Performance Evaluation of RIPng, EIGRPv6 and OSPFv3 for Real Time Applications

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ABSTRACT

In this modern Internet era and the transition to IPv6, routing protocols must adjust to assist this transformation. RIPng, EIGRPv6 and OSPFv3 are the dominant IPv6 IGRP (Interior Gateway Routing Protocols). Selecting the best routing protocol among the available is a critical task, which depends upon the network requirement and performance parameters of different real time applications. The primary motivation of this paper is to estimate the performance of these protocols in real time applications. The evaluation is based on a number of criteria including: network convergence duration, Http Page Response Time, DB Query Response Time, IPv6 traffic dropped, video packet delay variation and video packet end to end delay. After examining the simulation results, a conclusion will be extracted to reveal the findings of which protocol performs the best upon implementation within a IPv6 WAN. OPNET modeler simulator is used to evaluate the accomplishment of these protocols. To get the results, three scenarios are designed, one for each protocol.

Key words: RIPng, EIGRPv6, OSPFv3, routing protocols, OPNET, performance evaluation, IPv6, real time applications

تقييم اداء مجموعة من بروتوكولات التوجيه في تطبيقات الزمن الحقيقي

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الخلاصة

في عصر الإنترنت الحديث والانتقال من IPv4 نحو IPv6، توجب على بروتوكولات التوجيه التي تستخدم لإعادة توجيه البيانات ونقلها من المرسل الى المستلم عبر الشبكة التكيف والتطور لدعم هذا التحول. RIPng، EIGRPv6، ISIS وOSPFv3 هي البروتوكولات الاكثر شيوعاً واستخداما في الشبكات الداخلية. اختيار أفضل بروتوكول بين ما تقدم يعتبر مهمة حاسمة، والتي تعتمد على متطلبات وأداء الشبكة والتطبيقات المطلوبة منها. ان الهدف الرئيسي من هذا العمل المقدم هو تقييم أداء هذه البروتوكولات في ضوء مجموعة من التطبيقات العملية كالفيديو والصوت وقواعد البيانات وصفحات الويب. ويستند هذا التقييم على عدد من المعايير منها: مدة شبكة التقارب، زمن الاستجابة، كم البيانات المفقودة، وتباين وقت وصول بيانات الفيديو والصوت. سيتم دراسة اي من هذه البروتوكولات الثلاثة هو الافضل حسب كل معيار من المعايير المستخدمة لغرض المقارنة.

الكلمات المفتاحية: بروتوكولات التوجيه، تقييم الاداء، تطبيقات الزمن الحقيقي.

1. INTRODUCTION

Routing is choosing the best path from a source to a specific destination. It can be done dynamically using routing protocols that are stand on different routing algorithms. Routing protocols are broadly classifieds as Exterior Gateway Routing Protocols (EGRP) and Interior Gateway Routing Protocols (IGRP), **Odom, 2013.** BGP is an example of EGRPs. IGRP are classified as distance vector, link state and hybrid routing protocol. Most popular IGRPs are RIP, EIGRP, ISIS and OSPF. Elements that distinguish various routing protocols are convergence which means rapidity to adapt to network changes, their ability to choose the optimal route among different paths and the amount of routing traffic produced, **Sankar and Lancaster, 2010.** For the success of a network, routing protocols play a decisive role. Most of the routing protocols developed in IPv4 had been altered to be used for IPv6 addresses with its different header architecture. IPv6 routing protocols have some similarities in functions and configurations to their IPv4 equivalents, but since an IPv6 is longer than an IPv4, routing updates have to carry more information, **Kaur and Singh, 2014**. In this work, three IPv6 routing protocols, RIPng (distance vector routing protocol), EIGRP (hybrid routing protocol), OSPF (link state routing protocol) are analyzed on the basis of convergence time, packet drop, HTTP page response time, DB query response time, video packet end to end delay, video packet delay variation, jitter, voice packet end to end delay and voice packet delay variation. The scheme of this paper is as follows:

- Design the network topology
- Implement the routing protocols
- Setting up performance metrics
- Analysis of simulation results
- Comparison of results.

2. RELATED WORKS

In order to provide an overview of previous work, some researches presented by various authors are reviewed. **Hinds, et al., 2013,** compared two routing protocols; OSPF and EIGRP. The two protocols have been compared according to a number of criteria, including hardware resilience, routing metrics range, fast convergence when topology changes, throughput, scalability, lower routing overhead, difficulty in configuration and routing protocol security. The analysis showed that EIGRP protocol is better than OSPF. **Narula and Aggarwal, 2014,** evaluated the performance of RIP and OSPF for IPv6 using OPNET. Criteria to compare include packet delay variation, end to end delay, response time, jitter, page response time, object response time, traffic dropped for IPv6 Etc. They realized that the combined employment of OSPFv3 and RIPng performs better than RIPng and OSPFv3 when employed separately. **Whitfield and Zhu, 2015,** introduced each routing protocol security techniques and made a comparison of EIGRPv6 and OSPFv3. The principle conclusion was that EIGRPv6 exceeds OSPFv3 relating to start-up and re-convergence speed and is therefore the faster protocol. However, OSPFv3 is an attractive choice to use as a routing protocol since it combines a powerful security technique and runs in a hierarchical topology. **Sirika and Mahajine, 2016,** studied RIP, EIGRP and OSPF and compared their work in a number of applications including VoIP, Video conferencing based on convergence, end to end packet delay, packet delay variation and queuing delay which are considered as real-time applications. They found that even OSPF is complex to configure, it is considered a common protocol as it is an open standard with rapid convergence.

3. ROUTING PROTOCOLS OVERVIEW

3.1 RIPng

The Routing Information Protocol next generation (RIPng) is heavily built on IPv4 RIPv2. In fact, RIPng is the updated version RIPv2 with small changes desired to allow it to advertise IPv6 paths. Both RIPv2 and RIPng updates are sent at systematic intervals (30 seconds). A metric of 16 hop is still considered infinite. Since IPv6 addresses are longer than its IPv4 counterparts, the RIPng packet format did need change. Few changes have been done **Narula and Aggarwal, 2014:**

- RIPng uses UDP port 521while RIPv2 uses port number 520. The RIPng destination multicast address is FF02::9, while it is 224.0.0.9 in RIPv2.
- With every route entry in RIPv2 packet, there is a next hop field carried. While in RIPng, a particular entry is used to define a next-hop address.
- In RIPng, authentication is not a part of it. It is done by IPv6 IPsec in addition to encryption.
- In RIPng packets, no route tag information is carried.

3.2 OSPFv3

The Open Shortest Path First (OSPFv3) is considered a link state routing protocol which takes its routing decisions according to the links' states that connect source and destination nodes. A link-state protocol uses the Shortest Path First (SPF) algorithm. OSPFv3 is designed to work in IPv6 environment **Whitfield and Zhu, 2015.** OSPFv3 acts very much like OSPFv2 which had been designed to work in IPv4 environment. For example, both use link-state logic and both use the same metric. The biggest differences between OSPFv3 and the older OSPFv2 lay with internals and with configuration. OSPFv3 changes the structure of some OSPF LSAs (Link State Advertisements). OSPFv3 uses a more direct approach to configuration, enabling OSPFv3 on each interface using an interface subcommand, **Odom, 2013.**

3.3 EIGRPv6

The Enhanced Interior Gateway Routing Protocol (EIGRPv6) is considered a hybrid protocol because it has link state protocol properties, **Iqbal and Khan, 2015.** EIGRP runs by taking routing decisions according to a group of cost metrics associated with router interfaces, which are computed using the Diffusing Update Algorithm (DUAL) to determine the best route to a destination. This algorithm is considered faster than algorithms used by other routing protocols like the Distributed Bellman-Ford, while creating less CPU overhead than link state counterparts. Tor each link connected to the router, the metrics are bandwidth, load, reliability, delay and Maximum Transmission Unit (MTU), **Hinds, et al., 2013**. EIGRPv6 which is designed to operate in IPv6 environment behaves much like its EIGRPv4 IPv4 counterpart. Many similarities exist between EIGRPv6 and EIGRPv4 except for a few differences, **Odom, 2013:**

• EIGRPv6 announces IPv6 prefixes, whereas EIGRPv4 announces IPv4 subnets.

• EIGRPv6 routers may become neighbors if they have IPv6 addresses in different subnets, while in EIGRPv4, neighbors must be in the same IPv4 subnet.

• Unlike EIGRPv4, EIGRPv6 does not have an auto summary.

4. STATISTICS DEFINITIONS

1. DB Query response time: it is the time proceeded between sending a request and receiving the response.
2. HTTP Page response time: it is the time needed to restore the complete page with all its objects. In the proposed network, Heavy HTTP application is used by the users.
3. Traffic dropped: the packets are dropped when a router or switch is incapable to receive incoming packets at a specified time.
4. Network convergence duration: within the entire network, the duration of convergence cycles for the routing tables is kept.
5. Packet delay variation in video conferencing: for video packets, it means difference among end to end delays. This type of delay is evaluated from the time it is created to the time it is received.
6. Packet End-to-End delay in video conferencing: it is measured when the packets transmitted from source to destination. When packets take long time to reach destination, it causes delays in the overall process and it has a serious impact on the network performance, **Kaur and Singh, 2014.**
7. Packet delay variation in voice: for voice packets, it is the difference among end to end delays.
8. Packet End-to-End delay in voice: The complete voice packet delay equals to network delay + encoding delay + decoding delay + compression delay + decompression delay + dejitter buffer delay.
9. Jitter: in voice, jitter is the difference in delay times of received packets. This factor should be as small as possible, **Narula and Aggarwal, 2014.**

5. NETWORK TOPOLOGY

The interrelation of network devices is characterized by network topology. **Sethi and Hnatyshin, 2013**, distinguishes between physical and logical network topologies. Physical topology is the actual model of the nodes and the links connecting them, taking considerations like the physical locations of particular nodes and the real areas traversed by the communication links. Otherwise, logical topology affords a conceptual interpretation of the communication links between the nodes regardless for the actual physical positions and distances between nodes in the network.

In this paper, OPNET Modeler academic edition 17.5 Simulator has been used. OPNET is a simulation tool that is used in numerous studies. In a production network, such a topology cannot be created; only simulation is possible because it provides mathematical and graphical model of result and these results can be understood readily. The network topology presented in this paper is composed of the following network devices and configuration utilities:

1. Nine Ethernet IP Router
2. Seven Ethernet Switch
3. Seven 100 BaseT switched LAN
4. Four Ethernet Server
5. PPP DS3 Duplex Link
6. Ethernet 100 Base T Duplex Link
7. Application configuration
8. Profile configuration
9. Failure recovery

The presented network consists of nine routers distributed among nine different districts in Baghdad, the Iraqi capital as shown in **Fig. 1**. Routers are connected together using DS3 Duplex Link (data rate 44.736 Mbps) link model with point to point (PPP) protocol. There are seven Ethernet LANs, each LAN is connected to an Ethernet switch using Ethernet 100 Base T Duplex Link. Each switch is connected to a corresponding router using the same link type (Ethernet 100 Base T). There are four servers: video, voice, HTTP and database server. These servers are connected to a switch located in a central site. There are one application definition and one profile definition. The profile definition is used to create user profiles in the different network nodes to generate application layer traffic. Four profiles are prepared: video, voice, database and HTTP. Table (1) describes each application while table (2) specifies the location and status of the planned failure.

6. SIMULATION RESULTS

The simulation includes three scenarios. Simulation time is 900 seconds for RIPng, EIGRPv6 and OSPFv3 scenarios.

1. DB Query response time:
   In the performance metric of DB Query response time, OSPFv3 is better than RIPng and EIGRPv6 as shown in **Fig. 2.**
2. HTTP Page response time:
   Relating to Http Page response time, EIGRPv6 is better than RIPng and OSPFv3 as shown in **Fig. 3.**
3. Traffic dropped: in traffic drop performance metric, EIGRP is better than OSPFv3 and RIPng as shown in **Fig. 4.**
4. Network convergence duration: in network convergence duration, EIGRPv6 is the best among OSPFv3 and RIPng as shown in **Fig. 5.**
5. Packet delay variation in video conferencing: in packet delay variation performance metric, EIGRPv6 is better than OSPFv3 and RIPng as shown in **Fig. 6.**
6. Packet End-to-End delay in video conferencing: EIGRPv6 is better than OSPFv3 and RIPng as shown in **Fig. 7.**
7. Jitter: in voice jitter, EIGRPv6 is better than OSPFv3 and RIPng as shown in **Fig. 8.**
8. Packet delay variation in voice: in packet delay variation performance metric, EIGRPv6 is better than OSPFv3 and RIPng as shown in **Fig. 9.**

9. Packet End-to-End delay in voice: EIGRPv6 is better than OSPFv3 and RIPng as shown in **Fig. 10.**

7. CONCLUSIONS

Selecting the best protocol among available is found to be a critical task, therefore, this work focuses on evaluating the performance of IPv6 based protocols (RIPng, EIGRPv6 and OSPFv3) in various real time applications like database, video, voice and HTTP. The observations have been done using the same topology with different protocols. Performance has been calculated according to a number of metrics to find the effects of these routing protocols. EIGRPv6 still outperformed OSPFv3 and RIPng in terms of convergence and adjusting to failures, therefore it is the fastest protocol. In DB query response time, this is for the first time that EIGRPv6 performance was the poorest as compared to RIPng and OSPFv3. While in HTTP page response time, EIGRPv6 is better than RIPng and OSPFv3. In video and voice packet delay variation, packet end-to-end delay and voice jitter, EIGRPv6 is the best. As a next research step, work can be done on the security analysis of the presented protocols.

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Table 1. Application Description

Voice	IP Telephony and Silence Suppressed
Video	High resolution Video
Database	High Load
HTTP	Searching

Table 2. Node_11 and Node_9 link failure and recovery

Node_11 to Node_9 Failure and Recovery timing	
Time	Status
150	Failure
250	recovery

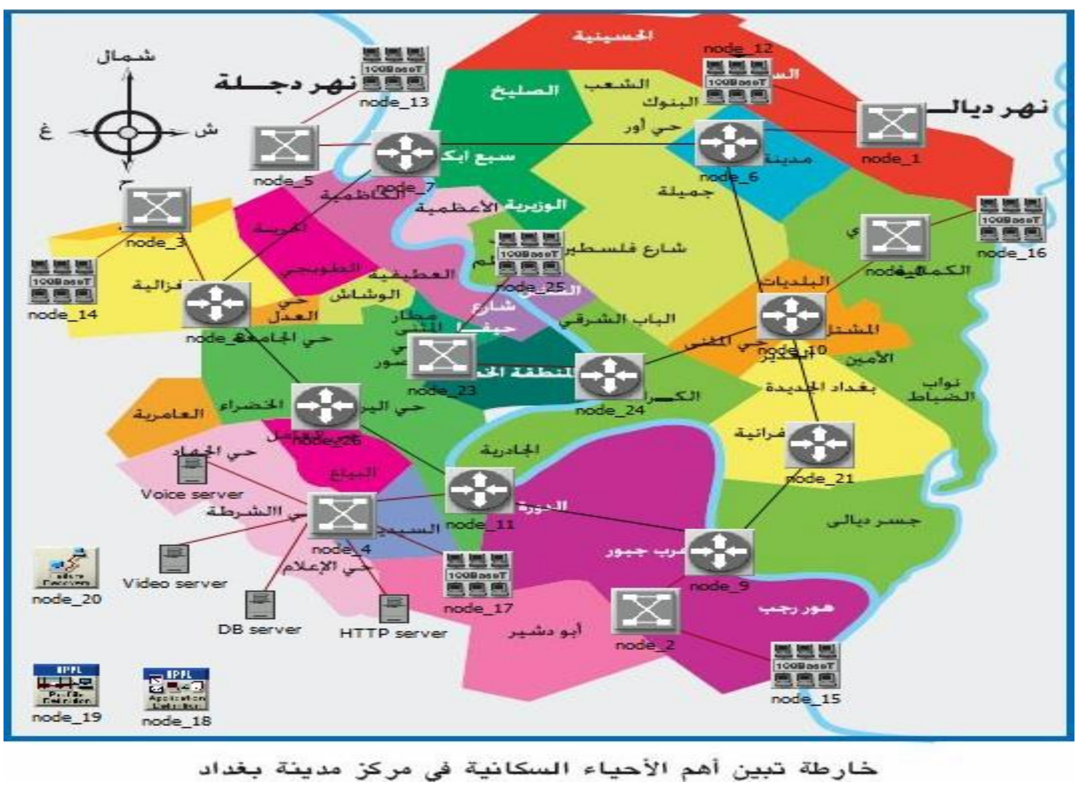

Figure 1. Network model.

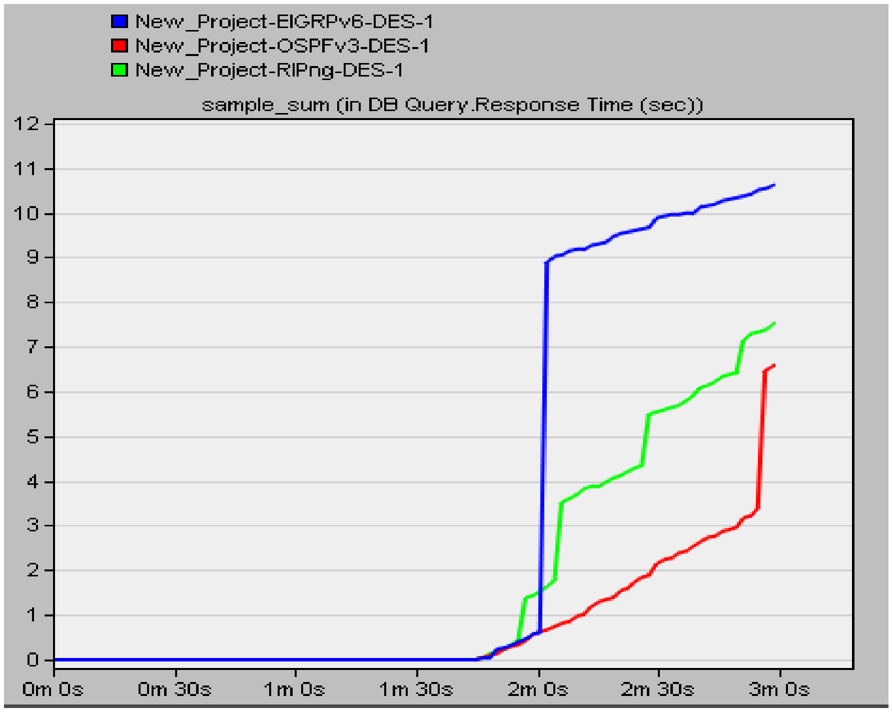

Figure 2. DB query response time.

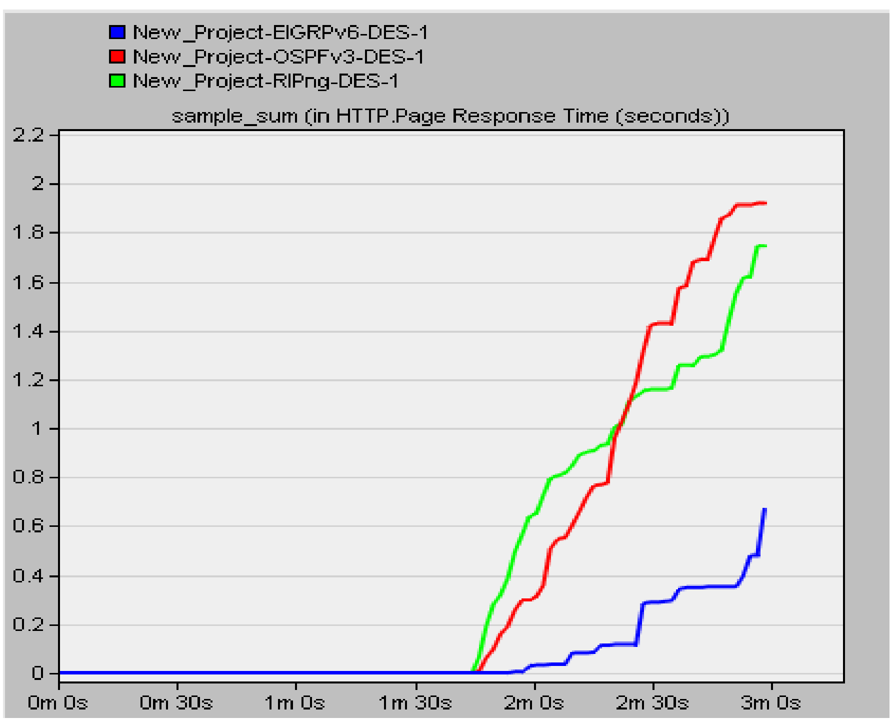

Figure 3. HTTP page response time.

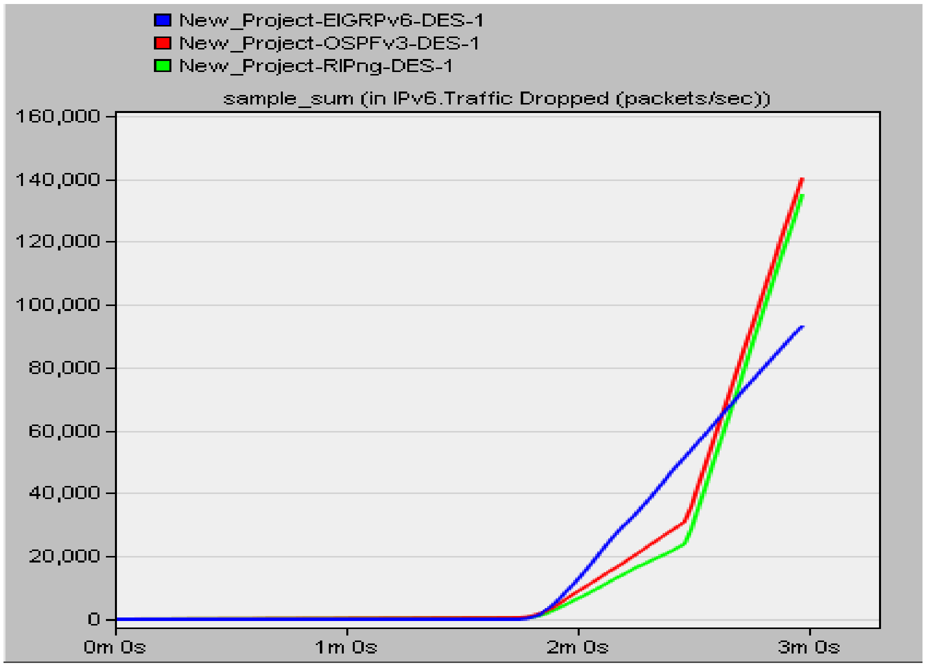

Figure 4. Traffic dropped.

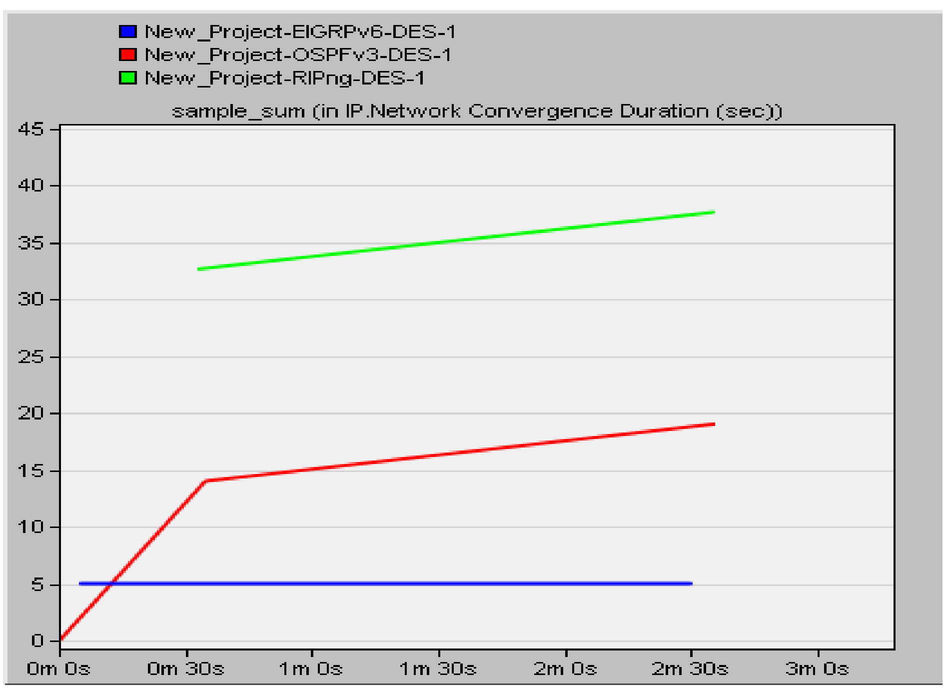

Figure 5. Network convergence duration.

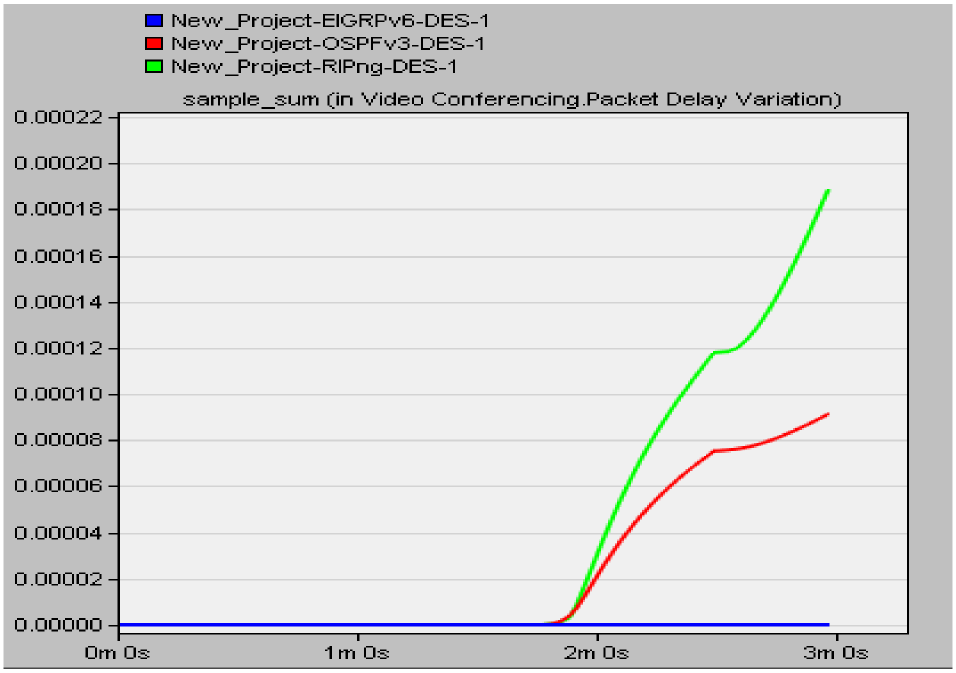

Figure 6. Packet delay variation in video conferencing.

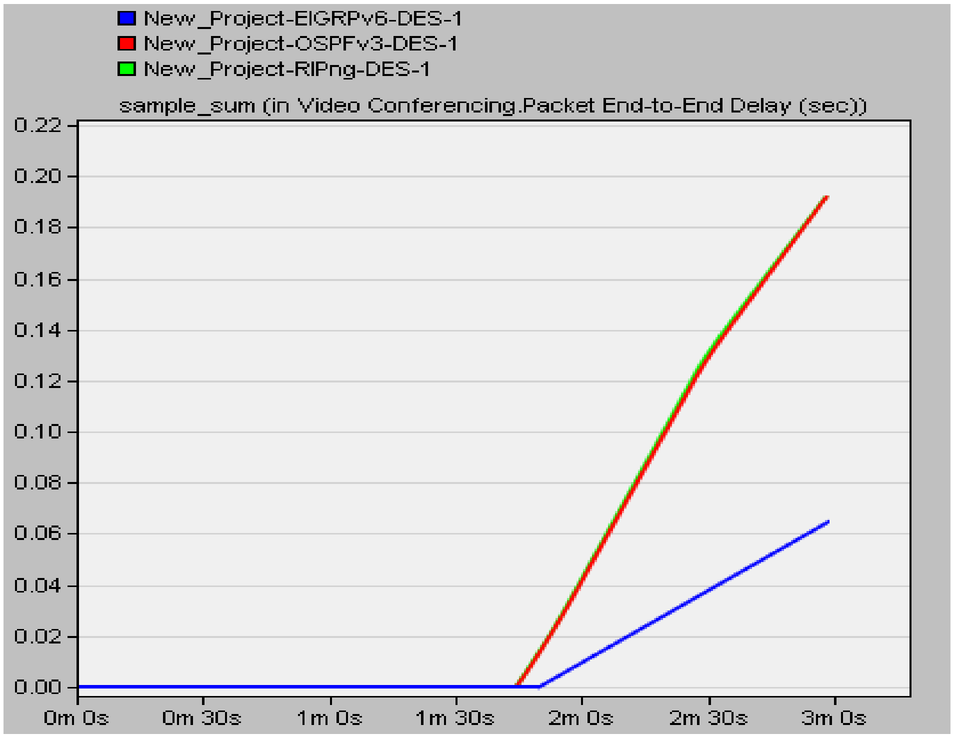

Figure 7. Packet end-to-end delay in video conferencing.

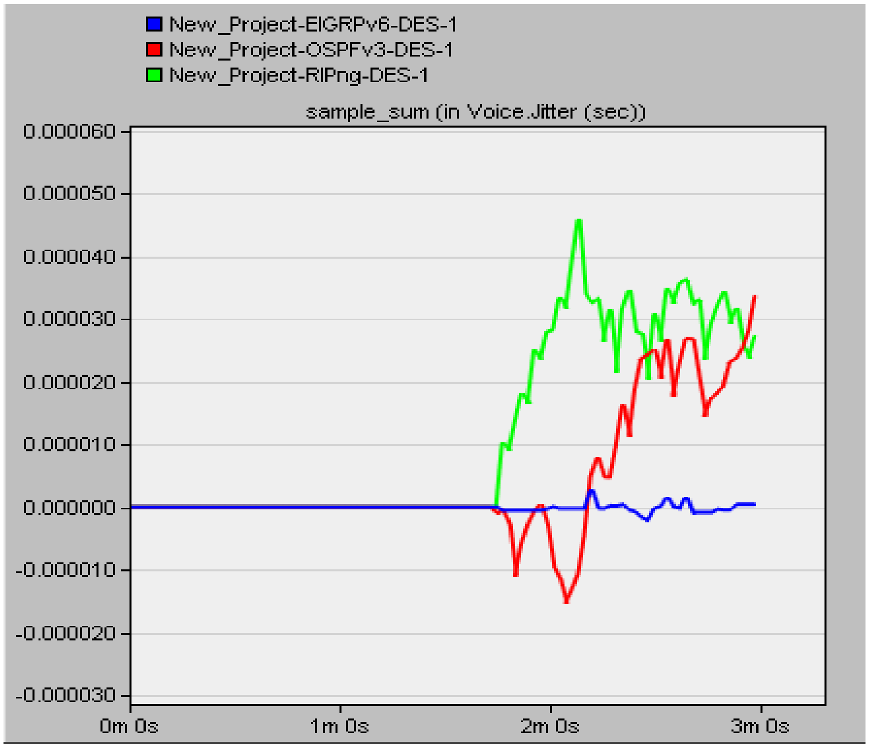

Figure 8. Voice jitter.

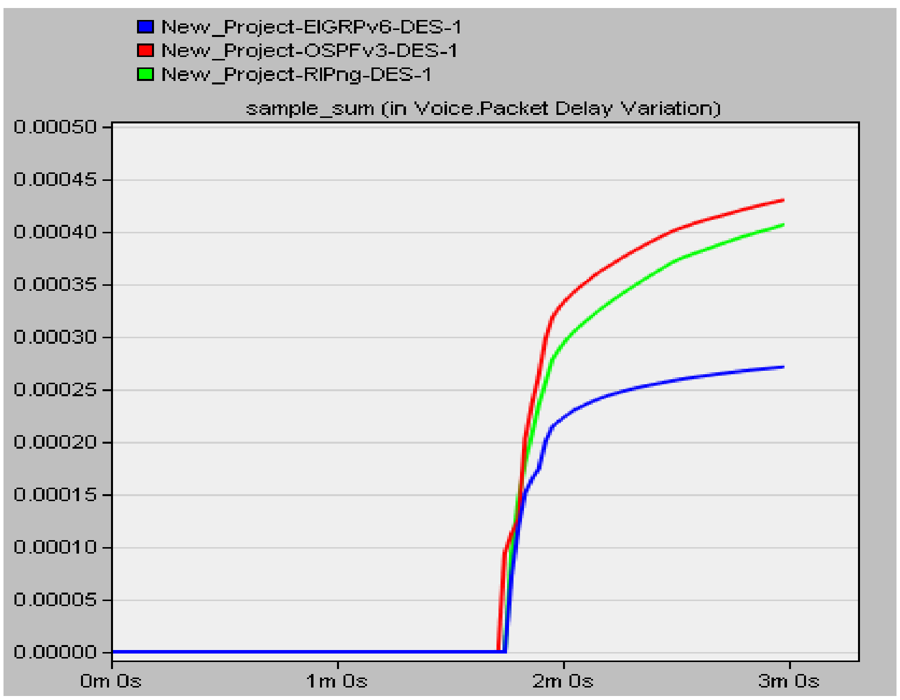

Figure 9. Packet delay variation in voice.

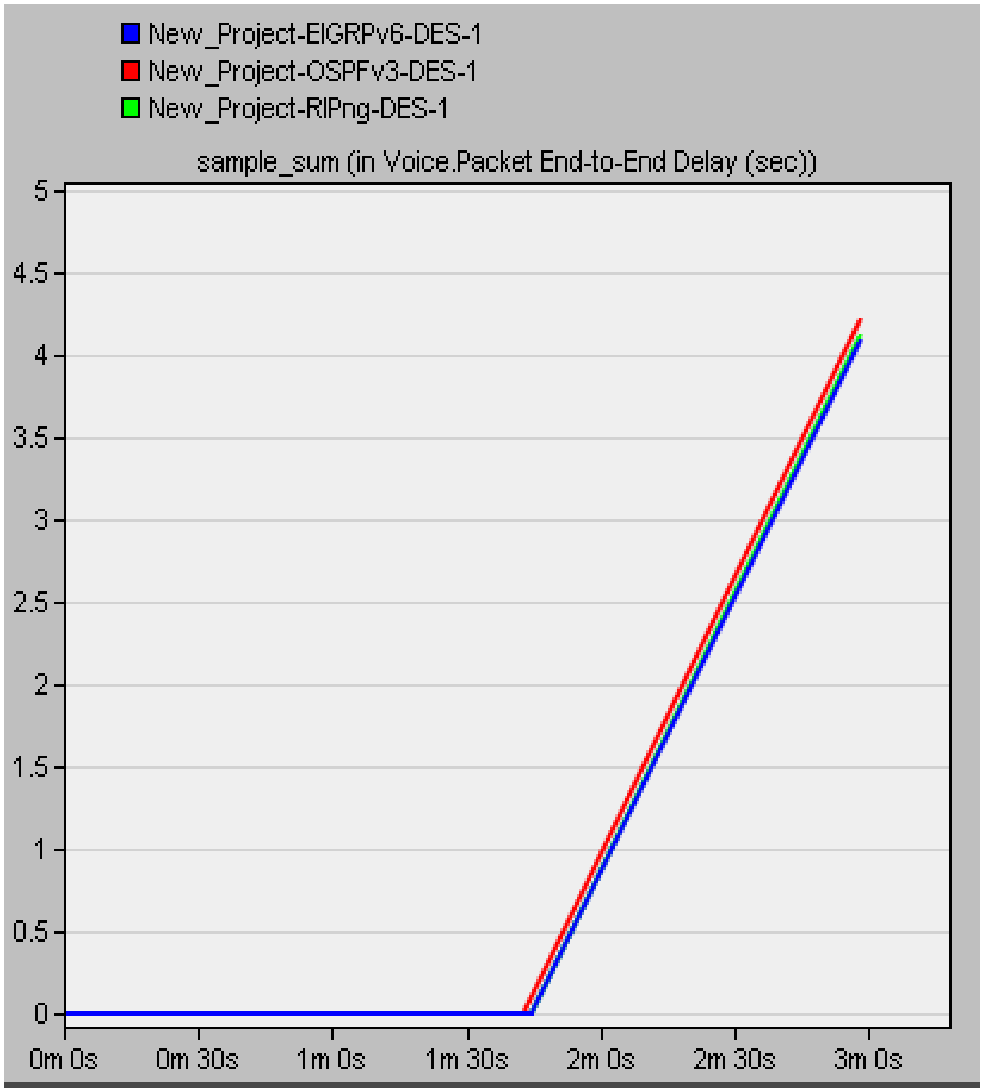

Figure 10. Packet end-to-end delay in voice.