Performance Comparison of Various Routing Protocols in IPv4-IPv6 Coexistence Environments

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***Abstract*— This aim was prescribed by the lack of research related to the routing protocols performance in dual-stack environments, and by the requirement to further examine the prevalent stereotype which describes that OSPF is most suitable for business networks and IS-IS is suitable for ISP networks. The objective of this paper was to examine the performance of the two most popular link-state routing protocols when employed in IPv4/IPv6 dual-stack business networks. The paper aimed to build the first step of scientific research in performance comparison of various routing protocols in IPv4-IPv6 coexistence environments that will become dominant and popular for a long time-space with the advent of IPv6. Moreover, IS-IS and OSPF were chosen for the comparison, as they build two proven efficient routing protocols with same routing function features. The purpose of the work was to offer proof-based advice for choosing the protocol that provides optimum performance in business organization networks, in the new growing network landscape, and recommend possible transfer from one protocol to another. This experiment was carried out by the renowned OPNET network simulator. The results of the simulations explored the appropriateness of IS-IS compared to OSPF, as far as it relates to routing table sizes, convergence times and throughput, where both protocols works equally in terms of jitter and end-to-end delay times. Depending on these results, it can be considered that IS-IS builds a more optimum solution for dual-stack business networks than OSPF.**

Keywords: IS, TCP, UDP, OSPF, OPNET

I. INTRODUCTION

IS-IS and OSPF are both link-state routing protocols that use same Dijkstra algorithm for calculating the lowest-cost paths to each existing destination. However, they introduce high differences as they were made on various protocol stacks i.e. IS-IS is based on the OSI, where OSPF is based on TCP/IP stack. Research displays that the dual-stack solution as well as other transition mechanisms can load the network in means of memory requirements, CPU processing power and may also add latency to the routing process. Particularly in dual-stack this is a result of the IPv6 and IPv4 stacks running simultaneously on each host and network device. This fact builds even more significant the choice of an optimal performing routing protocol for mitigating the inevitable dual-stack negative impacts. Furthermore, presently network performance is of critical significance because of the continuously increasing usage of real-time applications i.e. voice and video which demand low round-trip delay values and high throughput for working efficiently.

On the network layer, attaining routing convergence, the procedure in which routing tables are updated, is a necessary and complicated process. At each configuration change, involving a link failure or recovery, the routing tables required to be updated at which time the convergence procedure happens. The task of updating these tables is performed by routers that interact according to a set of rules defined by routing protocols. The primary objectives of any routing protocol are to attain fast convergence, while remaining flexible, simple, accurate and robust.

II. RELATED WORK

C. Hedrick in [5] presented a work which is defined in RFC 1058 and offers a lot of information about this routing protocol. RIP is the oldest protocol. It utilizes a distance vector algorithm to make the routing tables and computes the distance to a destination host in order to how many hops a packet must travel. It also describes technical views of the metric and packet format.

D. Pei et al. display the design and development of a mechanism for determining RIP routing updates. Particularly, RIP-TP protocol is introduced. It utilizes hop count as routing metric. The authors stress its simplicity, efficiency, low operating cost and compatibility with the standard RIP.

A. Basu et al., studies the consistency of the OSPF protocol under steady state and with interferences. In this study we will watch what impacts are provided by the TE (Traffic Engineering) extensions on the stability of a network when OSPF is performing. OSPF TE extensions offer mechanisms for assuring that all network nodes have a consistent view of the traffic parameters connected with the network. The authors also examine whether it is possible to accelerate the convergence time of the network, examining the Hello packets and the number of path flaps caused by a failure in the network.

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III. PROBLEM STATEMENT

The objective of this paper was to examine the performance of the two most appropriate link-state routing protocols when employed within IPv4/IPv6 dual-stack business networks. The purpose is to build the first step of scientific research in performance comparison of various routing protocols in IPv4-IPv6 coexistence environments that will become dominant and popular for a long time-space with the advent of IPv6. Moreover, OSPF and IS-IS were chosen for the comparison, as they build two proven efficient routing protocols with same routing function features. The purpose of the work was to offer proof-based advice for choosing the protocol that provides optimum performance in business networks, in the new growing network landscape, and recommend possible transfer from one protocol to another. The experiment was carried out by using the popular OPNET network simulator. The configured IS-IS and OSPF basic enterprise topologies over a dual-st*ack* network were chosen this manner, as to measure their performance related to IPv4 and IPv6 traffic, as well as under various Transport Layer UDP and TCP traffic patterns.

IV. SIMULATION PARAMETERS

After adjusting and configuring the suitable simulation IS-IS and OSPF scenarios for no traffic, UDP and TCP traffic and router failure situations, the parameters of the simulation process were adjusted. Initially, the intended to evaluate Global, Node and Link metrics that were defined formery, were chosen from the DES "Choose Individual Statistics" menu, Afterwards, the *optimized simulation kernel* which assures an optimized fast execution of the simulated scenarios was chosen. Moreover, the selection related to the simulation time was depend on the required measurements in every scenario. More particularly, in the traffic-less scenarios the simulation time was adjusted to 10 minutes, as the metrics computed were convergence duration and activity as well as routing table sizes, which are found clearly on the first few seconds of the simulation. On the other side, for the TCP/UDP traffic scenarios, the simulation time was adjusted to 24 hours.

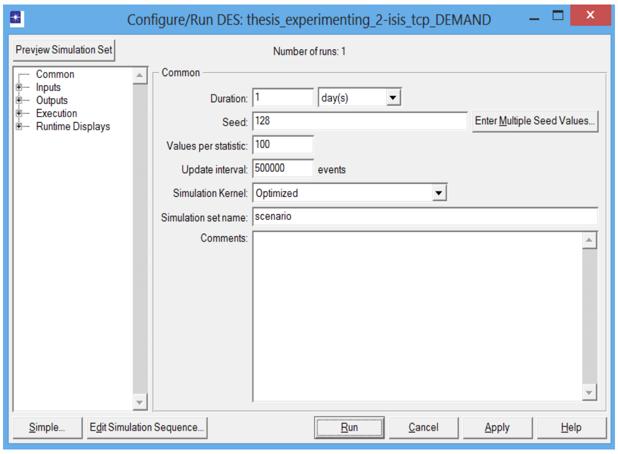

Figure 1 - DES Parameters

V. SIMULATION RESULT

This section shows the results that were generated by the simulations in all chosen simulation scenarios. The shown diagrams derive from the exact OPNET Simulator output.

5.1 IPv4 Traffic Metrics

The following results were evaluated at the Dual-Stack Server 1 which supports the IPv4-only clients of the network. Accordingly, they mirror the dual-stack network performance for IPv4 TCP traffic flows, for each of the two routing protocols.

5.1.1 Throughput

The above diagram explore a large differentiation between OSPF and IS-IS dual-stack network when running TCP traffic. Namely, in the long run, IS-IS attains a throughput of more than 190 bps where OSPF approaches 120 bps in the end of the simulation where stabilization has been arrived. In percentages, this means that IS-IS shows at least 58% increased throughput than OSPF.

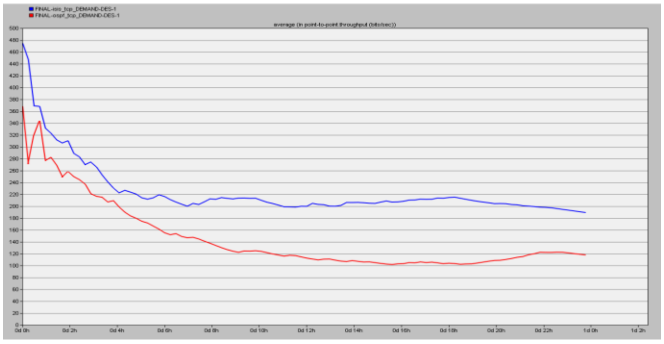

Figure 5.1 - IPv4 Throughput (TCP Traffic)

5.1.2 End-to-End Delay

The above results diagrams show end-to-end delay evaluations for the four IPv4 hosts of the dual-stack network. The first diagram concerns to the OSPF scenario where the second concerns to the IS-IS one

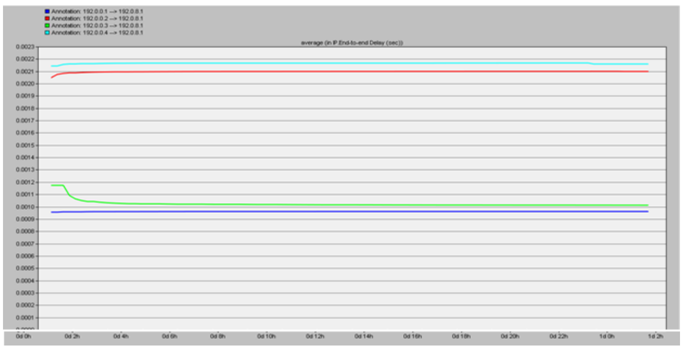

Figure 5.2 - OSPF IPv4 Clients End-to-End Delay (TCP Traffic)

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More exactly, the mean IPv4 end-to-end delay for OSPF is computed to nearly 1.6 ms, same as the IS-IS the mean value. From this evaluations, it can be considered that OSPF and IS-IS perform same in terms of end-to-end delay.

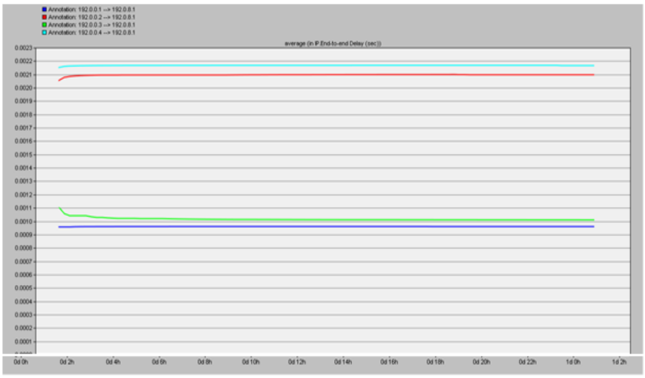

Figure 5.3 - IS-IS IPv4 Clients End-to-End Delay (TCP Traffic)

5.1.3 End-to-End Delay Variation (Jitter)

Same to the end-to-end delay results that were shown, the above diagrams display the jitter values for each IPv4 hosts in the OSPF configured dual-stack network initially, and the IS-IS configured dual-stack network secondly.

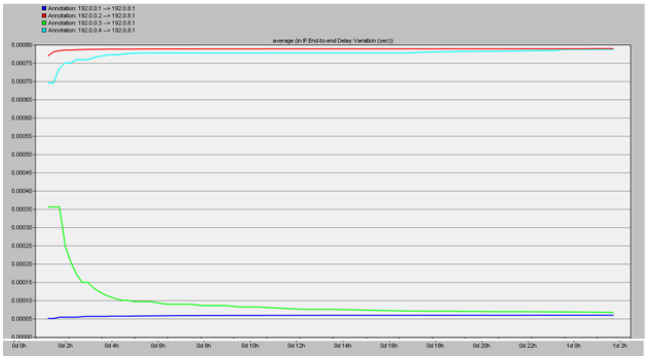

Figure 5.4 - OSPF IPv4 Clients End-to-End Delay Variation (TCP Traffic)

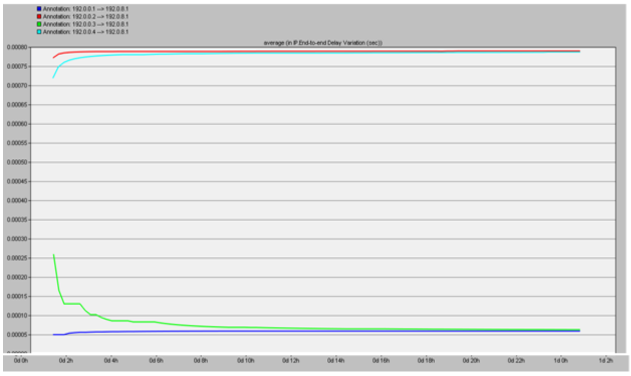

Figure 5.5 - IS-IS IPv4 Clients End-to-End Delay Variation (TCP Traffic)

5.2 IPv6 Traffic Metrics

Same to the IPv4 hosts, similar metrics were evaluated for the IPv6 hosts of the dual-stack network. This time, the evaluations were performed on the Dual-Stack Server 2 which is set to obtain the TCP traffic flows of the four IPv6 hosts, so the results provide a view of the dual-stack network when traversing IPv6-only traffic for the different configured routing protocols.

5.2.1 Throughput:

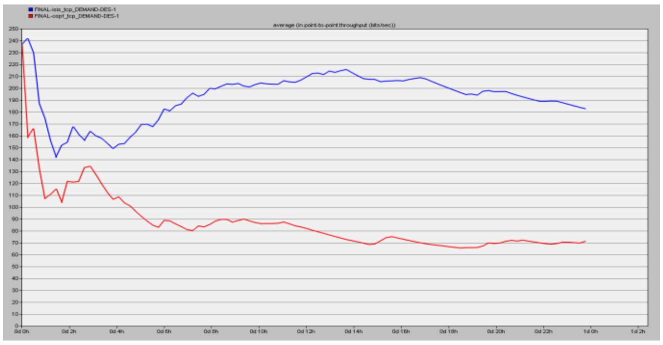

Figure 5.6 - IPv6 Throughput (TCP Traffic)

A similar picture to the one presented for the IPv4 traffic is also explored for IPv6 traffic, when it comes to incoming throughput at the receiving server.

5.2.2 End-to-End Delay:

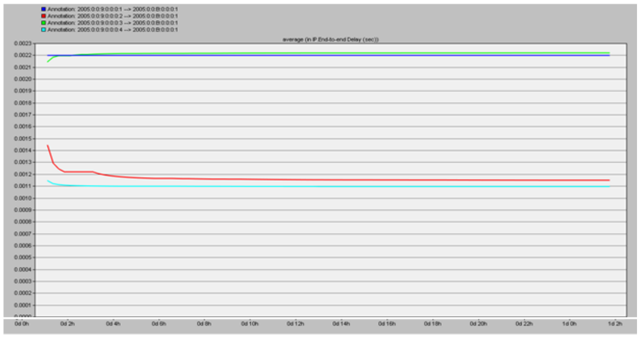

Figure 5.7 - OSPF IPv6 Clients End-to-End Delay (TCP Traffic)

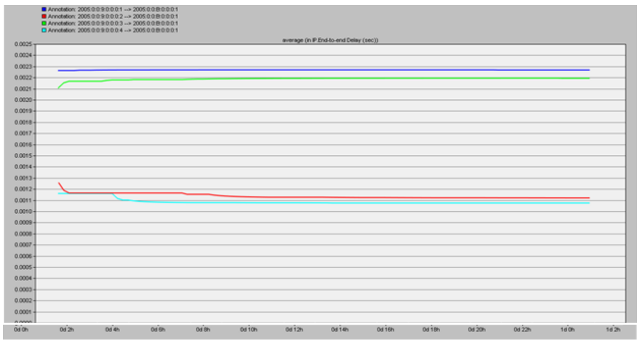

Figure 5.8 - IS-IS IPv6 Clients End-to-End Delay (TCP Traffic)

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5.2.3 End-to-End Delay Variation (Jitter)

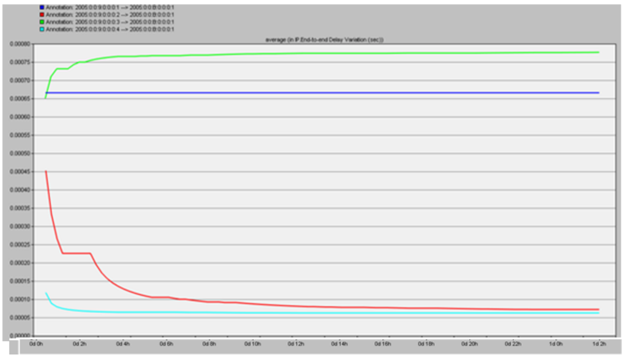

Figure 5.9 - OSPF IPv6 Clients End-to-End Delay Variation (TCP Traffic)

As viewed in the above diagrams, jitter for each IPv6 client was also evaluated on the Dual-Stack Server 2 for IS-IS and OSPF scenarios.

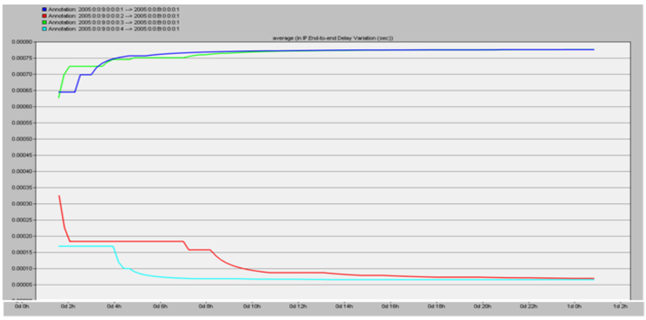

Figure 5.10 - IS-IS IPv6 Clients End-to-End Delay Variation (TCP Traffic)

5.3 IPv4 Traffic Metrics

The following results were again evaluated at the Dual-Stack Server 1 which supports the IPv4-only clients of the network. Accordingly, they mirror the dual-stack network performance for IPv4 UDP traffic flows, for each of the two routing protocols.

5.3.1 Throughput

The above diagram shows that IS-IS prevails over OSPF in terms of throughput for IPv4 UDP traffic flows attaining again a 42% increased throughput value in comparison of OSPF. In numbers, IS-IS has a throughput of nearly 200 bps, where OSPF arrives 140 bps, corresponding to a much less percentage of successfully obtained packets.

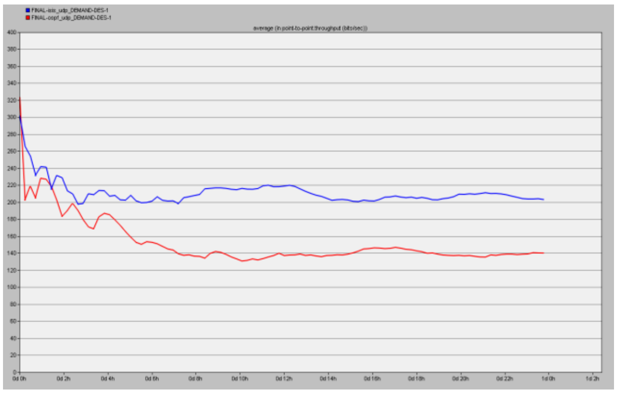

Figure 5.11 - IPv4 Throughput (UDP Traffic)

5.3.2 End-to-End Delay

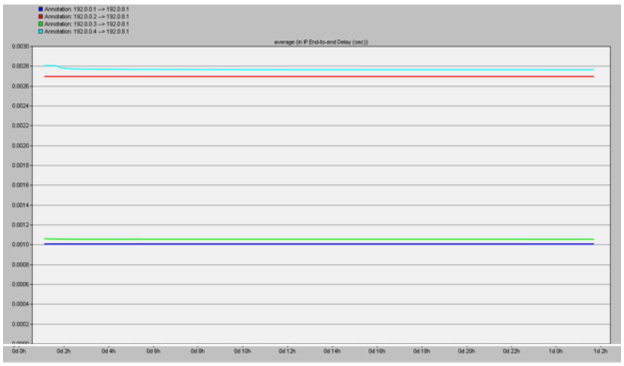

Figure 5.12- OSPF IPv4 Clients End-to-End Delay (UDP Traffic)

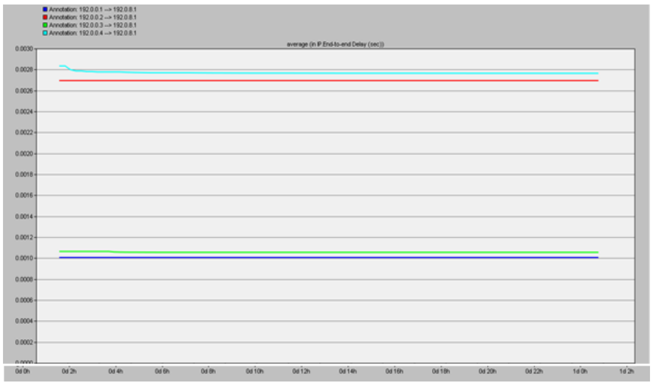

Figure 5.13 - IS-IS IPv4 Clients End-to-End Delay (UDP Traffic)

The above generated results show that IPv4 UDP end-to-end delay times for IS-IS and OSPF routing protocols are again almost similar.

5.3.3 End-to-End Delay Variation (Jitter)

Relating to jitter, which is a metric of high significance for UDP based applications, the mean values computed from each one of the above diagrams equaled nearly 0.00375 ms for both

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IS-IS and OSPF. As viewed, IS-IS and OSPF jitter values almost same in the long run of the simulation.

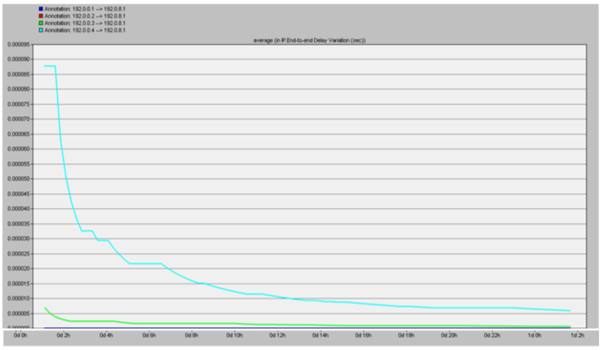

Figure 5.14 - OSPF IPv4 Clients End-to-End Delay Variation (UDP Traffic)

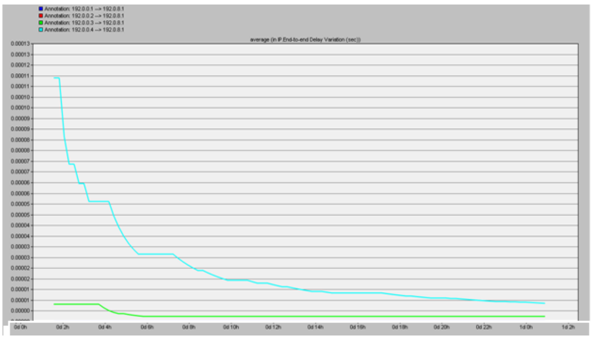

Figure 5.15 - IS-IS IPv4 Clients End-to-End Delay Variation (UDP Traffic)

5.4 IPv6 Traffic Metrics

This section show the results when the similar metrics were evaluated at the Dual-Stack 2 Server of the dual-stack network, in order to describe IS-IS and OSPF performance for IPv6 UDP traffic patterns.

5.4.1 Throughput

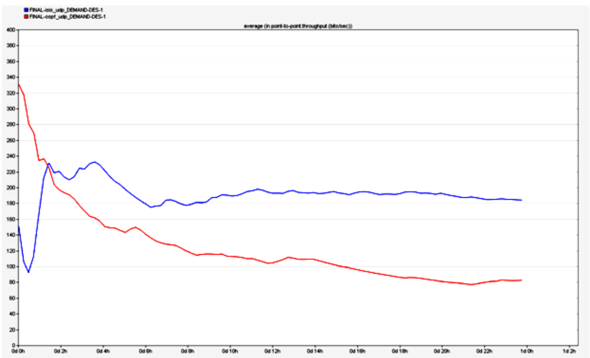

Figure 5.16 - IPv6 Throughput (UDP Traffic)

From the above shown results, it is concluded that IS-IS attains a 125% increased throughput in comparison of OSPF's respective value, having a value of 180 bps as compared to OSPF's 80 bps. As concluded in all previous throughput evaluations, IS-IS displays superiority over OSPF in terms of throughput.

5.4.2 End-to-End Delay

As far as it relates IPv6 UDP end-to-end delay, the average values obtained from the above diagrams equaled nearly 2 ms for IS-IS and OSPF. Like previous end-to-end delay calculations, both protocols perform similarly.

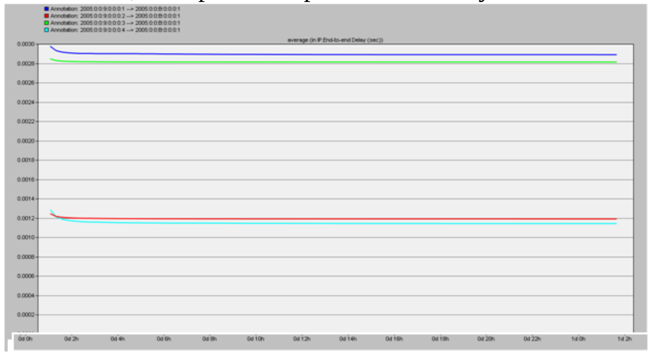

Figure 5.17 - OSPF IPv6 Clients End-to-End Delay (UDP Traffic)

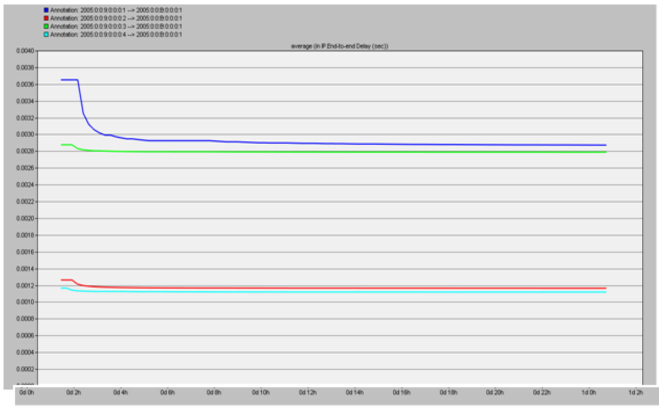

Figure 5.18 - IS-IS IPv6 Clients End-to-End Delay (UDP Traffic)

5.4.3 End-to-End Delay Variation (Jitter)

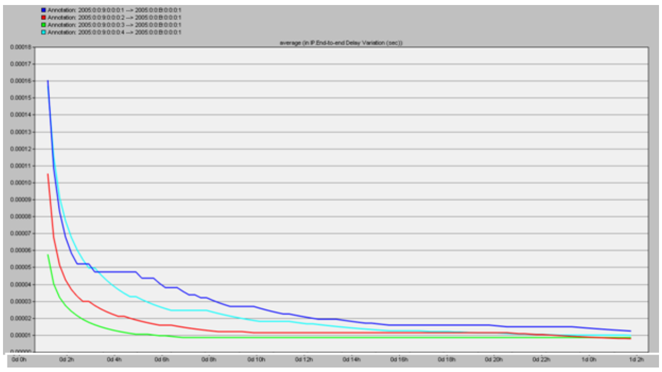

Figure 5.19 - OSPF IPv6 Clients End-to-End Delay Variation (UDP Traffic)

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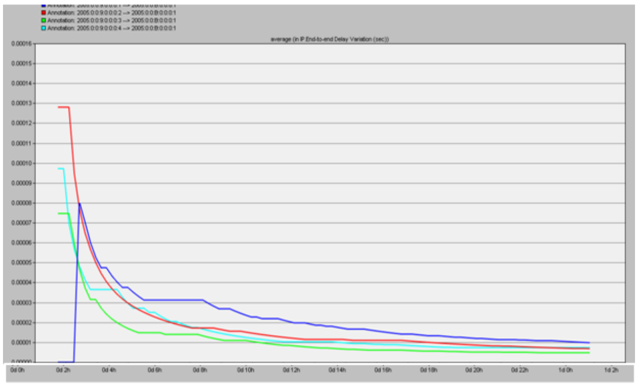

Figure 5.20 - IS-IS IPv6 Clients End-to-End Delay Variation (UDP Traffic)

CONCLUSION

Experimental analysis evidenced that IS-IS should be considered a more effective solution as compared to OSPF in the near future, as it establishes various performance advantages in comparison of the latter when configured in dual-stack business networks. New application demands require to be fulfilled by the IPv4 - IPv6 networks that will build the new networking world for a non-certain time space until the total prevalence of IPv6, and therefore, the efficiency of the configured routing protocol will be of high significance. In this model, the paper represented results which mean that IS-IS converges much quicker and attains much higher successful delivery of packets as compared to the competing link-state protocol OSPF. The chosen simulated network configuration size, and the fact that the experiment results established same contrasts and analogies for IPv4-only and IPv6-only clients, as well as for both UDP and TCP traffic, improves the idea that the dawn of the IPv6 era should bring reconsideration relating to the choice of IS-IS for business networks as a first selection. It is thought that the security and performance advantages that IS-IS provides particularly for the IPv4-IPv6 coexistence period outweigh the theoretical understanding complications, and should be elements combined in educational networking program for familiarizing potential new engineers.

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