ANALYSIS OF VoIP SERVICE THROUGHPUT PERFORMANCE ON 4G LTE NETWORKS USING NETWORK SIMULATOR 3 (NS-3)

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Abstract
This study evaluated the VoIP service throughput performance on a 4G LTE network using Network Simulator 3 (NS-3) with variations in the number of users. The simulation was conducted using a single eNodeB with user variations of 5, 10, 15, and 20 UEs. Traffic was generated using the UDP protocol with a packet size of 160 bytes and a send interval of 20 ms over 60 seconds. Measurements were done using NS-3, and results were displayed in the Flow Monitor on an Ubuntu terminal by observing the amount of data and packets successfully received as well as the total throughput in each scenario. The simulation results showed that the total throughput obtained for each user variation was 752.29 Kbps, 1,504.51 Kbps, 2,256.67 Kbps, and 3,008.83 Kbps. This increasing pattern indicates an almost linear relationship between the number of users and the aggregate throughput. Meanwhile, the average throughput, calculated by dividing the total throughput by the number of users, was around 150.44–150.46 Kbps. This research shows the characteristics of throughput in the traffic configurations and topologies tested. The results can serve as a basis for further testing with different traffic loads and other Quality of Service (QoS) parameters.

Keywords: *4g lte, voip, ns-3, throughput, number of users, flow monitor*

Introduction

The growth of digital communication services has led to an increasing need for reliable cellular networks. 4G Long Term Evolution (4G LTE) technology still plays an important role in supporting various communication activities, including voice services and data exchange. However, network performance isn't always the same, as it's affected by network conditions and the user's environment. Research by (Azizah, 2022) shows that 4G LTE network performance can be evaluated through Quality of Service (QoS) parameters. Studies by (Widyasmoro, 2023) and (Rochman et al., 2023) also highlight the importance of measuring cellular network performance to understand differences in service quality under various conditions.

One of the services that uses Internet Protocol (IP)-based networks is Voice over Internet Protocol (VoIP). This service allows voice communication to be carried out over a data network, but it requires regular packet delivery to ensure conversations go smoothly. Disruptions such as delays and packet loss can affect the quality of communication received by users. (Ramadhan, Alif Akbar, Andi Putra, Adetya, &

Murdiya, 2025) evaluated VoIP performance on 4G and 5G networks using NS-3. The research focuses on comparing VoIP performance between 4G and 5G under various conditions. Meanwhile, (Yuliani Putri, Anhar, Saputra, Caniago, & Harianja, 2024) analyzed VoIP service quality using several QoS parameters. The research focuses on evaluating the QoS of VoIP applications on 5G networks based on measurements in specific environments. Therefore, there still needs to be an analysis that specifically looks at changes in the total throughput of VoIP services on 4G LTE networks when the number of users varies in the same simulation setup. This focus allows the relationship between the increase in users and total throughput to be observed more directly. (Adibasyah, 2024) also highlighted the importance of QoS evaluation in implementing VoIP communication systems.

One of the parameters used to measure network performance is throughput, which is the amount of data successfully received over a certain period of time. This parameter can give an idea of the network's ability to handle communication traffic. (Nur, Salim, & Ramdaniah, 2024) used throughput to compare the performance of 4G LTE networks, while (Yuhanef, Aulia, & Indriani, 2025) examined the relationship between QoS parameters and throughput in LTE networks. Throughput measurements were also used by (Romli & Femy Mulya, 2023) to compare the performance of VoIP-based communication systems. Therefore, throughput can be used as one of the indicators to observe changes in network performance when the traffic load changes.

The number of users is one of the factors that needs to be considered, because each active user generates traffic that the network has to handle. The more users communicating, the higher the overall traffic passing through the network. Research by (M. Dimas Goworzky, Alex Wijaya, Ilman Zuhri Yadi, & Timur Dali Purwanto, 2024) shows that VoIP evaluation can be done under various test conditions to understand its performance characteristics. Meanwhile, (Koutlia, Bojovic, Ali, & Lagen, 2022) and (Lacava et al., 2023) indicate that NS-3-based simulators can be used to build and evaluate mobile network scenarios in a controlled way. This simulation approach gives a chance to observe changes in network performance without having to directly test on the operator's infrastructure.

Previous studies have extensively discussed the performance of VoIP on 4G and 5G networks with various QoS parameters. However, an analysis that specifically focuses on changes in total VoIP throughput due to variations in the number of users on 4G LTE networks still needs further examination. Theoretically, an increase in the number of users can enhance total throughput because more traffic is being transmitted, but the average throughput per user may decrease when network resources are also shared. Therefore, this study uses NS-3 to analyze VoIP service throughput in scenarios with 5, 10, 15, and 20 UEs in order to understand the effect of increasing the number of users on total throughput and per-user throughput.

Method

This research was carried out using a network simulation approach with NS-3 to analyze the throughput performance of VoIP services on a 4G LTE network. The simulation was designed to observe changes in total throughput based on variations in the number of users.

The simulation uses a single eNodeB with several User Equipment (UE) placed in different positions, with a distance of 60 meters between each UE. The number of users

is varied to 5, 10, 15, and 20 UEs. Each UE is connected to the same eNodeB and runs UDP traffic representing VoIP communication. The simulation runs for 60 seconds in each scenario. An illustration of the research scenario is shown in Figure 1.

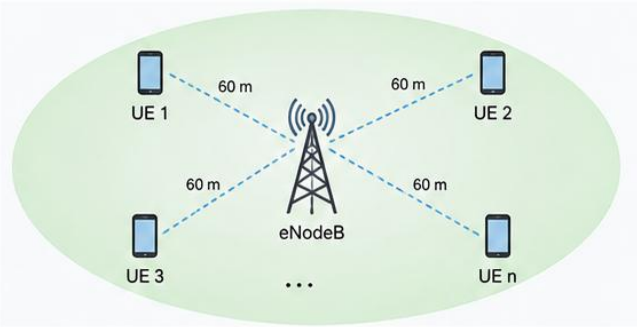


Figure 1. Simulation scenario

The network topology used in the simulation is shown in Figure 2. The network consists of UEs, eNodeB, EPC (Evolved Packet Core), which includes MME, S-GW, and P-GW, and a remote host that acts as the sender and receiver of VoIP traffic. All UEs connect to the eNodeB via the LTE radio interface, then are forwarded to the core network and connected to the remote host through the IP network.

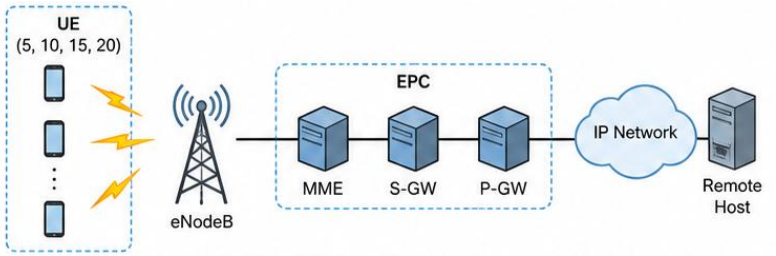


Figure 2. 4G LTE Network Topology

The main configuration used in the simulation is presented in Table 1. The parameters were kept the same for all user number scenarios.

Table 1. Simulation Parameters

Parameters	Values
Simulator	NS-3
Technology	4G LTE
Number of eNodeB	1
Number of users (UE)	5, 10, 15, 20
Distance between UEs	60 m
Simulation time	60 s
Traffic protocol	UDP
Package size	160 byte
Package interval	20 ms
Measurement	Total Throughput (FlowMonitor)

Data throughput was obtained using FlowMonitor by measuring the amount of data received during the simulation. Total throughput values were then compared for each

user count scenario. The measurement results were analyzed to see how the total throughput changed as the number of users increased.

Result and Discussion

The simulation results were obtained from the Flow Monitor output in the Ubuntu terminal for four user scenarios, namely 5, 10, 15, and 20 UEs. The observed statistics include the amount of data received, the number of packets received, and the total throughput. Flow Monitor is used to collect packet flow statistics on the network during the simulation.

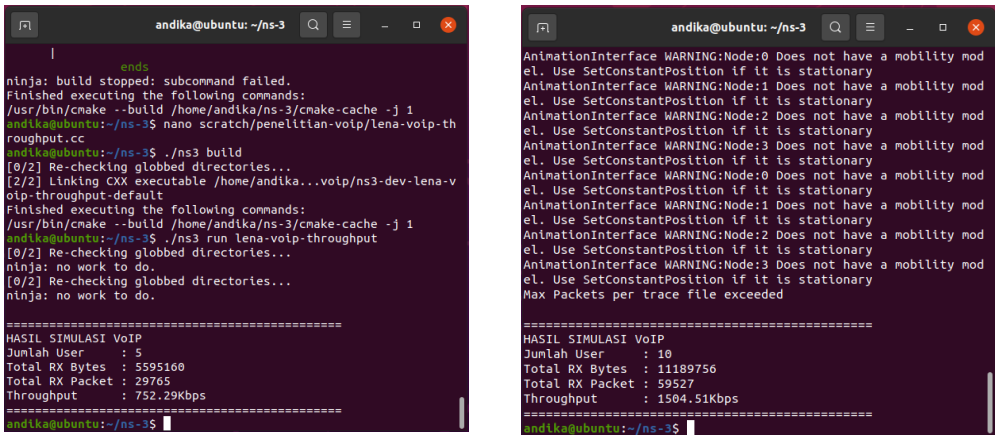


Figure 3. Throughput simulation results at the terminal (a) 5 UEs, (b) 10 UEs

In the 5-user scenario, the aggregate throughput achieved was 752.29 Kbps, with a total of 5,595,160 bytes and 29,765 packets received. These results serve as a benchmark for scenarios with a larger number of users. Meanwhile, in the 10-user scenario, the total throughput increased to 1,504.51 Kbps. The total data received reached 11,189,756 bytes with 59,527 packets. Compared to the 5-user scenario, total throughput increased as the number of users generating traffic increased.

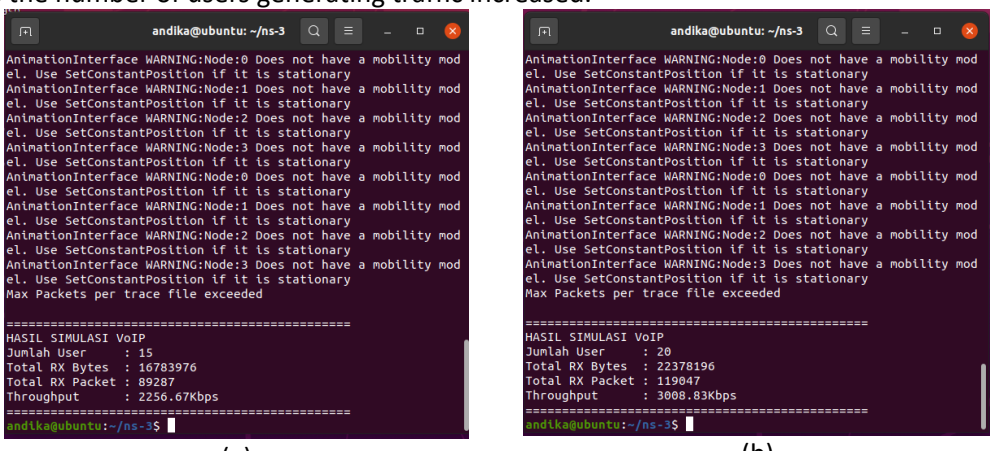


Figure 4. Throughput simulation results at the terminal (a) 15 UEs, (b) 20 UEs

In the 15-user scenario, the total throughput reached 2,256.67 Kbps, with a total of 16,783,976 bytes of data received and 89,287 packets. These results show that adding users is followed by an increase in the amount of data successfully received in that simulation scenario. Meanwhile, in the 20-user scenario, the total throughput reached 3,008.83 Kbps, with a total of 22,378,196 bytes of data received and 119,047 packets. Out of the four scenarios tested, this value represents the highest total throughput. To make comparisons easier, all the measurement results are summarized in Table 2.

Table 2. Simulation Results Recap

Number of Users/UEs	Received data (Bytes)	Received packets (Packets)	Total Throughput (Kbps)
5	5.595.160	29.765	752,29
10	11.189.756	59.527	1.504,51
15	16.783.976	89.287	2.256,6
20	22.378.19	119.047	3.008,83

Based on Table 2, the total throughput increased from 752.29 Kbps with 5 users to 3,008.83 Kbps with 20 users. This pattern of increase shows that the number of users is related to the total traffic successfully received by the network in the simulation setup used. To make it clearer, take a look at Figure 5 below.

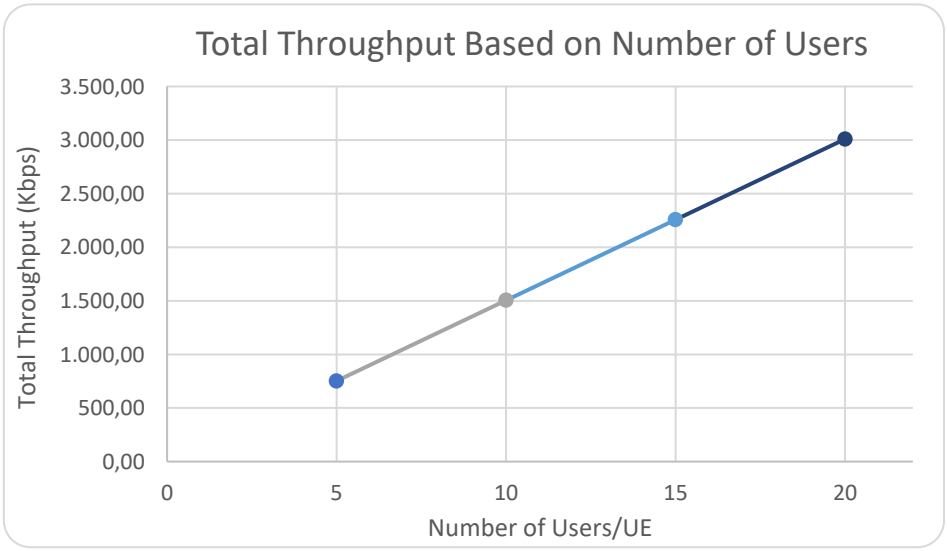


Figure 5. Total Throughput Based on Number of Users

The increase in total throughput happens because each user generates UDP traffic with a packet size of 160 bytes and a sending interval of 20 ms. As the number of users grows, the total packets sent also increase, making the total amount of received data larger. These results need to be interpreted correctly.

The results can be explained through the mechanism of radio resource management in LTE networks. The eNodeB allocates LTE radio resources, including Resource Blocks (RBs), to active users through a packet scheduling mechanism. When the number of users increases, the eNodeB must manage the available resources to accommodate the additional users. As long as the network capacity is sufficient, the total throughput can increase with the traffic being successfully served. However, when the network load approaches its capacity limit, the increase in throughput may slow down, and the

throughput per user may potentially decrease. This condition is influenced by bandwidth, channel quality, and the scheduling algorithm used.

The simulation results show that the total throughput increased from 752.29 Kbps with 5 users to 3,008.83 Kbps with 20 users. However, a higher total throughput does not automatically indicate better VoIP call quality because this value is a combination of the throughput from all measured traffic flows. Meanwhile, the average throughput per user, calculated by dividing the total throughput by the number of users, remains relatively constant at around 150.45 Kbps. Thus, an increase in the number of users increases the total throughput in the tested scenario without showing any significant change in the calculated average throughput per user.

The findings of this study are only applicable to the tested system configurations and number of users. This is because RB allocation, packet scheduling performance, and channel capacity utilization were not measured directly. The influence of these three aspects cannot be confirmed based solely on total throughput results. A more comprehensive evaluation of VoIP quality also requires measurement of delay, jitter, and packet loss, which has not been the primary focus of this study.

Conclusion

This study analyzed the total throughput performance of VoIP services on 4G LTE networks using NS-3 with variations in the number of users: 5, 10, 15, and 20 UEs. The simulation results showed that total throughput increased from 752.29 Kbps with 5 users to 3,008.83 Kbps with 20 users, as the traffic generated by users increased. Meanwhile, the average throughput per user remained relatively constant, around 150.45 Kbps. These results indicate that adding more users increases total throughput in the tested simulation configuration, but it cannot yet be used as an indicator of overall voice service quality improvement. Therefore, future research is recommended to include parameters like delay, jitter, and packet loss to get a more comprehensive evaluation of VoIP service quality.

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