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Performance Comparison of Mixed Protocols Based on EIGRP, IS-IS and OSPF for Real-time Applications

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Abstract: Developing of Internet networks and increasing demand of real-time applications, such as voice, video conferencing and routing algorithms play important roles in the real network in recent years. Considering rate and type of the demanding traffic, choosing of the routing protocol can cause the best performance in function of a network. Interior Gateway Routing Protocol (EIGRP) and Open Shortest Path First (OSPF) protocols have been proposed, because of their better performance for real-time applications that both of them are based on dynamic routing algorithms. Intermediate Systems-Intermediate Systems (IS-IS) Protocol is main interior gateway routing protocol designed to operate in complex network topologies. In this paper, we demonstrate that with combination of protocols better results rather than single protocol configuration can be obtained. We show that combination of three protocols EIGRP, OSPF and IS-IS and applying these mixed protocols to a semi-mesh topology propose better results in performance of end-to-end delay, packet delay variation, Voice Jitter and Link throughput parameters. To design and implement of our proposed algorithm, we have employed OPNET software.

Key words: Dynamic routing algorithms · IS-IS · OSPF · EIGRP · OPNET and protocol combination

INTRODUCTION

Routing protocols provide essential role in the modern communication networks. A routing protocol determines how routers communicate with each other and forward the packets through the optimal path to travel from a source to a destination node. Each routing protocol has different configuration in comparison with others, so in a network with a special structure, different protocols depending on their parameteres demonstrates better performance. As we know, Routing protocol operates based on routing algorithms. Dynamic and static routing algorithms are important algorithms for modern communication networks. Modern communication networks such as internet network use dynamic algorithms instead of static algorithms, because static algorithms don't utilize network's current load in finding the best paths [1]. Dynamic routing algorithms have different kinds, but there are two essential and important algorithms Distance Vector Routing and Link State Routing algorithms which are employed in recent communication networks [2]. Adaptivity and scalability are important factors of Link State Routing algorithm in comparison with Vector Routing algorithm [3]. Enhanced Interior Gateway Routing Protocol (EIGRP) is based on Distance Vector Routing algorithm where Intermediate Systems-Intermediate Systems (IS-IS) and Open Shortest Path First (OSPF) are based on Link State Routing algorithm [4]. All of the above Protocols are from the interior gateway protocol (IGP) and are used for Autonomous Systems (AS) [2].

IS-IS can be extended easily and utilizes Dijkstra algorithm for finding the best routh. Meanwhile, EIGRP and OSPF utilize Diffusing Update Algorithm (DUA), which consist of Distance Vector and Link State routing algorithms [4]. EIGRP has been CISCO didicated protocol in opposite to other general protocols. The cost of routing in EIGRP protocol is based on bandwidth and delay [5] and also the cost of routing OSPF is based on just the bandwidth utilization [6].

Performance analysis of different routing protocols has been done based on various performance metrics like network convergence, router convergence, queuing delay, throughput [3], network bandwidth utilization,

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CPU utilization and amount of route traffic [7]. Another noticeable advance in routing techniques is to employ combination of two protocols for improving network performance parameters [2, 4, 8-10].

In this paper, comparative analysis of protocols will be studied. This comparison is based on simulation in OPNET for a given network with a semi-mesh topology. In this research, the combination of EIGRP/OSPF, EIGRP/IS-IS, OSPF/IS-IS and EIGRP/IS-IS/OSPF in comparison with each other for real-time applications have been considered. Results of our simulations, demonstrate an enhancement in Packet delay variation, Packet End to End delay, Voice Jitter and link throughput for the combination of EIGRP/IS-IS/OSPF protocols is achived.

Survey of Related Works: Todayes, increasing of high speed Internet and large amount of traffic demand in the communication networks, the problems of congestion occurres in the network operation and its performance should be greatly reduced. To increase the efficiency of a network with given topology, the data stream in the router should be configured utilizing communication protocols. Selection of appropriate protocol in order to improve performance and increasing the efficiency of IP networks is an essential issue. Selecting of the appropriate protocol in real-time applications is more apparent, increasing in real-time demands, parameters such as Packet Delay Variation and End-to-End delay, can even lead to received video packets loss and sound quality reduction at the receiver side and hence reduce traffic delivery severity [1]. Also in real communication networks (including Internet networks) network topology due to node or link failures, permanently changes and hence the convergence time as an important parameter in networks with real-time applications is affected, strongly.

There is various numbers of dynamic routing protocols such as EIGRP and OSPF protocols have proposed due to their better performance in real-time applications [1]. According to reference [1], a general comparison between EIGRP and OSPF has been accomplished and EIGRP is suggested due to its better performance. Furthermore, this description has been studied in reference [9] and the comparison between EIGRP and OSPF protocols, with combination of these protocols has been done for the same network. Comparing packet delay variation, end-to-end delay and traffic sent parameters, the network with combination of two protocols has demonstrated better performance rather than the network configured under the single protocol. Also it has been demonstrated that the network convergence time is less merely in network with single configuration EIGRP protocol [9]. The other comparison has been studied between EIGRP and combination of IS-IS and RIP protocols, which is still maintaining superior network convergence time in network with EIGRP protocol [4]. Also in reference [4], throughput of video, FTP and Email traffic, in a network with combination of two protocols has demonstrated better performance rather than the network configured under the single protocol and End to End delay parameter for video conferencing traffic has demonstrated better performance in the configuration utilizing single protocol. In reference [8], a general comparison between networks utilizing IS-IS, OSPF and EIGRP protocols and networks with mixed protocoles of combination of EIGRP and IS-IS and combination of OSPF and IS-IS has been done. Regarding traffic sent, convergence time, HTTP object response time and E-mail download response time parameters, the network with combination of EIGRP and IS-IS has shown better performance rather than the network configured under a single protocol.

As mentioned above, network performance in the network with configuration with combination of two protocols is better in comparison with single protocol. So, the main purpose of this paper is to propose a combination of multiple protocols based on protocols outlined in this section to achieve better network performance rather than mixing of two protocols. We are going to compare performance of a given network under scenarios of mixed protocols as OSPF/EIGRP, OSPF/IS-IS, EIGRP/IS-IS and IS-IS/OSPF/EIGRP.

Implementation of the Proposed Algorithms on the Network: I this section, we demonstrate the topology of the proposed network. Also, we evaluate this network performance under different senario schemes regarding network evaluation parameters.

Network Topology and Simulation Parameters: Fig. 1 is illustrates shematics of a given Network with a semi-mesh topology. A schematic view of the internal nodes of C, as an example is illustrated in Fig. 2 that consists of a central router, a switch and the workstation. According to Fig. 2, the central router which used for the sub-division is Cisco 12000 routers and the switches are ethernet16-switch. Other specifications which applied in the network simulations are given in Table. 1. For internal communication inside the subnet of the networks, which presented in Fig. 2, we applied the Links with transmission rates of 100Mbps, which is called 100BaseT in the software library.

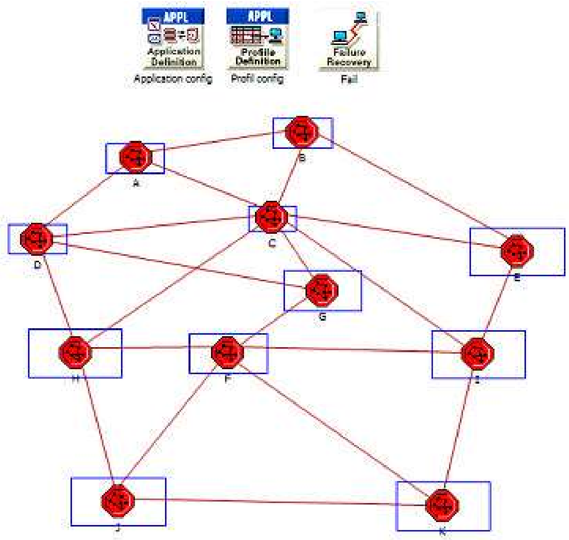

Fig. 1: a view of the network simulation in OPNET

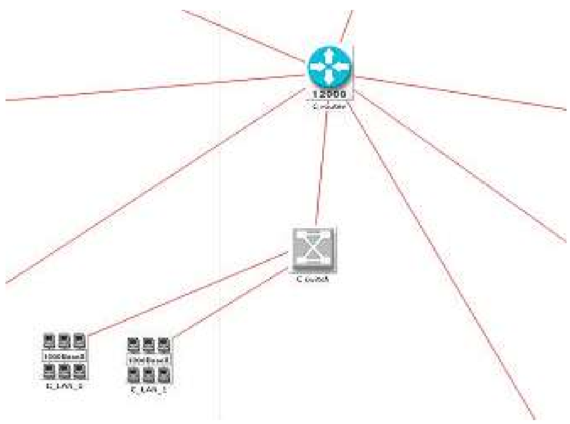

Fig. 2: Schematic view of the internal nodes sub-section

In order to investigate the convergence time of the given network, we applied a Failure Recovery node which is the simulator of fails in nodes or links of the real communication networks. The link between C and H nodes is an important communication link of the given, so during our simulations, we apply a failure event after 250sec of simulation start, with recovery time of 350sec of that failure to the simulator. The total simulation time for scenarios is taken to be 600sec. Real-time voice and videoconferencing traffic are applied in whole network links, where parameters are given in Table. 2.

Table 1: Selected devices for network simulation

Part of title	Selected from the software library
Workstations	1000baseX_LAN
Network switches	Ethernet16_switch
The following router networks	CS_4000_3s_e6_f_fr2_sl2
Core router nodes	CS_12016_16s_ a10_fe8_ge3_sl24
Traffic Node configuration	Application Configuration
Node's configuration	Profile Configuration
Configuration node failure and recovery	Failure Recovery

Table 2: Type of network traffic.

Traffic	Optional rates
Voice	PCM Quality and silence Suppressed
Videoconferencing	Low Resolution Video

Networks Scenarios: Our simulation involves four scenarios for the illustrated network topology of Fig. 1. Name and definition of scenarios are given in Table. 3. In the all of scenarios, the combination of two and three protocols is used for networks configuration. A snapshot of the configuration scenarios, OSPF/IS-IS, OSPF/EIGRP, EIGRP/IS-IS and EIGRP/IS-IS/OSPF respectively is shown in Fig. 3(a), 3(b), 3(c) and 3(d).

Networks Analysis: We have analyzed network performance under different scenarios applying different protocoles from the view of five initial parameters.

Convergence Duration: Convergence Duration time parameter in a series networks demonstrates that how fast the convergence is Conditions. This parameter is an effective factor in dynamic routing for a group of routers, which are connected together. For real-time applications, convergence duration time is a key point and the small value of it is an advantage for the network. Fig. 4 illustrates the convergence time parameter for four scenarios of Figs 3(a)-3(d). According to Fig. 4, the OSPF/IS-IS scenario has minimal value in convergence time before a failure to be occurred in the network and after network recovery between all other scenarios. So, convergence duration time parameter in combination of two protocols OSPF and IS-IS is fine.

Table 3: Name the four scenarios that simulated

Name of the scenario	Configured for networks protocol
EIGRP and IS-IS	combination of the two protocols EIGRP, IS-IS
OSPF and IS-IS	combination of the two protocols OSPF, IS-IS
EIGRP and IS-IS and OSPF	combination of the threes protocols IS-IS, OSPF, EIGRP
OSPF and EIGRP	combination of the two protocols OSPF, EIGRP

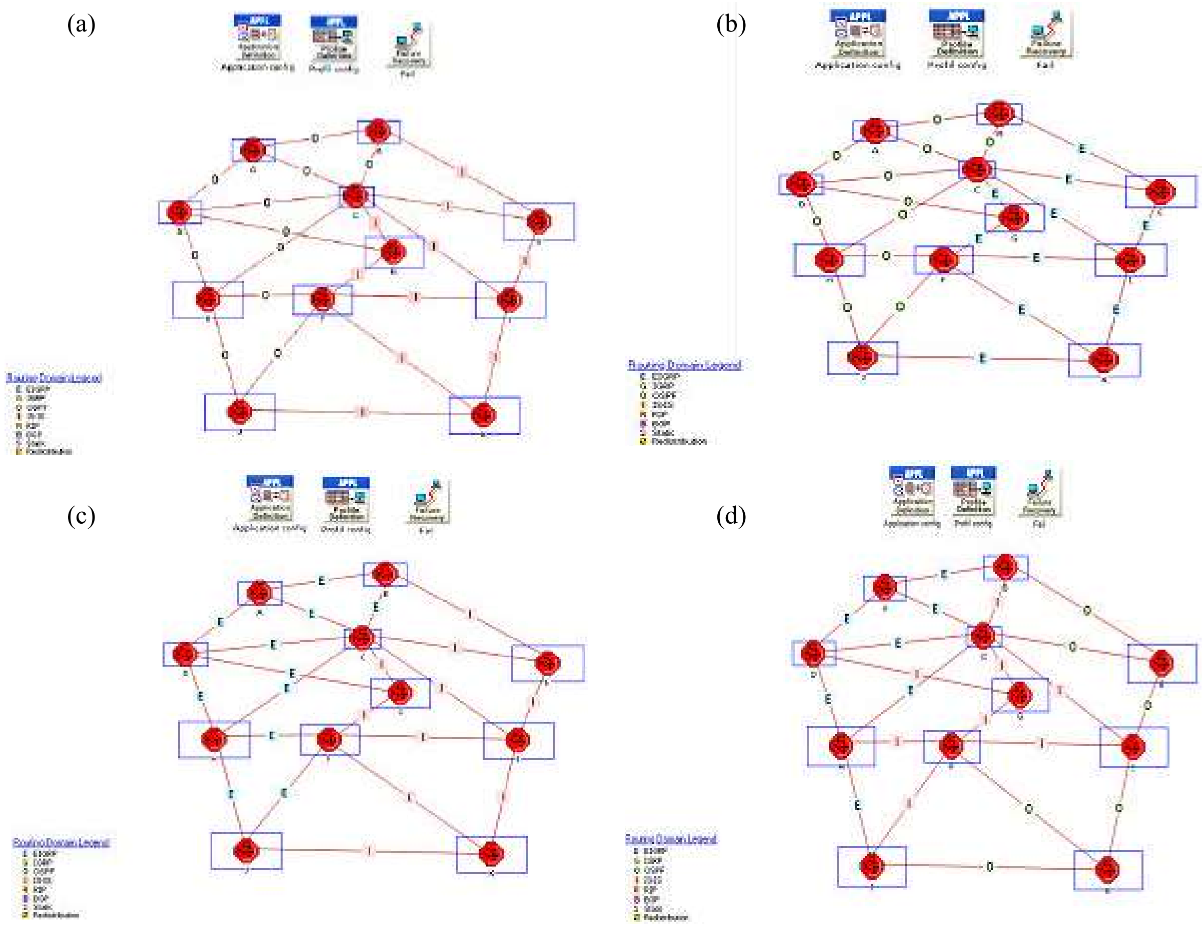

Fig. 3: A View of the networks configuration in a scenario combining (a) two protocols OSPF/IS-IS, (b) two protocols OSPF/EIGRP, (c) two protocols EIGRP/IS-IS and (d) three protocols EIGRP/IS-IS/OSPF.

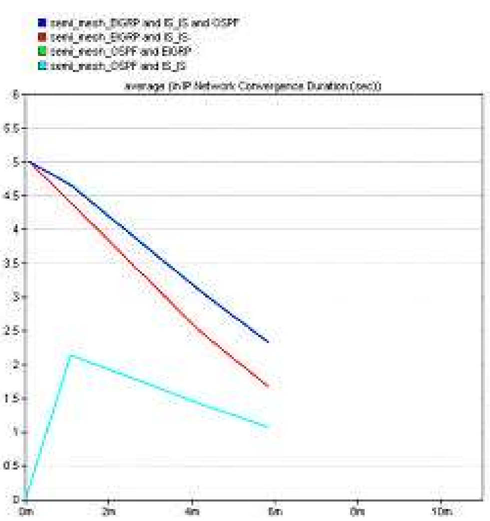

Fig. 4: A comparative study of the convergence duration time parameter for scenarios given in Fig. 3. OSPF/IS-IS scenario has lower average convergence duration time.

Packet Delay Variation: This parameter is defined as a delay in receiving packets at the receiver. On the transmitter side, data packets are sent continuously in the channel. Due to networks congestion, improper queuing, or configuration errors, the packet may not receive, in the order that the transmitter and receiver with the same period were sent. In real-time applications such as videoconferencing and voice packets delay cannot be ignored due to the Packet delay variation, which causes packet loss and also there will be no recovery of voice or video.

Packet delay variation for voice and videoconferencing traffic is illustrated in Figs. 5(a) and 5(b), respectively. According to these figures, EIGRP/IS-IS/OSPF scenario, before of failure occurrence and after network recovery, has lower value than the other three scenarios and shows better performance.

End-to-end Delay: When the packet transmitted via a network from source to destination then end-to-end delay

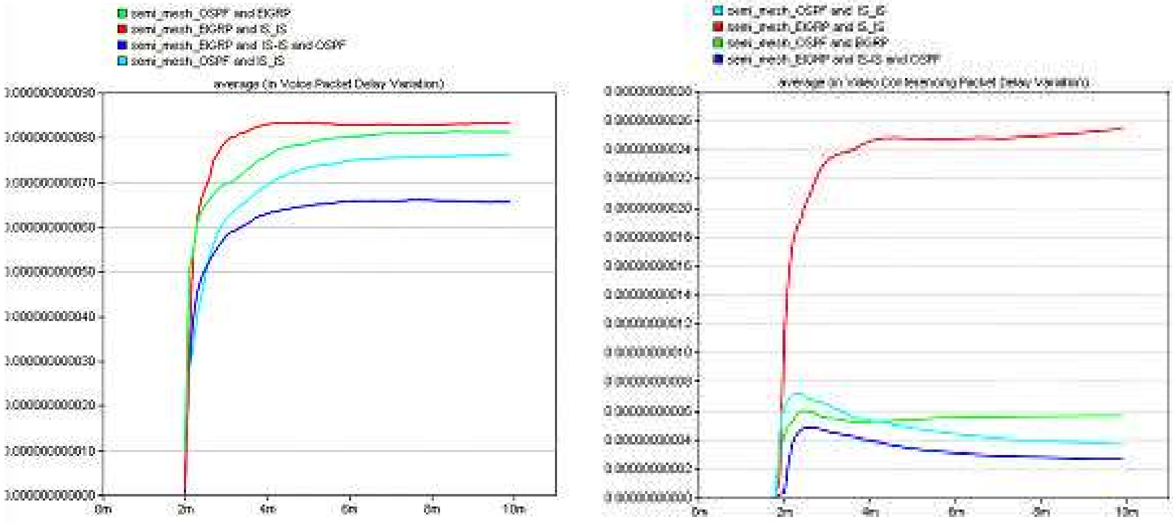

Fig. 5: Comparison of packet delay variation for (a) voice traffic and (b) Videoconferencing traffic. EIGRP/IS-IS/OSPF scenario has the lowest packet delay variation.

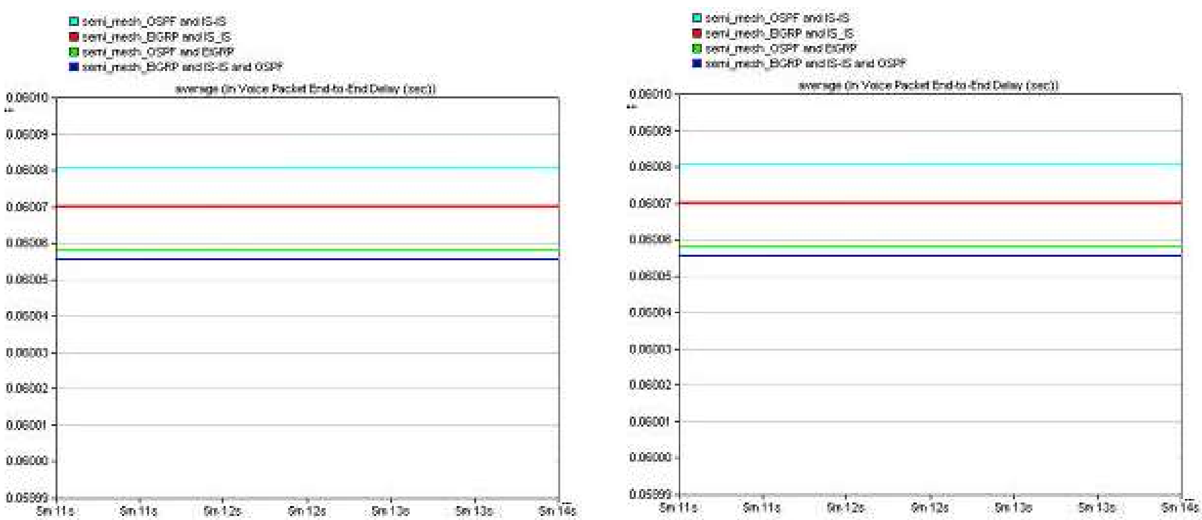

Fig. 6: End-to-end delay parameter for (a) voice traffic and (b) videoconferencing. EIGRP/IS-IS/OSPF scenario has the lowest end-to-end delay.

time has been considered. When it takes too much time to arrive the packet to the receiver, it causing delays in the whole process and therefore has a critical effect on performance of a communication network. Networks with large values of end-to-end delay, the packet can be effectively destroyed. Packet losses due to large end-to-end delay will have impact on the quality of both audio and video traffic on the receiver. The end-to-end delay parameter for voice and videoconferencing traffic is shown in Figs. 6(a) and 6(b), respectively. According to these figures, EIGRP/IS-IS/OSPF scenario has minimum end-to-end delay in comparison with other scenarios of Fig. 3. The average amount of end-to-end delay for detailed comparative study is given in Tables 4 and 5, respectively.

Throughput: Throughput is a basic parameter for determining the total rate of data packet which successfully delivered and received through channels in the network. The unit of Throughput are bits per second and packets per second which expressed in some cases already [2].

Here, we investigate the efficiency of the C to H link because this link is a one of the important links in the whole network. Throughput of the C to H link is demonstrated in Fig. 7 for the four scenarios of the Fig. 3.

Table 4: Numerical values of parameters of end-to-end delay for voice traffic

Name of the scenario	End-to-end delay (msec)
EIGRP and IS-IS	60.0705
OSPF and IS-IS	60.0816
OSPF and EIGRP	60.0588
EIGRP and IS-IS and OSPF	60.0554

Table 5: Numerical values of parameters of end-to-end delay for videoconferencing traffic

Name of the scenario	End-to-end delay (msec)
EIGRP and IS-IS	0.3434034
OSPF and IS-IS	0.3435964
OSPF and EIGRP	0.3433837
EIGRP and IS-IS and OSPF	0.3433538

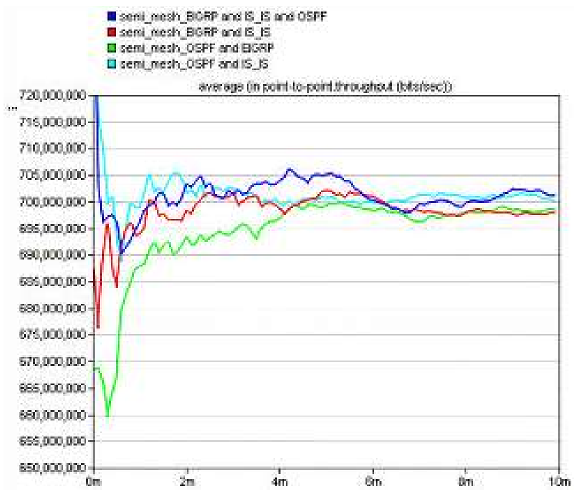

Fig. 7: Comparison of Throughput for C to H link for different scenarios of Fig. 3. Blue diagram shows Throughput of EIGRP/IS-IS/OSPF scenario in comparison with other scenarios has the largest value in most of the time interval after the network recovery.

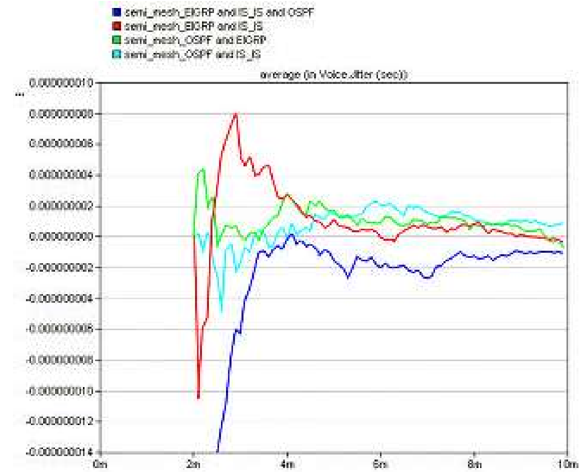

Fig. 8: Comparison of the Jitter parameter for given scenarios of Fig.3. The blue curve, belongs to the EIGRP/IS-IS/OSPF scenario, demonstrates the least amount of Jitter.

The average values of the Throughput of the C to H link, before the failure event and after recovery of the network are presented in Table 6. From the given values in Table 6, we see that the EIGRP/IS-IS/OSPF scenario has highest efficiency in comparison with other three scenarios at any given time in Table 6. In Table 6, the selected sample times are the time of failure event and after recovery in the network.

Voice Jitter: Jitter is defined as variation in delay times of received packets. At sending sides, packets are sent in a continuous stream in an equally spaced time slots. This rate is much lower than the average rate, resulting from traffic congestion and for improving performance of a voice network this factor should be as small as possible.

Table 6: Comparison of Throughput parameter for the communication link between C to H, The time of the network simulation before failure event is 228sec and after recovery is 528sec

Name of the scenario	Before the failure event (bits/sec)	After recovery (bits/sec)
EIGRP and IS-IS	699835353.5	697996157.3
OSPF and IS-IS	700009810.6	701031036.0
OSPF and EIGRP	696327042.7	699083414.0
EIGRP and IS-IS and OSPF	703148639.5	701443288.5

Table 7: Comparison of the jitter parameter, the time of the network simulation before failure event is 228sec and after recovery is 528sec

Name of the scenario	Before the failure event (µsec)	After recovery (µsec)
EIGRP and IS-IS	0.002516	0.000185
OSPF and IS-IS	0.000201	0.001035
OSPF and EIGRP	0.001316	0.000707
EIGRP and IS-IS and OSPF	-0.000602	-0.001098

This parameter is illustrated in Fig. 8 for different scenarios of Fig. 3. As is clear from this Figure, the EIGRP/IS-IS/OSPF scenario has the lowest jitter in comparison with other three scenarios. The numerical values of Jitter before failure event and after recovery for the network are presented in Table 7. Comparing given values of Table. 7, we see that the EIGRP/IS-IS/OSPF scenario has better performance in rather than other scenarios.

CONCLUSION

Configuring a routing protocol is one of the most prominent parts of the network design. In this paper, we have presented a comparative analysis in a typical semi-mehed network utilizing combination of EIGRP, IS-IS and OSPF routing protocols. The comparative analysis has been done in a network for voice and videoconferencing traffic. The results obtained from our simulations; show that OSPF/IS-IS scenario has minimal convergence time whereas EIGRP/IS-IS/OSPF scenario has minimum Packet delay variation, packet End to End delay, Voice Jitter and link Throughput. From these results, we can say with certainty that combination of three protocols has better performance rather than combination of two protocols. In conclusion, we suggest combination of three or more protocols to increase efficiency and network performance.

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