuration is complex to implement, as well as the removal of non-washes;

– Connection status scaling issues due mainly to LSA flooding;

– The SFP algorithm requires high CPU usage;

– More memory is needed to maintain neighborhood tables, routing and topology;

– Cannot maintain an uneven load balance.

3.5. EIGRP. Enhanced Interior Gateway Routing Protocol is a dynamic Cisco protocol for IP, IPX and AppleTalk networks, designed by Cisco Systems at the University of California in 1992.

EIGRP belongs to the family of distance vector routing protocols characterized as more advanced of its kind due to the fact that it is more scalable in medium and large networks. Although it belongs to the family of distance vectors, it carries characteristics of the connection state protocol and is publicly characterized as a hybrid remote vector protocol. It is used to distribute routing information within the same autonomous system, sending gradual updates, and minimizing the amount of operation of the router, as well as the data required for transmission.

EIGRP uses both equal-cost load balancing (ECLB) and unequal-cost load balancing. EIGRP is the only protocol that essentially makes it an equal and unequal balancing of value load. This occurs by using the parameter "variance" [19].

The EIGRP links six different vector indicators to each route and takes into account only four of them to calculate the composite indicator. They are described in Table 1.

Table 1. EIGRP Indicators

Bandwidth	Minimum bandwidth on the way from the router to the destination
Load	Number ranging from 1 to 255
Total Delay	Delay on the way from router to destination.
Reliability	Number ranging from 1 to 255
Man	Maximum transmission unit. Not used in metric calculation.
Hop Count	Number of routers through which the package passes through the network. Not used in metric calculation.

EIGRP calculates routing metrics using the minimum bandwidth on the network path as well as the overall delay. Four vector metrics – bandwidth, reliability, delay and load – are connected to calculate the composite indicator for determining the preferred route (successor) [19].

The following lines summarize the main advantages and disadvantages of the EIGRP protocol.

Advantages:

– Use multicast 224.0.0.10 to send "Hello" packets checking connection performance without transferring the entire routing table, thereby storing the network bandwidth [15];

– Routes without cycles, thanks to Haze Condition (FC);

– Supports variable length subnet masks (VLSM) and CIDR, allowing automatic aggregation of routes on the network;

– Easy to configure;

– Fast convergence thanks to the dual algorithm. The EIGRP router stores all adjacent tables to adapt very quickly to alternative routes;

– EIGRP depends on the Reliable Transport Protocol (RTP) for the correct delivery of packages to all neighbors;

– The EIGRP package is indicated by IP header 88;

– Replacement routes through feasible successors;
– Activation updates shall notify when network changes occur;
– Supports aggregation in each interface, which reduces the routing table;
– Supports multiple network layer protocols, such as IP, IPX and Apple-Talk;
– Zoom for large dynamic multipoint deployments (DM).
– Disadvantages:
– EIGRP summarizes routes in class borders automatically, by default. This function can be undone with the command "no auto-summary";
– Owned by Cisco (only one part has been open source since 2013);
– Difficulties in managing large hierarchical networks;
– Routers from other providers cannot use EIGRP and therefore the redistribution of the protocol must be configured inside the autonomous system;
– In any design, when the network increases significantly in size, cases of Stuck-In-Active can lead to slow convergence;
– Triggers must be included in summarization.

3.6. Differences between OSPF and EIGRP based on literature. Open Shortest Path First (OSPF) is a protocol for routing connection status. It collects connection status data from routers on the network and determines the information from the package forwarding route table. OSPF exchanges routing information only when there is a change in network topology. The protocol is best suited for complex networks that consist of multiple subnets working to facilitate administration and optimize traffic. OSPF effectively calculates the shortest path with minimal network traffic when the change occurs [14, 16].

Enhanced Interior Gateway Routing Protocol (EIGRP) is an advanced Cisco-based vector routing protocol. EIGRP is considered hybrid because it combines the characteristics of the remote routing protocol with a vector and the connection status routing protocol. It can determine the shortest vector of the distance on the road and uses indicators such as bandwidth, load and delays to calculate the shortest optimal route. EIGRP is a complex protocol, but can be configured and operates easily in small and large networks [14, 16].

The main differences between the two dynamic protocols are shown in Table 2.

Table 2. Comparison of the main characteristics of OSPF and EIGRP [17]

Characteristics	**OSPF**	**EIGRP**
Type of routing protocol	Connection Status *\/Link state/*	Hybrid */Hybrid/*
Standard	IETF Open Standard	Cisco Proprietary
Routing metrics	Interface bandwidth	Combination of bandwidth, reliability, load and delay
Administrative distance/distance	110	90 (Internal) 170 (External)
CPU requirements	High cpu and memory requirements	Lower cpu and memory requirements
Algorithm	Dijkstra link state	DUAL distance vector
Hierarchical design	Yes I do	Not
Complexity of implementation	Difficult	Easy, but without providing an automatic summary
Prevention of cycles	Full knowledge of topology	Split Horizon and DUAL
Filter & Summarize	ASBR or ABR only	Possible anywhere on the web

4. Simulation scenarios. Network simulation is the most useful and common methodology used to evaluate different network topologies – providing a real system through virtual reality. Network simulation is used in various fields and academic research, for industrial development, for analyzing, designing, simulating and checking the work of various network theories and hypotheses [20].

Modeling using a simulation tool – a simulator is the best way to conduct experiments in virtual environments that would otherwise be impractical due to the necessary equipment, the high cost to be spent, or even the fact that the system may not support extensive testing. A simulator is a computer-based mathematical software that performs multiple algorithms and equations to output results based on input data. This allows you to quickly and easily explore complex systems as well as scenarios under a wide range of conditions [22].

For the study in this research, the output results were obtained using a computer-based software simulation with OPNET Modeler – Edition 14.5. OPNET has a convenient graphical user interface that can be used to build different network configurations and test their performance [23]. Also, it contains a huge library of models that simulate most of the existing hardware devices and communication protocols. This makes it possible to easily simulate the most complex computer networks and configure protocols that implement state-of-the-art communication technologies [21, 26]. Appropriate equipment is attached, as well as the necessary procedures for measuring the effectiveness of OSPF and EIGRP routing protocols on the basis of the desired quantitative indicators.

To achieve a simulation-based comparison between OSPF and EIGRP routing protocols, specific steps must be followed to design the simulator. Figure 1 shows a block-chart of steps.

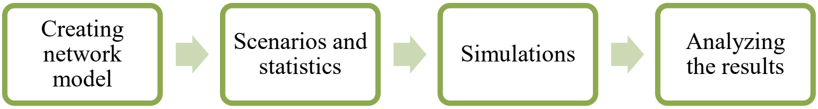

Fig. 1. OPNET design and analysis

Two scenarios have been created that consist of three interconnected subnets, with routers in each subnet configured using OSPF and EIGRP routing protocols.

Network topology is composed of the following network drives and configuration utilities:

– CS_7000 Cisco Routers;
– CS_2948G Cisco Switches;
– Ethernet Workstations;
– Ethernet 1000BaseX Links;
– Application Configuration;
– Profile Configuration;
– Failure Recovery Configuration.

The design of the network topology is based on the geographical layout of Bulgaria, shown in Figures 2 and 3. Three subnets are considered – each of which is located in a different Bulgarian city – Sofia, Plovdiv, and Pleven. Subnets contain workstations, switches, routers, and connections. The internal infrastructure of network topology in individual cities is similar, that is why only one is shown in Figure 3.

The topology of Plovdiv and Pleven are similar.

The Application Definition Object and Profile Definition Object and saved as Application Config and Profile Config, have been added from the workspace object palette.

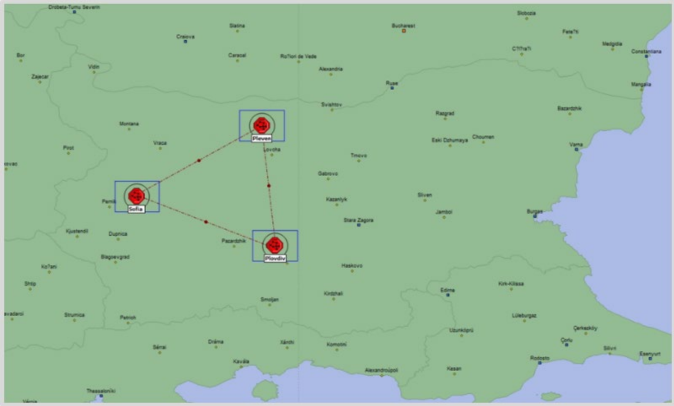

Fig. 2. Network Topology

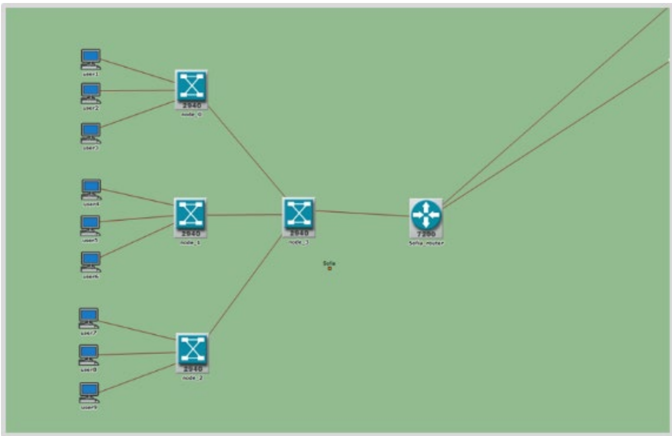

Fig. 3. Subnet – Sofia

Application Config enables the generation of different types of application traffic. In this research, the application definition object is set to support:

– Video Conferencing – High-Resolution Video;
– Voice – IP Telephony and Silence Suppressed;
– HTTP – Heavy Browsing.

Profile Config defines profiles within the defined traffic from the Application Definition Object. Three accounts have been created – to support Video Conferencing, Voice, and HTTP.

Failure Recovery is configured in the scenarios. Fault events cause interference in the routing topology, resulting in additional convergence activity intervals. Ten failed connections with different time intervals between the Sofia subnet and the Pleven subnet shown in Table 3 have been used.

Table 3. Failure recovery

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

To evaluate the performance of OSPF and EIGRP dynamic routing protocols, two scenarios with the same network topologies were created. In the first scenario, the OSPF routing protocol is enabled for all routers on the network. After configuring it, individual DES statistics are set to select performance indicators and evaluate the behavior of the protocol. In the second scenario, the same steps are performed, but the configured protocol is EIGRP. The EIGRP network model is shown in Figure 4.

The performance of the two simulations is shown in Figure 5 and Figure 6. The graph depicts the differences between the current simulation speed and the average simulation speed measured in events/sec. The reporting time was 15 minutes, with the OSPF simulation at 848,011 events/sec and the EIGRP simulation at 920,337 events/sec. This indicates that more simulation events were performed in the second scenario per unit of time.

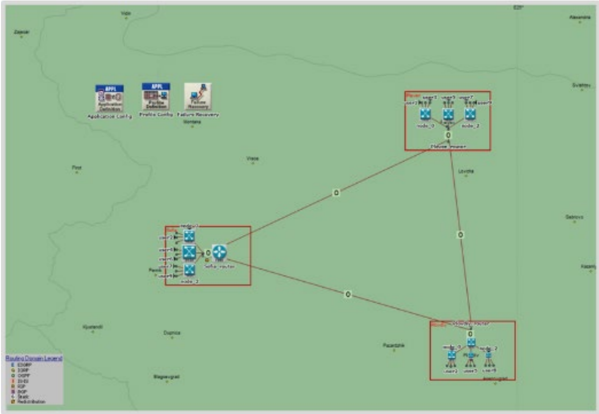

Fig. 4. EIGRP Scenario

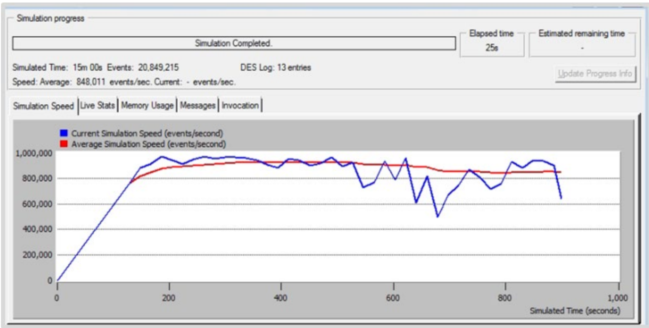

Fig. 5. OSPF Simulation

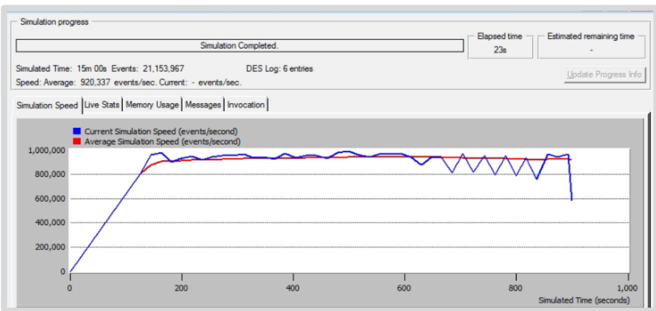

Fig. 6. EIGRP Simulation

5. Results. Specific quantitative indicators were selected for the study to measure performance, as well as to assess the behavior of the OSPF and EIGRP protocols in each scenario. The quantitative indicators are presented graphically in OPNET.

The following quantitative indicators are measured:

– Network Convergence duration (sec);
– Point-to-point Throughput /Recovery – Sofia-Pleven (packets/sec);
– Point-to-point Throughput – Sofia-Plovdiv (packets/sec);
– HTTP – Object Response Time (sec);
– HTTP – Traffic Received (bytes/sec);
– HTTP – Traffic Sent (bytes/sec);
– Voice – Jitter (sec);
– Video conferencing – Packet Delay Variation;
– Video conferencing – Packet End-to-End Delay (sec);
– Video conferencing – Traffic Received (packets/sec);
– Video conferencing – Traffic Sent (packets/sec).

5.1. Network Convergence duration. The convergence time of the two protocols is shown in Figure 7. The main difference between OSPF and EIGRP is seen at the beginning of the graph, after which they almost level off. The average convergence time of OSPF is faster than that of EIGRP. This means that when a change occurs in the OSPF network, the routing table is recalculated and all routers in the area update the topology database by populating the neighbors' LSAs, while in the EIGRP network, routers send queries to direct neighbors to propagate the updated routing table where the successor is recalculated.

Fig. 7. Network Convergence duration (sec)

5.2. Point-to-Point Throughput (packets/sec). Bandwidth is a key parameter for determining the speed at which all data packets are successfully delivered through the network channel. The bandwidth is measured from point to point, in packets/sec. Figure 8 shows the point-to-point bandwidth – from router Sofia to router Pleven. Ten failed connections (failure recovery) with different time intervals were made between the two subnets. Figure 9 shows the bandwidth from router Sofia to router Plovdiv. It is clear from the results between the points in both cases that the EIGRP network has a higher bandwidth than the OSPF network.

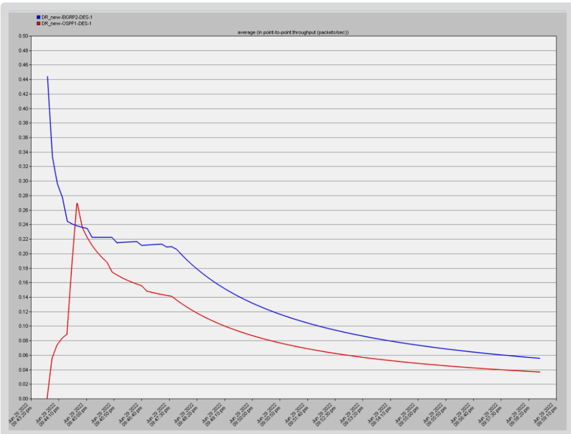

Fig. 8. Point-to-Point Throughput – Sofia-Pleven (packets/sec)

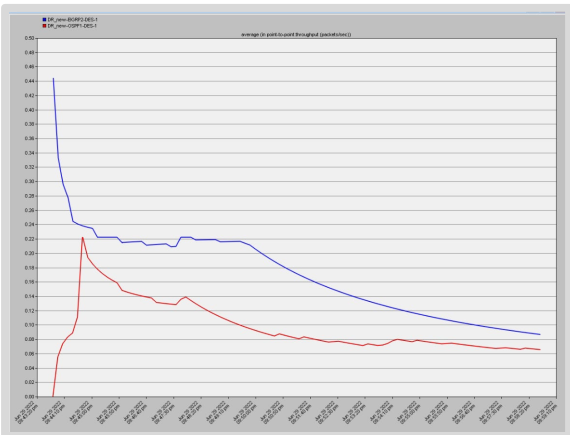

Fig. 9. Point-to-Point Throughput – Sofia-Plovdiv (packets/sec)

5.3. HTTP. Through the Application Definition Object, Hypertext Transfer Protocol (HTTP) – heavy browsing – is introduced in both network scenarios. In Figure 10 shows a summary of Object Response Time (sec) and Page Response Time (sec) – for each of the networks – OSPF and EIGRP. In Object Response Time it is reported that the values are very close and the graphs overlap. In Page Response Time – OSPF protocol shows shorter time and better results. In Figures 11 and 12 show Traffic Sent (bytes/sec) and Traffic Received (bytes/sec). At the beginning of the graph, the values in the OSPF and EIGRP networks are close, and then the bytes/sec for the EIGRP network increases and it gives a better result.

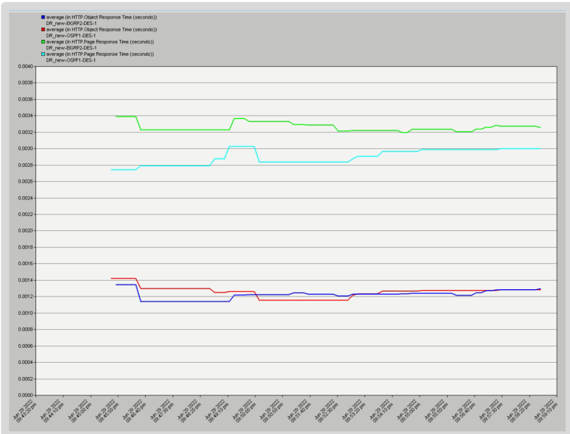

Fig. 10. HTTP – Object and Page Response Time (sec)

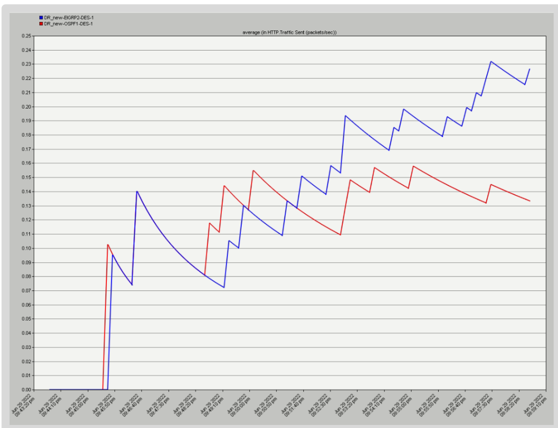

Fig. 11. HTTP – Traffic Sent (packets/sec)

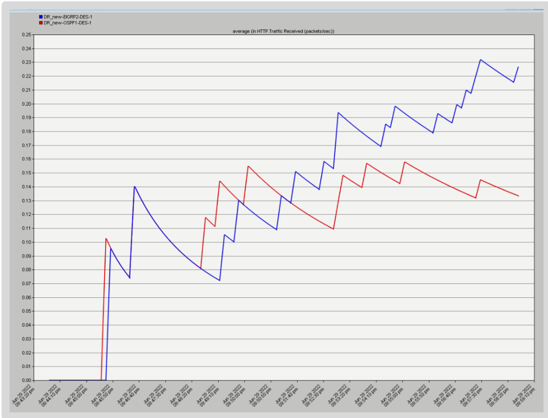

Fig. 12. HTTP – Traffic Received (packets/sec)

5.4. Voice. With Application Definition Object, Voice – Jitter (sec) is introduced in both network scenarios. Voice flicker is defined as a variation in the delay of the received voice data packets, which affects sound quality as well as data. This constant flow may be uneven or the delay between each package may vary instead of remaining constant. Figure 13 clearly shows a much higher average OSPF network flicker level than with EIGRP.

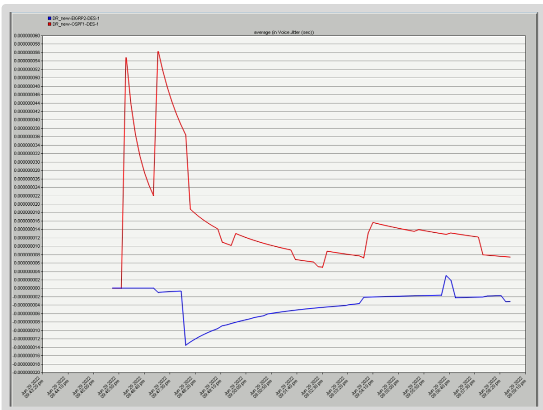

Fig. 13. Voice – Jitter (sec)

5.5. Video conferencing. Through the Application Definition Object, in both network scenarios, there is Video conferencing, and the parameters are reported – Packet Delay Variation, Packet End-to-End Delay (sec), Traffic Received (packets/sec), Traffic Sent (packets/sec).

Packet Delay Variation – delay variation is measured by the difference in packet delay. This metric has a huge impact on how video is delivered. Figure 14 shows that the average delay in the two scenarios has very close values. However, EIGRP reflects a slightly higher average packet delay for video traffic, thus having a lower throughput compared to OSPF.

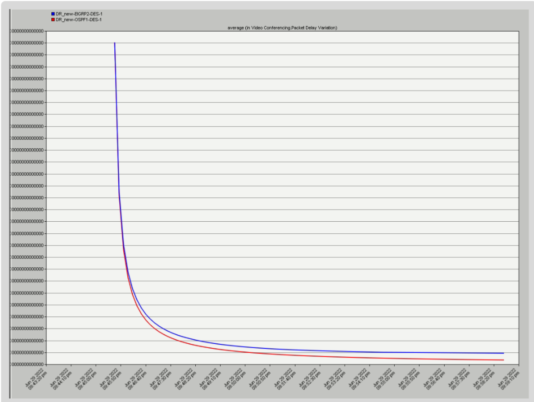

Fig. 14. Video conferencing – Packet Delay Variation

Traffic Sent, Traffic Received – Figures 15 and 16 demonstrate the number of traffic sent and received in both the OSPF and EIGRP networks. The graph shows that a significant difference between the sent and received traffic in OSPF and EIGRP is not observed.

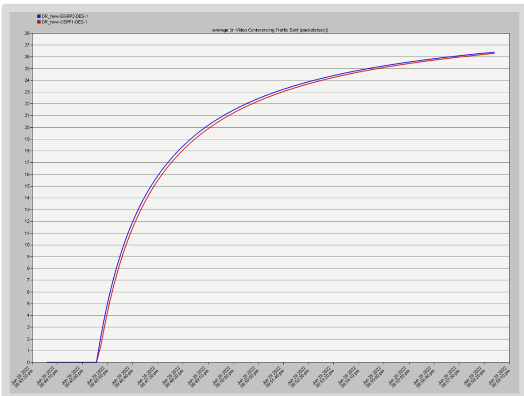

Fig. 15. Video conferencing – Traffic Sent (packets/sec)

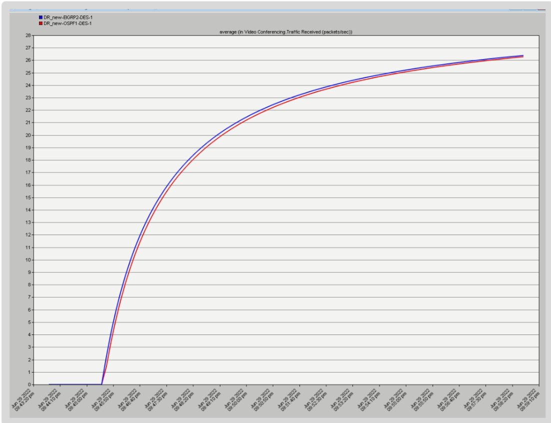

Fig. 16. Video conferencing – Traffic Received (packets/sec)

4. Conclusion. Internal dynamic routing protocols OSPF and EIGRP are widely implemented in most network infrastructures. Through this research, a comparative study based on simulation was conducted to indicate which of the above protocols dominates according to specific quantitative indicators. After a thorough review of the literature, the presentation of the characteristics of the two protocols and the execution of the simulation, all the information was critically evaluated and the results of the simulation were collected to indicate which protocol had optimal performance.

Despite claims from other studies that the EIGRP protocol has a faster duration of network convergence than OSPF, the simulation shows that the OSPF protocol has a faster average convergence duration. With the results obtained, the main difference between OSPF and EIGRP is observed at the beginning of the graph, after which there is an alignment.

As a key parameter for determining speed, point-to-point bandwidth measurement, in both cases, shows a better performance of the EIGRP protocol and a correspondingly higher bandwidth.

With HTTP – Heavy browsing, the results for Object Response Time and Page Response Time in both protocols are very close and there is an overlap of the graphics. When comparing the received and sent traffic, it is apparent that the EIGRP protocol is faster.

Voice jitter, as a variation in the delay of received voice data packets, indicates a higher average OSPF protocol flicker level than with EIGRP.

OSPF and EIGRP performance has also been measured based on real-time traffic via video conference. The simulation gives important information about the parameters of Packet Delay Variation, Packet End-to-End Delay, Traffic Received, and Traffic Sent (packets/sec). The packet delay variation is very similar for the two protocols, but EIGRP reflects a slightly higher average delay and, thus, has a lower throughput compared to OSPF. In end-to-end delay, no significant difference was observed between the performance of OSPF and EIGRP. The results for the received and sent traffic for the two protocols are also close, with slightly higher values for EIGRP.

A transition between the two protocols was also made during the study. OSPF was found to be the more commonly used protocol of this group. This is, on the one hand, due to the fact that EIGRP is a closed protocol and property of CISCO, on the other hand, better performance in some respects. The comparison between the two protocols showed that the combined implementation of EIGRP and OSPF for network routing is to be recommended. Migrating from one protocol to the other can be a procedure that can be addressed in a separate study due to different work scenarios.

The detailed simulation research helps to find the best solution to research questions. Although the objective of this research has been achieved, the limitations of the OPNET Modeler – Edition 14.5 simulation tool should be taken into account. It is therefore difficult to give an unambiguous answer to the question of 'which of the two protocols is the best in terms of performance'. It should be stressed that many factors play a crucial role in choosing the protocol to be used in each case – such as infrastructure, network size and requirements to be met each time. This experiment contributes to the existing knowledge, enriching the research in the field of network protocols and contributing to the selection of the right protocol for the investigated parameters: convergence, speed, point-to-point bandwidth measurement, HTTP – Heavy browsing, Voice jitter and video conference. Based on the obtained result, it is clearly stated that the hardware implementations of the routing protocol are better than using a network simulator. In addition, large network scaling experiments can be conducted to highlight the multiarea in the OSPF routing protocol. Finally, the research can continue with extensive OSPF and EIGRP experiments in IPv6, using professionally applied research.

Future work will include an analysis of the members of IGP (Interior Gateway Protocol) from an energy perspective. In-depth research will be carried out for Greener Internetworking.

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СРАВНИТЕЛЬНОЕ ИССЛЕДОВАНИЕ МОДЕЛИРОВАНИЕМ ПРОТОКОЛОВ МАРШРУТИЗАЦИИ OSPF И EIGRP

Цочев Г.Р., Попова К.К., Станков И.С. **Сравнительное исследование моделированием протоколов маршрутизации OSPF и EIGRP.**

Аннотация. Компьютерные сети основаны на технологии, обеспечивающей техническую инфраструктуру, в которой протоколы маршрутизации используются для передачи пакетов через Интернет. Протоколы маршрутизации определяют, как маршрутизаторы взаимодействуют друг с другом путем распространения информации. Они используются для описания того, как маршрутизаторы взаимодействуют друг с другом, изучения доступных маршрутов, построения таблиц маршрутизации, принятия решений о маршрутизации и обмена информацией между соседями. Основная цель протоколов маршрутизации — определить наилучший маршрут от источника к месту назначения. Частный случай протокола маршрутизации, работающего в автономной системе, называется протоколом внутренней маршрутизации (IGP — Internal Gateway Protocol). В статье анализируется проблема правильного выбора протокола маршрутизации. Open Shortest Path First (OSPF) и Enhanced Internal Gateway Routing Protocol (EIGRP) считаются ведущими протоколами маршрутизации для приложений реального времени. Для этого их выбирают для изучения. Основной целью исследования является сравнение предложенных протоколов маршрутизации и их оценка на основе различных показателей производительности. Эта оценка осуществляется теоретически – путем анализа их характеристик и действия, и практически – посредством имитационных экспериментов. После изучения литературы определяются сценарии моделирования и количественные показатели, по которым сравнивается производительность протоколов. Во-первых, сетевая модель с OSPF разрабатывается и моделируется с помощью симулятора OPNET Modeler. Во-вторых, EIGRP реализован в том же сетевом сценарии, и выполняется новое моделирование. Реализация сценариев должна собрать необходимые результаты и проанализировать работу двух протоколов. Данные должны быть получены, а оценка и вывод должны быть сделаны в отношении определенных количественных показателей.

Ключевые слова: протоколы маршрутизации, конвергенция, пропускная способность, компьютерные сети, топология сети, OSPF, EIGRP.

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