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Simulation Based Comparative Performance Analysis of OSPF and EIGRP Routing Protocols

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Abstract. In the computer networks, the data traffic transmission is based on the routing protocol which select the best routes between two nodes. Variety of routing protocols are applied to specific network environments. Routing protocol is taking a crucial role in the modern communication networks and its functionality is to determine how the routers communicate with each other and forward the packets through the optimal path from source to destination node. In this paper, two typical types of routing protocol are chosen as the simulation samples: EIGRP and OSPF. Each of them has different architecture, route delays and convergence characteristics. The aim is to present a simulation based comparative analysis between EIGRP and OSPF for real time applications considering realistic backbone communication links and existing subnets. The evaluation of the proposed routing protocols is performed based on the widely accepted quantitative metrics such as: convergence time, end-to-end delay, jitter, packet loss and throughput of the simulated network models. Tractable conclusions and discussions are presented for each protocols and multi-protocol network implementations.

Keywords: BGP, EIGRP, OSPF, routing protocols, performance evaluation.

1. Introduction

Nowadays, the communication networks are growing rapidly day by day. In the complex infrastructure computer networks, routing protocols are used to transmit packets across the Internet. There are different types of routing protocols in the IP networks. However, three classes are common in the IP networks: Interior gateway routing over link state routing protocols, such as IS-IS and OSPF; Interior gateway routing over distance-vector protocols, such as RIP, IGRP and EIGRP and Exterior gateway routing, such as BGP routing protocol [1][2][4].

Among all routing protocols, we have chosen EIGRP and OSPF routing protocols for realizing performance evaluation in a simulation based network model for real time applications such video streaming and voice conferencing. The evaluation is based on different parameters such: convergence time, jitter, delay variation, end-to-end delay and throughput. Optimized Network Engineering Tool (OPNET) [6] is employed as a simulator to analyze and measure the performance of these routing protocols. We organized this work as follows. First of all, network model with EIGRP is simulated with OPNET while observing the results of such EIGRP-only implementation for real time applications. Second, in the same network scenario, we implemented OSPF instead of EIGRP to simulate the network model while observing the impact of OSPF-only real time applications, and finally, we designed a network model by implementing subnets and nodes using EIGRP and OSPF and measure the performance for real-time traffic.

2. Routing Protocols

A routing protocol is the "language" a router speaks with other routers in order to share information about the reachability and status of the network. It includes a procedure to select the best path based and for storing this information in a so-called routing table. In a network, routing can be defined as transmitting information from a source to a destination by one hop or multiple hops. Generally, the routing protocols should provide at least two functionalities [4][6]: selecting routes for different pairs of source/destination nodes and successful transmission of the data to a given destination.
Different routing protocols have specific performance metrics of interest. When there is more than one route between two nodes, a router shall determine the routing protocol to calculate the best path considering the current metrics parameters. In IP routing protocols, the following metrics are used mostly: hop count, bandwidth, delay, load and reliability.

2.1. Enhanced Interior Gateway Routing Protocol (EIGRP)

EIGRP is a CISCO proprietary protocol, which is an improved version of the Interior Gateway Routing Protocol (IGRP). EIGRP is considered as advanced distance-vector routing protocol with automatic routing decisions and configuration. There are four basic components to operate EIGRP, which are: Neighbor discovery/recovery, Reliable Transport Protocol (RTP), Diffusing Update Algoritm (DUAL) and Protocol Dependent Modules (PDMs) [3]. The neighbor discovery/recovery method allows the routers to gain knowledge about other routers which are directly linked to their networks. Reliable Transport Protocol insures fast transport when there are unacknowledged packets pending. The Diffusing Update Algorithm (DUAL) is the default convergence algorithm which is used in EIGRP to prevent routing loops from recalculating routes. DUAL tracks all routes and detect the optimal path in terms of efficiency and cost which will be added in the routing table. There also exist backup routes that can be used in case the optimal route is dropped. DUAL uses some provisions and theories which has a significant role in loop-avoidance mechanism as follows: Feasible Distance (FD), Reported Distance (RD), Successor, Feasible Successor (FS) and Feasible Condition (FC). Protocol Dependent Modules are used to encapsulate the IP packets for network layer. It determines if an additional route is necessary from sources such as routing table. In addition to the routing table, EIGRP uses three types of tables to store the information: neighbor table, topology table and routing table. EIGRP associates six different vector metrics with each route and considers only four of the vector metrics in computing the composite metric: bandwidth, load, delay, reliability, MTU (Maximum Transmission Unit) and hop count. There are some advantages provides by EIGRP as follows [3][9]:

- Simple configuration;
- Back up path to reach the destination;
- Multiple network layer protocols;
- Low convergence time and reduction of the bandwidth utilization;
- Support of routing update authentication.

2.2. Open Shortest Path First (OSPF)

Open Shortest Path First (OSPF) is a routing protocol for Internet Protocol (IP) networks. It based on link-state routing algorithm which calculates the shortest path and falls into the group of interior routing protocols. OSPF is the most widely used routing protocol in large enterprise networks [7]. It gathers link state information from available routers and constructs a topology map of the network. OSPF packets consist of nine fields: version, type, lenghth, router ID, area ID, checksum, autype, authentication and data. There are five different types of OSPF packets in which each packet has a specific purpose in OSPF process that are: Hello, Database Description (DBD), Link State Request (LSR), Link State Update (LSU) и Link State Acknowledgement (LSAck). OSPF should be designed in a hierarchical manner, which basically means that can separate large interconnected networks into smaller interconnected networks called areas. OSPF will have at least one area in the network. If more than one area exists in the network, one of the areas must be a backbone area which has to be connected to all other areas. OSPF areas are: backbone area, stub area, totally stub area, not-so-stubby area (NSSA), totally not-so-stubby area. OSPF routers play a various roles in the network where they are placed and the areas in which they are positioned. Different types of OSPF routers are defined as follows: internal router, backbone router, area border router, autonomous system boundary router and designated router. Route summarizaton is used to merge up the list of multiple routes into one route. The main purpose of summarization is to reduce the bandwidth and processing time. There are two types of route summarization which can be performed in OSPF [9][10]: Inter-Area Route Summarization and External Route Summarization. OSPF is a link state routing protocol which uses a Shortest Path First Algorithm to calculate the lowest cost path to all known destinations. Dijkstra algorithm is used for calculating the shortest path. Dijkstra is a type of search algorithm graph that can solve a problem in the form of the shortest path in a graph with non-negative values (weights) on the branches of a graph (the distance from one point to another is a branch), such that the algorithm produced the shortest path tree (shortest path tree).
OSPF is characterized by several key advantages [13]:

- OSPF always determine the loop free routes;
- Fast reaction (updates) to changes;
- Minimizing the routes and reducing the size of routing table

- Low bandwidth utilization
- Multiple routes support
- Cost effectiveness
- Support Variable Length Subnet Mask (VLSM);
- Suitability for large networks

Disadvantages of OSPF are:

- Complex Configuration;
- Link state scaling issues;
- Memory requirements

3. Simulation

In this paper, network simulator Optimized Network Engineering Tool (OPNET) modeler (v.14.5) is used as a simulation environment. OPNET is among leading simulators for network research and development and allows users to plan and study communication networks, devices, protocols and applications with flexibility. OPNET model is divided into three domains: network domain, node domain and process domain [5][13]. The protocols used in this paperwork are EIGRP and OSPF routing protocol. The proposed routing protocols are compared and evaluated based on quantitative metrics such as convergence duration, packet delay variation, jitter, end to end delay and throughput. These protocols are intended to use to get better performance of one over the other for real time traffic such as video streaming and voice conferencing in the entire network [14]. In this paperwork, three scenarios are created that consists of six interconnected subnets where routers within each subnet are configured by using EIGRP and OSPF routing protocols. The network topology composed of the following network devices and configuration utilities:

- Cisco 7304 Routers;
- Application Server;
- Layer 2 Switch;
- PPP_DS3 Duplex Links
- PPP_DS1 Duplex Links;
- Ethernet 10 BaseT Duplex Links;
- Ethernet Workstations;
- Six Subnets;
- Application Configuration;
- Profile Configuration;
- Failure Recovery Configuration;
- QoS Attribute Configuration.

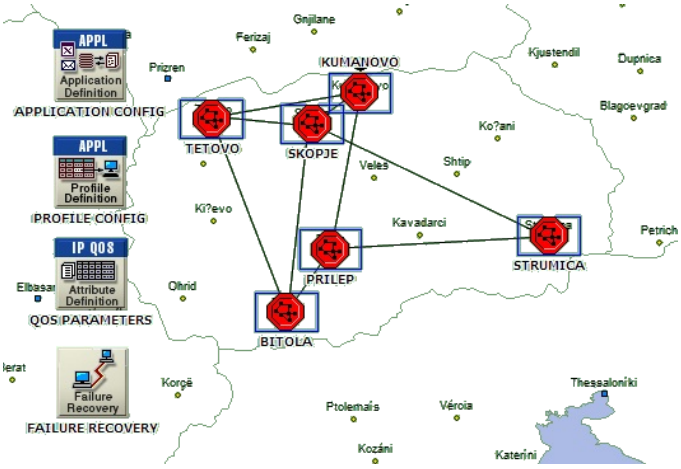

Fig. 1. Network Topology

The subnet in Skopje consist of one Cisco 7304 Router and one Ethernet Server. The subnet of Bitola consists of two Cisco 7304 Routers, one Ethernet Switch and four Ethernet workstations. The subnet in Kumanovo consists of one Cisco 7304 Router, one Ethernet Switch and four Ethernet workstations. The subnet of Prilep consists of one Cisco 7304 Router, one Ethernet Switch and four Ethernet workstations. The subnet in Tetovo consists of two Cisco 7304 Routers and six Ethernet workstations. The subnet of Strumica consists of three Cisco 7304 Routers and four Ethernet workstations. An Application Config and a Profile Config are added from the object palette into the workspace. The Application Config in OPNET allows generating different application traffic patterns. As we are considering real time applications, the Application Definition Object is set to support Video Streaming (Low Resolution Video) and Voice Conferencing with Pulse Code Modulation - PCM. A Profile Definition Object defines the profiles within the defined application traffic. In the Profile Config, two profiles are created. One of the Profiles (Video) has the application support of Video Streaming (Light) and another one (Voice) has Voice Conferencing (PCM Quality) support. Failure link has been configured in the scenarios. Failure events introduce disturbances in the routing topology, leading to additional intervals of convergence activity. The link connected between Kumanovo and Prilep is set to be failure for 300 seconds and to recover after 500 seconds. One Video server is connected to Router-Skopje which is set to the Video Streaming Service of the Video Broadcasting Server.

3.1. Scenarios

In the first scenario, EIGRP routing protocol is enabled first for all routers on the network. After configuring routing protocols, individual DES statistics was chosen to select performance metrics and to measure the behavior of this routing protocol. Then simulation run time was set to 20 minutes

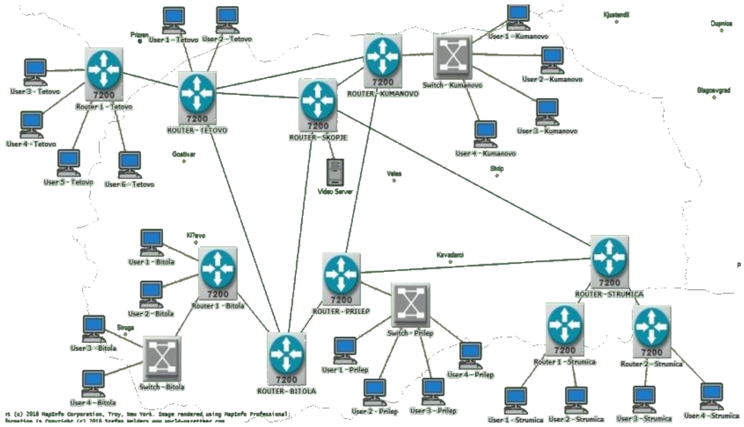

Fig. 2. Internal Infrastructure of Network Topology (Subnets Architecture)

In the second scenario, OSPF routing protocol is enabled first for all routers on the network. After configuring routing protocols, individual DES statistics was chosen to select performance metrics and to measure the behavior of this routing protocol. Then simulation run time was set to 20 minutes. In the third scenario, a key issue is to analyze the performance of the network where both EIGRP and OSPF are running concurrently. In this scenario the subnets of Skopje, Kumanovo and Strumica are configured with EIGRP and the subnets of Bitola, Prilep and Tetovo are configured with OSPF (Fig.3.).

4. Results

4.1. Convergence time

The time of convergence in a network determines the time it takes for all routers have an identical routing table. From the Figure 4 can be observed that the time of convergence of EIGRP network is faster than the convergence of OSPF and EIGRP_OSPF networks. The convergence time of EIGRP_OSPF network is slower than EIGRP and OSPF networks. Figure 4 shows that the convergence time of EIGRP network decreases rapidly growing the EIGRP_OSPF network. Conversely, the time of convergence of OSPF network is faster than EIGRP_OSPF network.

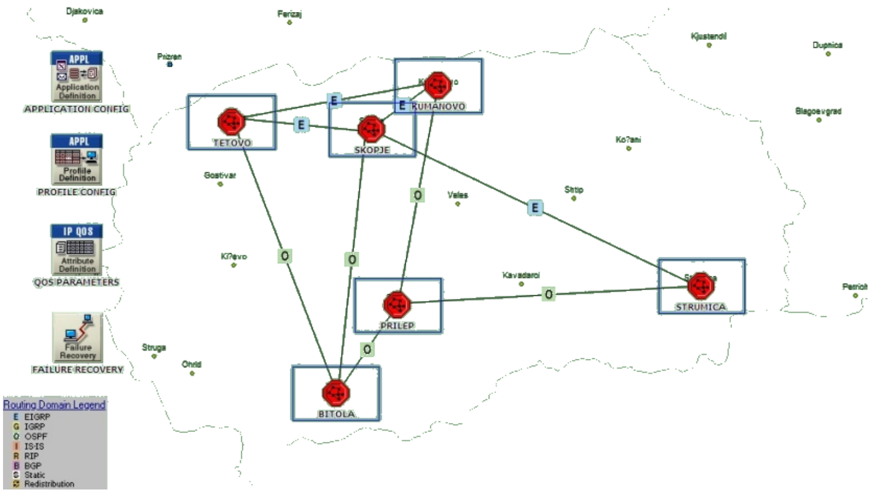

Fig. 3. Network topology of EIGRP_OSPF scenario

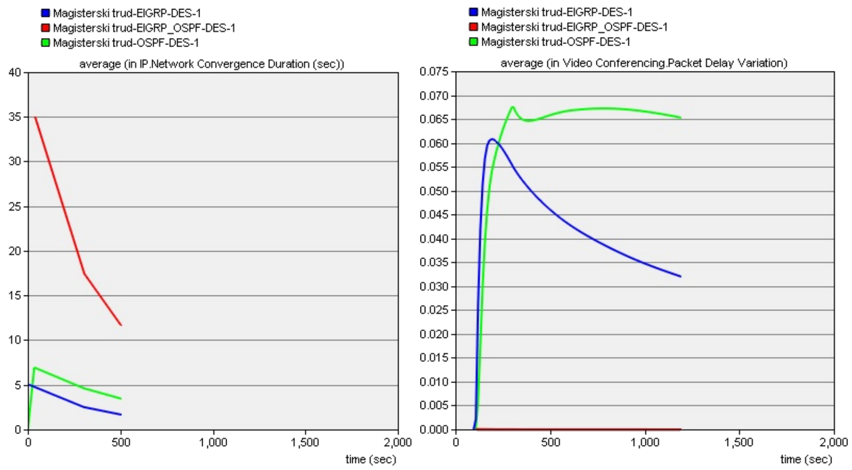

Fig. 4. Convergence time (left subplot) and Packet Delay Variation (right subplot)

4.2. Packet Delay Variation for Video Streaming

Packet delay variation is measured by the difference in the delay of the packets. This metric has significant influence on video applications. It is observed from the Fig. 5. that EIGRP_OSPF network has less packet delay variation than EIGRP and OSPF networks. It is also shown that despite of high congestion, EIGRP_OSPF network is experiencing significantly better performance than other two networks in terms of packet delay variation.

4.3. End-to-end Delay for Video Streaming

End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination. End-to-end delay has a critical importance when a packet arrives too late at the receiver as a consequence, the packet can be effectively lost. Lost packets due to delay have a negative effects on the received quality for both video and voice traffic. Figure 6 illustrates the behavior of end-to-end delay across the networks. As shown in figure 6, end-to-end delay of EIGRP_OSPF network is comparatively smaller than EIGRP and OSPF networks. End-to-end delay of EIGRP network is slightly higher than end-to-end delay of OSPF network.

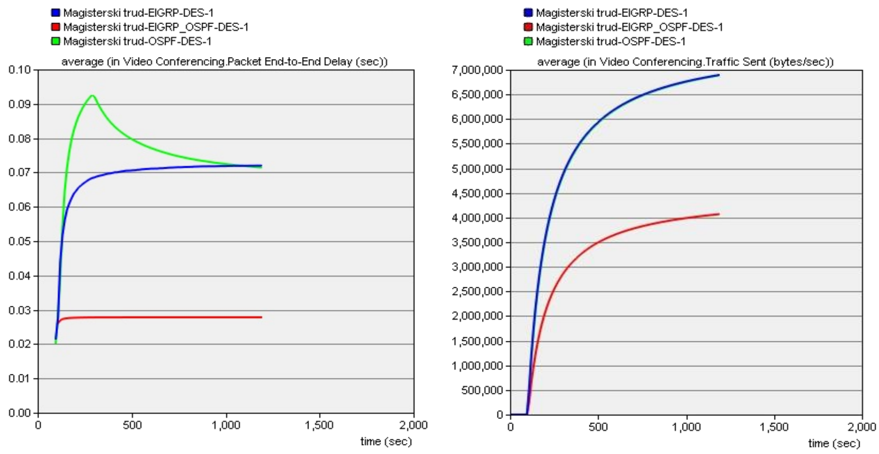

Fig. 5. End-to-end Delay for Video Streaming (left) and Sent Traffic (right)

4.4. Sent and received traffic for Video Streaming

We have considered the multimedia streaming traffic class for low resolution video traffic. All users in the network are watching video from a video server. Figure 7 demonstrates that a sent traffic in EIGRP and OSPF networks is almost the same, apart from EIGRP_OSPF network where the sent traffic is less.

As shown on Fig. 6., some packets are being dropped due to the very high congestion in the network. EIGRP network has the smallest packet loss and OSPF network has the largest packet loss. Jitter is the variation of delay of each packet. It is a very experienced problem in the packet switched network due to the fact that information is segmented into packets that travel to the receiver via different paths.

4.5. Jitter for voice conferencing

Jitter is measured by the variance of time latency in a network. It is caused by poor quality of connections or traffic congestion. It also occurs due to the dynamic change of network traffic loads. However, for real time applications, such as voice, jitter has an imposed upper limit. When a packet arrives beyond the upper limit, the packet is discarded. Figure 9 illustrates that packet delay variation is decreasing faster while packets are being transmitted from source to destination. As shown in Figure 9, it can be seen that the lowest jitter has EIGRP_OSPF network and the highest jitter has EIGRP network.

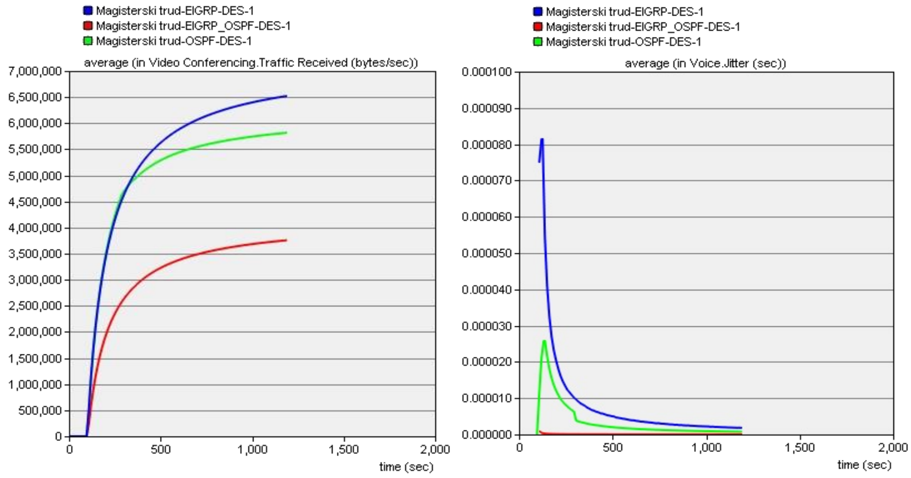

Fig. 6. Received traffic for video streaming (left subplot) and Jitter for voice conferencing (right subplot)

4.6. End-to-end delay for voice conferencing

End-to-end delay is defined as the time interval between data packets transmission from source to the destination. Some packets may be dropped if they don't arrive in time and this can cause short interruptions in the audio stream. From Fig. 10. We can see that end-to-end delay of EIGRP_OSPF network is relatively smaller than end-to-end delay of the other two networks. The highest end-to-end delay is measured in the EIGRP network.

4.7. Sent and received traffic for voice conferencing

Packet loss as a term is defining the packets that are dropped while servicing the network traffic. It is inevitable, especially in the IP networks, and occurs as a result of various reasons. For example, it may occur when routers or switch work beyond capacity or queue buffers are overflowed. Dropped packets in voice conferencing have similar effect as noise. However, some applications may tolerate packet loss as they can wait until packets are retransmitted, but in time-sensitive applications which are not tolerant to packet loss, it can produce significant performance degradation. Packet loss must be managed or controlled in voice conferencing since it effect voice signal distortion. From the results, we can realize that EIGRP network has less packet loss than OSPF and EIGRP_OSPF networks. Also, It can be observed that in the network OSPF and EIGRP are performed simultaneously, EIGRP_OSPF has a very large packet loss.

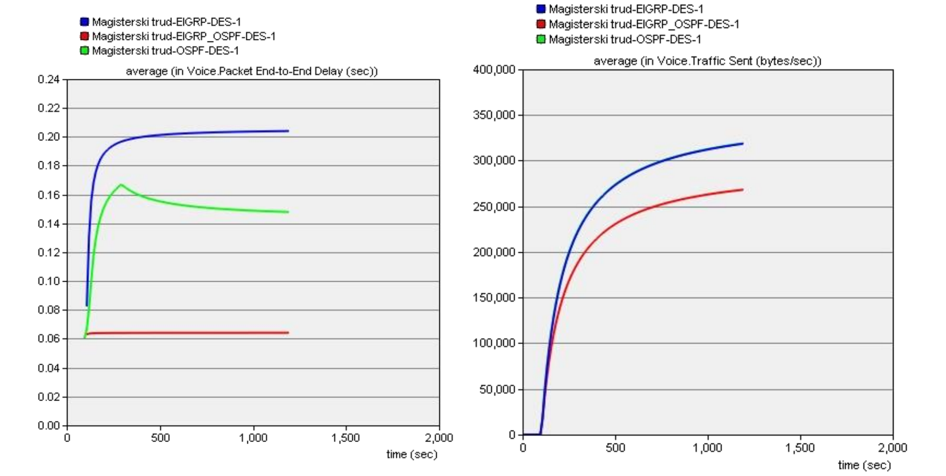

Fig. 7. End to end delay for voice conferencing and Sent traffic for voice conferencing

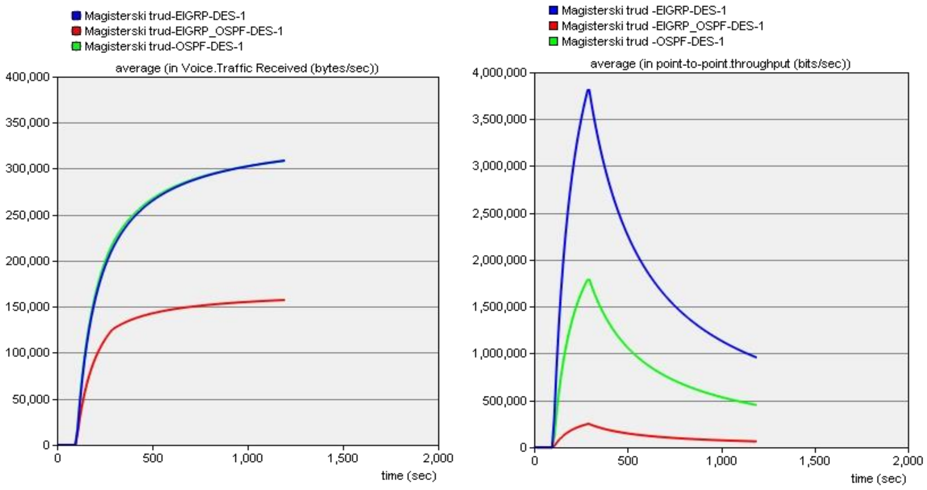

Fig. 8. Received traffic for voice conferencing (left) and Throughput (right)

5. Conclusion

Interior routing protocols such as EIGRP and OSPF are widely being used in the computer networking. In this study, we presented a comparative analysis of selected routing protocols such as EIGRP, OSPF and the combination of EIGRP and OSPF. The comparative analysis has been done in the same network with different protocols for real time applications. Performance has been measured on the basis of paperwork, the implementation of EIGRP shows that network convergence time is much faster than EIGRP_OSPF and OSPF networks because EIGRP network learns some parameters that aimed to figure out the effects of routing protocols.

The throughput is a key parameter to determine the rate at which total data packets are successfully delivered through the channel in the network. EIGRP network has higher throughput and less packet loss than OSPF and EIGRP_OSPF networks. EIGRP_OSPF network has lowest throughput and largest packet loss.

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