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Modeling and simulation of Campus Area Network (CAN) for The University of Zawia using OPNET

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ABSTRACT:

This research proposes the design and performance evaluation of a Campus Area Network (CAN) for the University of Zawia using OPNET Modeler Academic 14.5. The study focuses on the northern campus, which consists of seven colleges and administrative offices, aiming to enhance academic and administrative communication through efficient network design. The proposed network supports multiple services, including FTP, printing, VoIP, email, database applications, and HTTP under heavy traffic loads. The network performance was evaluated based on key Quality of Service (QoS) metrics, such as delay, throughput, traffic sent and received, response time, jitter, end-to-end packet delay, and queuing delay. The results indicate that the proposed CAN demonstrates satisfactory performance under heavy loads, with efficient handling of applications like HTTP, email, and printing. However, applications such as VoIP and FTP require further optimization to reduce delays and improve throughput.

The study also highlights the scalability of the network, suggesting that the northern campus can be connected to the southern campus without significant performance degradation. Recommendations for future research include optimizing VoIP, FTP and database performance. With potential for future expansion and improvement through advanced technologies and optimized network management.

Keywords: Campus Area Network, Quality of Service, Network Performance, Scalability, Traffic Management.

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نمذجة ومحاكاة شبكة جامعية (CAN) لجامعة الزاوية باستخدام OPNET

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قسم هندسة البرمجيات، كلية تقنية المعلومات، جامعة الزاوية، الزاوية، ليبيا

الملخـص:

يقترح هذا البحث تصميم وتقييم أداء شبكة منطقة الحرم الجامعي (CAN) لجامعة الزاوية باستخدام برنامج OPNET Modeler Academic الإصدار 14.5. تُركز الدراسة على الحرم الجامعي الشمالي، الذي يتكون من سبع كليات بالإضافة إلى المكاتب الإدارية، بهدف تعزيز التواصل الأكاديمي والإداري من خلال تصميم شبكة فعّالة. تدعم الشبكة المقترحة خدمات متعددة، بما في ذلك بروتوكول نقل الملفات (FTP)، والطباعة، وبروتوكول الصوت عبر الإنترنت (VoIP)، والبريد الإلكتروني، وتطبيقات قواعد البيانات، وبروتوكول (HTTP) في ظل أحمال مرورية كثيفة. تم تقييم أداء الشبكة بناءً على مقاييس جودة الخدمة (QoS) الرئيسية، مثل التأخير، والإنتاجية، وحركة المرور المرسلة والمستلمة، وزمن الاستجابة، والتذبذب، وتأخير الحزمة من طرف إلى طرف، وتأخير الانتظار. تشير النتائج إلى أن شبكة منطقة الحرم الجامعي المقترحة تُظهر أداءً مُرضيًا في ظل الأحمال الثقيلة، مع معالجة فعّالة لتطبيقات مثل HTTP والبريد الإلكتروني والطباعة. ومع ذلك، تتطلب تطبيقات مثل بروتوكول الصوت عبر الإنترنت (VoIP) وبروتوكول (FTP) مزيدًا من التحسين لتقليل التأخير وتحسين الإنتاجية. تُسلّط الدراسة الضوء أيضًا على قابلية توسع الشبكة، مما يُشير إلى إمكانية ربط الحرم الجامعي الشمالي بالحرم الجامعي الجنوبي دون انخفاض كبير في الأداء. تشمل توصيات البحوث المستقبلية تحسين أداء VoIP وقواعد البيانات وبروتوكول (FTP). مع إمكانية التوسع والتحسين مستقبلًا من خلال التقنيات المتقدمة وإدارة الشبكة المُحسّنة.

الكلمات المفتاحية: شبكة جامعية، جودة الخدمة، اختناق الشبكة، التأخير، وقت الاستجابة.

1.INTRODUCTION

With the increasing need for sharing information within an organization in the form of messages, sharing files, resources and so forth. Whether the organization is located in a small area like as in one building or more over a large area it needs for networking the

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computers .A Campus area network is an essential part of university system. A Campus network has several uses such as teaching, learning, result publishing, resource sharing, file sharing, communication, etc. To design a network for University of Zawia, which connects various departments and buildings to each other,'s, it puts forward communication among them. One of the purpose of networking is to reduce isolated users. The systems should be capable of communicating with others and should provide the desired information. A simulation tool offers a way to predict the impact on the network of a hardware upgrade, a change in topology. This research aims to design and analyze the performance efficiency of the proposed campus network by measuring the Quality of Service (QoS) across several factors, which are delay, throughput, sent and received traffic, response time, jitter, end-to-end packet delay, and queues. a CAN network is designed using OPNET is multitasking network simulation software that can be used to perform and analyze various network activities such as the implementation of different topologies, provides pre-built models of protocols and devices, selection of optimum path based on various routers, analysis of different network configurations [1].This Campus Area Network Scenario is about designing a topology of a network that is a Local Area Network contains multiple subnets, where each college is represented as a subnet, and each subnet supports 30 computers, where each user can use all the services provided by the network to improve functional and academic performance and facilitate work for network users. This network connects the university main headquarters to the colleges of the northern campus of the university as shown in Figure (1).

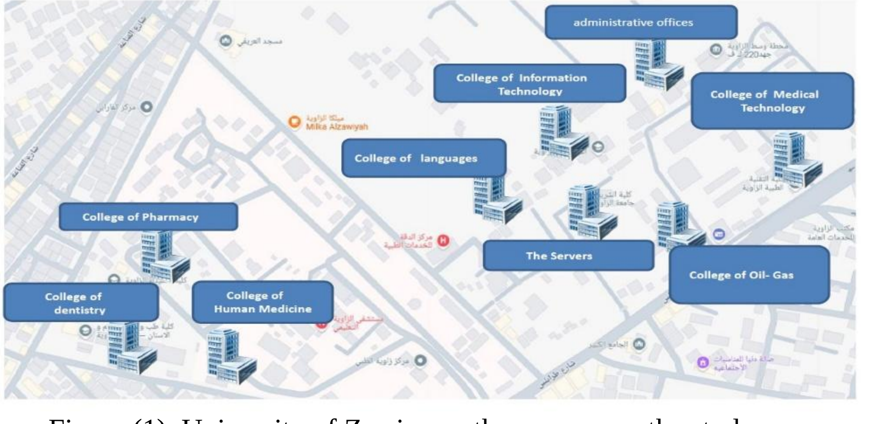

Figure (1). University of Zawia- northern campus -the study area

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The colleges are as follows (College of Oil, Gas and Natural Resources, College of Information Technology, College of Medical Technology, College of Human Medicine, College of Dentistry, College of Pharmacy, College of Languages[2]. This network provides many applications such as file transfer via FTP protocol, printing, VoIP protocol, email, databases and HTTP protocol across multiple servers.

2.LITERATURE REVIEW

University networks are a vital essential infrastructures infrastructure that supports academic, research, and administrative activities. With their increasing use and reliance, significant challenges arise emerge regarding performance, security, and reliability. Therefore, simulating and studying the performance of these networks is crucial to enhancing their efficiency and identifying potential vulnerabilities before making any changes to their physical infrastructure.

In this section, we review previous studies and current work related to the study, analysis, and simulation of university networks, focusing on the methodologies and tools used in network performance analysis. We also examine common challenges, including network congestion and measuring the of service (QoS) metrics . Through a critical analysis of this work, we aim to identify research gaps and opportunities for improving the modeling and simulation of university networks more efficiently.

This comprehensive review will establish a solid theoretical foundation for existing research and contribute to the development of an integrated framework for debugging and simulating university networks in a way that accurately reflects real-world conditions while providing generalize results.

• This study examined the competition between institutional repositories and academic social networks, such as ResearchGate. It found that researchers in academic institutions tend to rely more on these networks due to their ease of access and dynamic interaction, making it difficult for institutional repositories to collect the required content in sufficient quantities. The primary challenge is making repository interfaces more attractive to enhance interaction and improve social networking features. The study also revealed a

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research gap in the limited efforts made to integrate social networks into institutional repositories, with the aim of increasing user engagement and motivating their use[3].

• The researcher used the Agile methodology to design an academic system implemented at the Federal Polytechnic, Kura Namoda, with the aim of improving the learning experience for students and enhancing the delivery of educational content to lecturers. The results showed that the system worked efficiently, but there is a lack of research examining its impact on long-term academic achievement. Furthermore, studies have not adequately addressed the potential for scaling these systems across multiple universities within a broader academic environment, indicating the need for further research in this area[4].

• An English language-teaching platform was designed using VBScript and SQL Server. The platform provides a self-paced learning environment that enhances learner autonomy by presenting content in a simplified manner by the instructor. However, the study indicated a gap in learner interaction and language proficiency, reflecting a lack of research on the effectiveness of language teaching systems within university institutions. The study also did not provide any analysis of the efficiency of the protocols used in the university network for data transfer[5] .

• Regarding the exchange of open educational resources within open universities, one study discussed the challenges hindering the sharing of these resources, such as intellectual property rights, resource management, and the lack of clear standards. The study recommended the need to strengthen efforts to ensure broader sharing of open educational resources. Among the notable research gaps is the lack of studies aimed at establishing comprehensive standards for the exchange of these resources between academic institutions, which is essential to foster collaboration and ensure the availability of educational materials for all[6].

The reviewed studies collectively highlight the growing emphasis on improving user experience, resource sharing, and technical infrastructure in academic settings. Key themes include the integration of social features in institutional repositories, the long-term effects of educational platforms, and the development of standardized protocols for OER sharing and network scalability. However, several gaps remain unaddressed:

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- Incorporation of Social Features: There is a gap in research concerning the implementation of social network features to institutional repositories, which would facilitate user interaction.
- Long-term Impact of Educational Platforms: Research is lacking on the enduring impact of academic network systems on student engagement and institutional productivity.
- Standardization of OER Sharing: There is a need for research on the development of comprehensive guidelines and procedures for sharing OERs among institutions.
- Scalability and Security of Academic Networks: There is a need for more study on the scalability and security of academic networks for large environment.

3. RESEARCH METHODOLOGY

This research aims to design and evaluate the performance of the Campus Area Network (CAN) of University of Zawia using the OPNET Modeler Academic 14.5 tool as showing in Figure (2)..

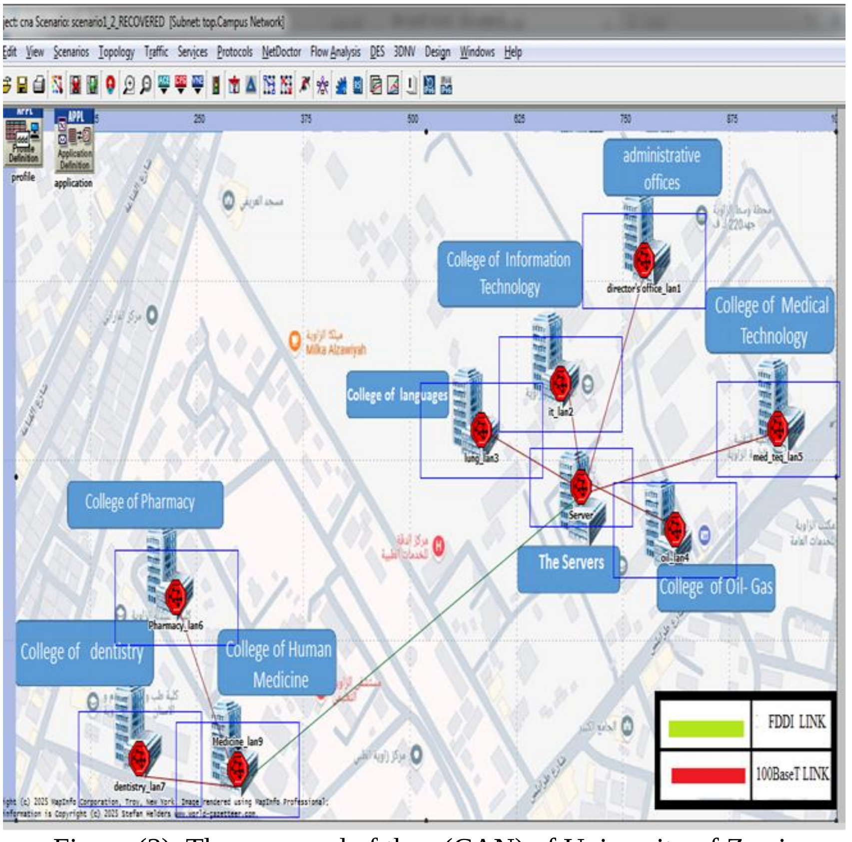

Figure (2). The proposed of the (CAN) of University of Zawia.

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The methodology is structured to ensure a comprehensive analysis of network performance under high traffic loads, focusing on Quality of Service (QoS) metrics such as delay, throughput, and response time

Network Design:

The North Campus of University of Zawia was selected for this study, consisting of seven colleges and administrative offices. Figure (3) showing A hierarchical network designed, with each college represented as a subnet. Each subnet consists of 30 computers connected via a 100BaseT LAN and an Ethernet switch. Specialized switches supporting IEEE 802.1D, IEEE 802.3, and FDDI protocols were used to connect remote colleges, ensuring seamless connectivity across the campus.

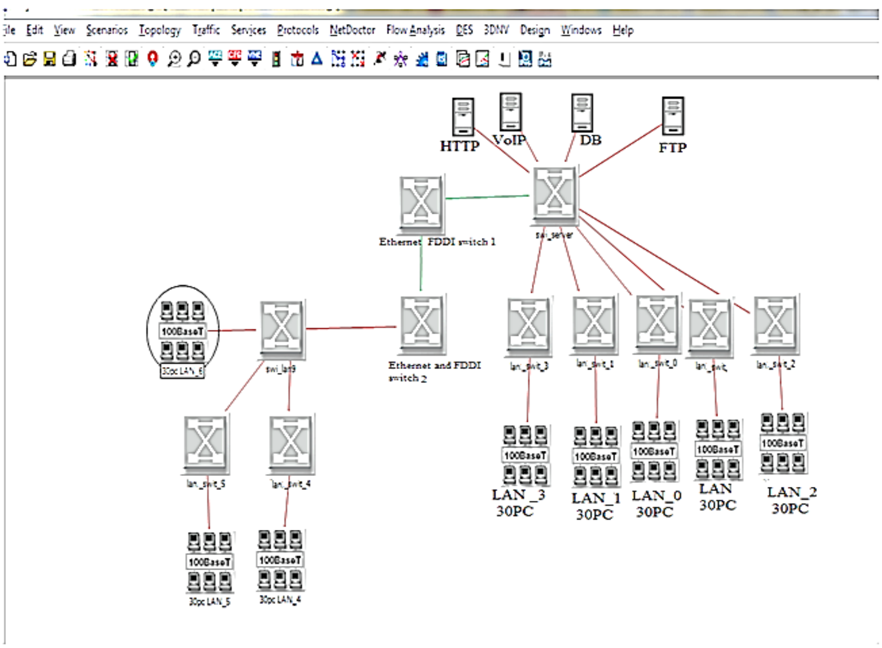

Figure (3). The Hierarchical design of the proposed network

Service Configuration in heavy mode:

- File Transfer Protocol (FTP): Configured for file sharing and transfer between colleges.
- Print Services: Configured to simulate printing across the campus network.

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- Voice Over Internet Protocol (VoIP): Implemented for voice communications, prioritizing Quality of Service (QoS) to reduce latency.
- Email Services: Configured to simulate email traffic using standard protocols.
- Database Applications: Deployed to simulate data storage and retrieval operations.
- HTTP: Enabled to simulate high web traffic, such as accessing online resources.

Simulation Setup and Implementation

The simulation was implemented using OPNET Modeler Academic 14.5[7], where Each subnet was assigned a unique IP address range to ensure seamless connectivity between colleges with the following performance metrics (end-to-end delay, queuing delay, Traffic sent and received in packets /second , Response time for FTP, email, and database applications ,Jitter and packet delay variance for VoIP).
OPNET Modeler Academic 14.5 was selected to simulate the CAN network for the following reasons [8]:

- OPNET provides a wide range of pre-built models for protocols, devices, and applications, making it suitable for simulating complex campus networks.
- Supports heterogeneous networks, allowing the integration of different technologies..
- OPNET provides built-in tools for visualizing and analyzing network performance, including customizable graphs and statistical reports.
- OPNET Modeler Academic 14.5 is widely used in academic research, providing a cost-effective solution for educational institutions.

4. PERFORMANCE ANALYSIS AND RESULTS

This section describes the analysis of the simulated CAN network model, which was simulated using OPNET Modeler Academic 14.5.After calculating the DES (Discrete Event Simulation) ,The DES engine in OPNET enables accurate modelling of network behavior by processing every event in the system[9] . DES metrics and determining the highest value for each statistic, the network performance was evaluated, determining its operational capacity and the extent to which the network can be expanded to facilitate

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administrative and academic work at the university. The results were as follows:

- **Received and Sent Traffic (packets /Second)**

Figure (4): shows the traffic received (Traffic Received) in packets /second, and Figure (5) shows the traffic sent (Traffic Sent) in packets /second. The results show that some applications, such as VoIP and databases (DB), have high traffic rates, while other applications, such as HTTP and printing, have low traffic rates.

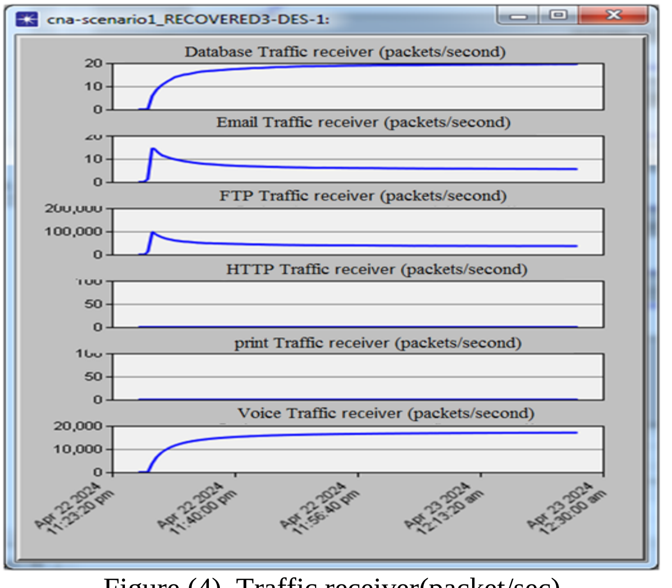

Figure (4). Traffic receiver(packet/sec)

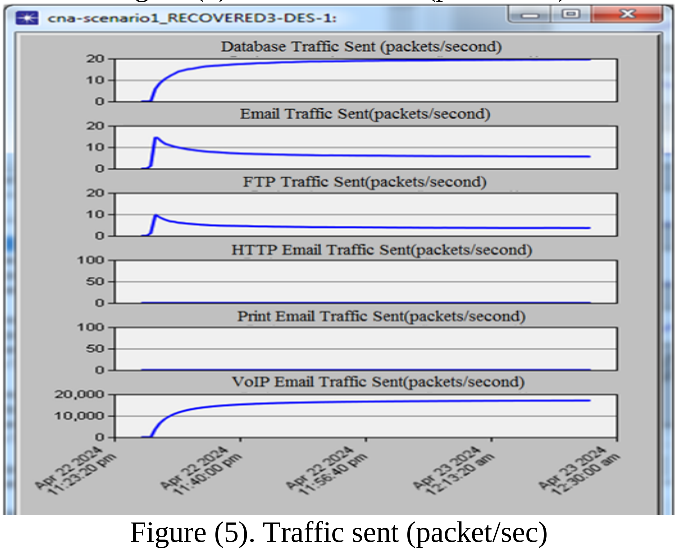

Figure (5). Traffic sent (packet/sec)

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- **Response Time for FTP and Email**

Figure (6) Figure (7) demonstrates the average response time for both FTP and email (upload - download) , where the result shows that the FTP response time rate is ten times higher than the email response time rate while Figure (8) shows the database entry response time about 3.9ms.

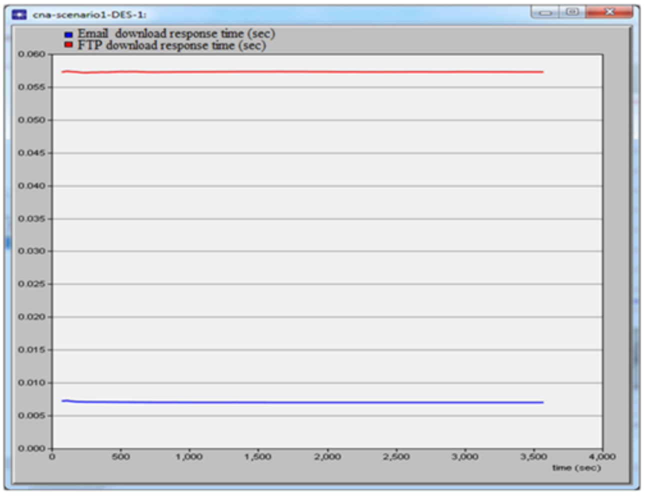
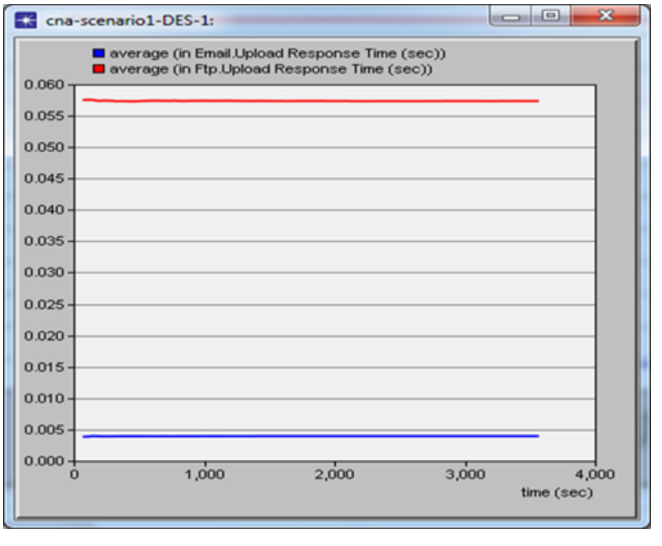


Figure (6). FTP - email download response time.



Figure(7) FTP - email upload response time

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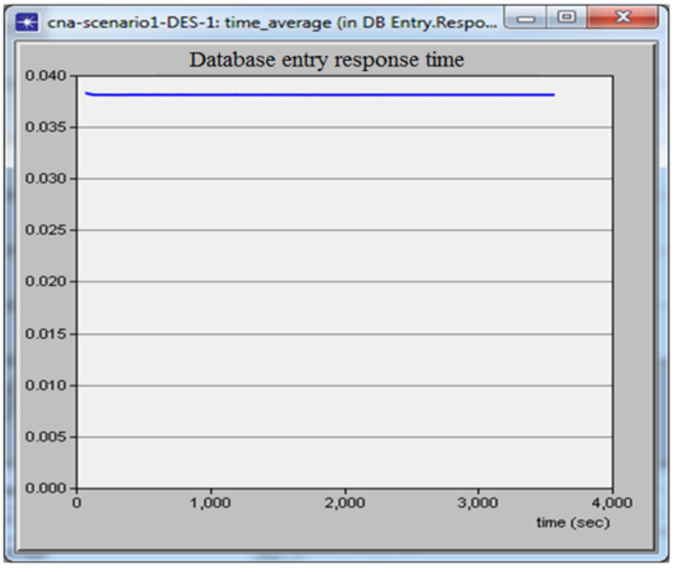

Figure (8). Database entry response time

. VoIP Performance

Figure(9) demonstrates the VoIP performance metrics evaluated where the highest value for (EtoE) End-to-end packet delay was 6ms and Jitter was 0.2 μs, while packet delay Variation was 0.013 μs .

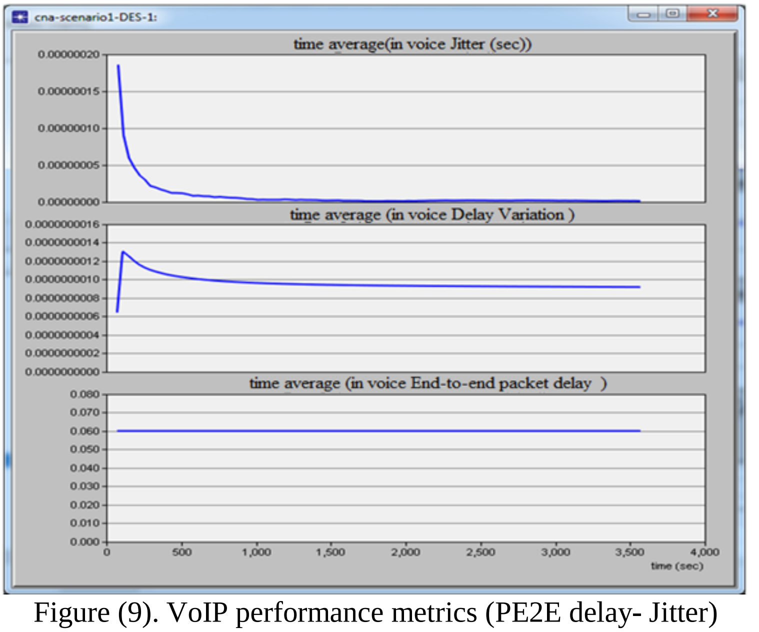

Figure (9). VoIP performance metrics (PE2E delay- Jitter)

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- **Point-to-Point Queuing Delay**

Figure (10) demonstrates the point-to-point queuing delay performance measure of all servers with all implemented applications described with VoIP server reported the best point-to-point queuing delay which is around 1µs seconds While the database server recorded the Worst values that is which around 79µs.

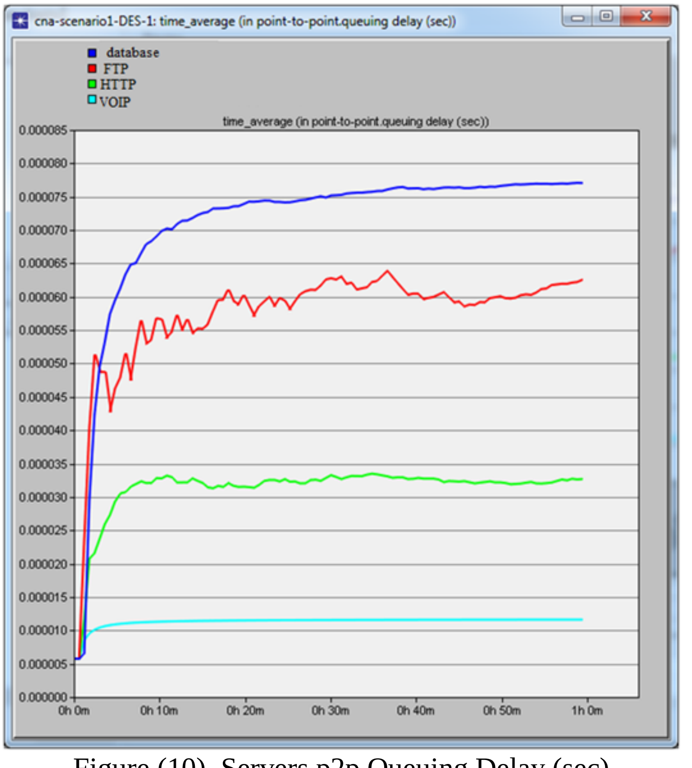

Figure (10). Servers p2p Queuing Delay (sec)

5. CONCLUSION

The impact of different network configurations on its performance was analyzed using the OPNET network simulator. It was found that the CAN network performs well under heavy network loads. The load balancing mechanism improves performance by reducing the load and distributing it evenly across multiple servers, thus reducing server response time. The proposed Campus Network (CAN) for the University of Zawia demonstrated average performance under high traffic loads, with college network applications such as HTTP, email, printing, VoIP, and databases performing effectively. Most applications performed well overall in terms of quality of service

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levels, while in other cases, FTP and VoIP protocols faced challenges that required improvements in response and latency.
The current network architecture is scalable, allowing the North and South campuses of the University of Zawia to be connected without significantly compromising overall performance.

6. FUTURE WORK

In future work, it should consider implementing techniques to improve the performance of the campus network, particularly in improving the following points:

- Improve database server performance to reduce latency and increase data throughput. • Improve traffic management policies to achieve a better balance between server load and the number of connections.
- Improve VoIP application performance to ensure high-quality voice and video communications.
- Evaluate the impact of new applications on network performance before deployment.
- Use technologies such as MPLS (Multiprotocol Label Switching) to improve packet routing and reduce latency.

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