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LTE Advanced Network Performance Analysis for Smartfren and Telkomsel in the City of Yogyakarta

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Abstract – *This study investigates comprehensive assessment of LTE-Advanced network performance in urban environment of Sudirman Road and Malioboro Road, Yogyakarta, Indonesia. This study aims to measure and assess the performance or quality of the LTE-Advanced network based on the Quality of Service (QoS) and Signal Strength parameters using the drive test measurements data collection method. This study analyses signal strength parameters (RSRP and RSRQ) and quality of service metrics (delay and jitter) across two prominent operators, Smartfren and Telkomsel. Our investigation unveils robust signal strength from both operators at Sudirman Road, with Smartfren demonstrating notable superiority in RSRQ. Similarly, at the Malioboro Road, both operators exhibit commendable RSRP, with Smartfren maintaining a marginal advantage. In terms of quality of service, our findings affirm that both Smartfren and Telkomsel consistently deliver low latency and maintain satisfactory jitter levels, ensuring uninterrupted connectivity experiences for users. While Telkomsel typically leads in delay performance, Smartfren showcases superior jitter performance at specific points at Sudirman Road. Conversely, at Malioboro Road, Telkomsel outperforms Smartfren in both delay and jitter metrics. These insights offer invaluable guidance for network optimization strategies, empowering operators to enhance service quality and enrich connectivity for the users in Yogyakarta. Furthermore, our study contributes to the broader understanding of LTE-Advanced network performance, emphasizing the significance of signal strength and quality of service parameters in ensuring optimal user experiences in urban environments.*

Keywords*: LTE-Advanced; drive test measurement; signal strength; quality of service (QoS)*

I. Introduction

The number of cellular network users in Indonesia has always increased from year to year, this is because of mobility of users, and people tend to choose cellular communication to exchange information anytime and anywhere for daily life. With such a high demand, good network quality is important to support the performance and accessibility of the available networks. The recent rapid advancement of technology demands that the state provide telecommunication infrastructure facilities to improve the economy and social life of the community, which will help boost the regional economy and open up job opportunities [16].

The era of wireless communications has developed from analog to digital and has undergone an evolution from the first generation (1G) to the 4th generation (4G). Long Term Evolution (LTE), also known as 4G LTE, is a technology developed by the 3rd Generation Partnership Project (3GPP) to replace the previous generation, namely Universal Mobile Telecommunication Services (UMTS) and High-Speed Downlink Packet Access (HSDPA) or, better known as 3G Technology. The 4G LTE network has undergone various upgrades and has given rise to new technology, namely Long-Term

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Evolution Advanced (LTE-A). In 2010, 3GPP introduced LTE-Advanced technology, this technology is capable of providing data rates of up to 3 Gbps on the downlink side and 1.5 Gbps on the uplink side [8].

In the implementation of 4G LTE and LTE-Advanced technology in Indonesia, especially in the city of Yogyakarta, there are still some challenges in the distribution of network infrastructure which causes some locations are still not be able to access the LTE-Advanced network. In addition, in areas that have entered the LTE-Advanced network coverage area, network connectivity problems are still found, for example, experiencing lagging and delays to play games or access live streaming video.

All of the problems described above are related to the quality of network performance, where each cellular operator has a different performance even though it is accessed from the same location area. Therefore, it is important to measure and to compare the network performance between two different cellular operators in order to compare the quality of services.

Following the existing background, this study aims to measure and to compare the performance of LTE-Advanced network between two different cellular operators, namely Smartfren and Telkomsel in the city of Yogyakarta, Indonesia.

II. Study of Literature

II.1. Long Term Evolution (LTE)

Long Term Evolution (LTE) is 4G cellular technology as an evolution from the previous-generation cellular technology, known as the second-generation (2G) or GSM (Global System for Mobile Communication) and the third-generation (3G) cellular technology Universal Mobile Telephone Standard (UMTS). LTE technology has an uplink speed of 75Mbps and a downlink of 300 Mbps, which has significant improvement compared to the previous technology. The 4G system will be able to provide a comprehensive IP solution where voice, data, and streamed multimedia can reach users anytime and anywhere at higher data rates than previous generations [13].

II.2.LTE-Advenced

Long Term Evolution Advanced (LTE-Advanced) is the next step in LTE evolution. It enables carriers to enhance network performance and service capabilities by seamlessly deploying new techniques and technologies. LTE-Advanced uses several new features on top of the existing LTE standard to provide a better user experience and higher throughput [3].

LTE-Advanced, commonly known as 4.5G, is a refinement of the previous technology, namely LTE using 3GPP Standard Release 10, which applies carrier aggregation technology to obtain a larger bandwidth allocation and increase the number of antennas used to allow for an increase in the transfer rate to up to 1Gbps for Downlink and 500Mbps for Uplink. This technology also uses a different bandwidth allocation, 70 MHz for Downlink and 40 MHz for Uplink.

II.3. Quality of Service (QoS)

QoS is an important aspect in various ways, but when viewed from a networking perspective, QoS or Quality of service refers to the service capability provided by a network for data traffic that aims to provide better and planned network services [7].

QoS is a method for measuring network quality and knowing the service characteristics of a network. QoS always focuses on the ability of the network to provide better services [17]. As for some parameters of Quality of Service, namely:

II.3.1. Received Signal Strength Indicator (RSSI)

Received Signal Strength Indicator (RSSI) is the average of the total received power observed in OFDM symbols by the UE of all sources, including non-serving cells, serving co-channels, adjacent channel interference and noise thermal, in bandwidth measurements through NRBs [1].

Received Signal Strength Indicator (RSSI) is the overall signal intensity received by the user. RSSI can be defined as a combination of the power emitted by the signal, noise, and signal interference so that it can be stated as follows:

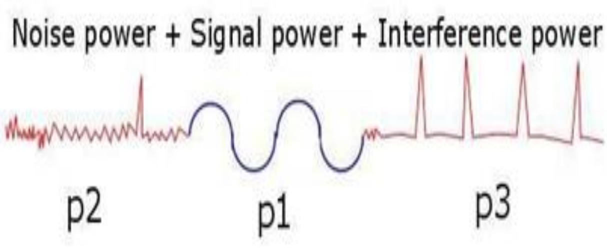


Fig. 1 Received Signal Strength Indicator (RSSI)

II.3.2. Reference Signal Received Power (RSRP)

RSRP (Reference Signal Received Power) is defined as the linear average of the power contribution of the resource elements that carry cell-specific reference signals within the considered measurement frequency bandwidth [14]. In simple terms, it can be expressed as the signal strength received by the user from the site [4].

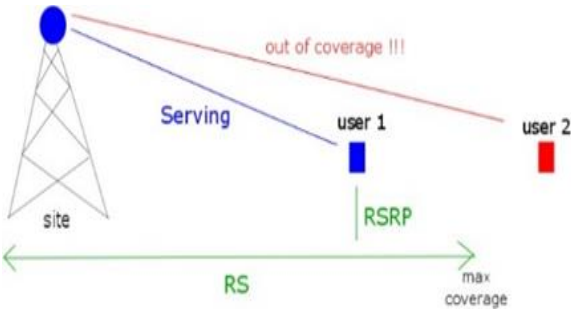


Fig. 2 Reference Signal Received Power (RSRP)

From Fig.2, the reference signal radiates in a certain area called the serving site, therefore the further the user's position from the serving site, the worse the signal quality obtained by the user, and vice versa.

Table 1. Standard RSRP value

Category	RSRP range value (dB)
Very Good	RSRP≤(-80)
Good	(-90) ≤ RSRP < (-80)
Normal	(-100) ≤ RSRP < (-90)
Bad	(-120) ≤ RSRP< (-100)
Very Bad	RSRP≤(-120)

II.3.3. Reference Signal Received Quality (RSRQ)

RSRQ is a parameter for measuring LTE radio frequency signals, using the reference signal emitted by the eNodeB to determine the signal quality received by the UE. RSRQ can also be defined as a comparison or ratio between RSRP and RSSI. Similar to the RSRP measurement, this metric is used primarily to rank different candidate cells according to their signal quality [1].

Table 2. Standard RSRQ value

Category	*RSRQ range value* (dB)
Very Good	RSRQ≤(-9)
Good	(-10)dB ≤ RSRQ < (-9)dB
Normal	(-15)dB ≤ RSRQ < (-10)dB
Bad	(-19)dB ≤ RSRQ < (-15)dB
Very Bad	RSRQ≤(-20)dB

II.3.4. Delay

Delay is the travel time required for packet data travel from the transmitter point to the receiver's location.

Table 3. Standard latency value

Category	*Delay (ms)*
Very Good	<150 ms
Good	150 ms s/d 300 ms
Bad	300 ms s/d 450 ms
Very Bad	>450 ms

II.3.5. Jitter

The large number of delay variations in data transmission on a network is commonly called jitter. It is also showing that jitter is closely related to delay. Jitter arises due to variations in data processing time and packet preparation at the end of data transmission, causing variations in queue length. The impact of jitter on the network performance can be seen clearly if both parameters jitter and delay are at a high value.

Table 4. Standard jitter value

Category	*Jitter (ms)*
Good	0 s/d 20 ms
Medium	20 s/d 50 ms
Poor	>50 ms

III. Research Method

This research was conducted by taking various data collections for the Signal Strength and the Quality of Service (QoS) parameters. To obtain the data required, in this research, it uses the drive test measurement method. The drive test measurement method is a method of collecting some network parameters data by driving constantly through a route in a predetermined area with a constant driving speed. The data obtained from the drive test measurement is then analyzed based on predetermined parameters whether the results obtained to meet the standards or not.

In this research, data collections were conducted for 5 days, from December 10 to October 14, 2023, with details, 3 days during the day time and 2 days at night. In this study, drive test measurements were conducted at Sudirman Road and Malioboro Road, Yogyakarta. The cellular network operators used in this study are Telkomsel and Smartfren. Furthermore, we also compare and analyze the data that has been collected and obtained from the drive test measurement in order to obtain comprehensive conclusions for this study.

A. *Research Flowchart*

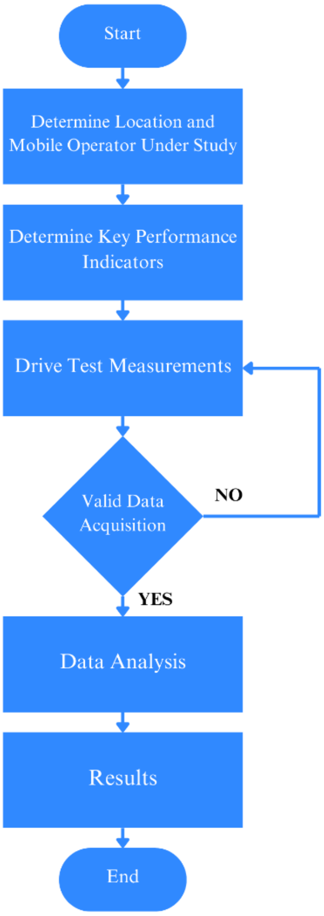


Fig. 3 Flowchart of Research

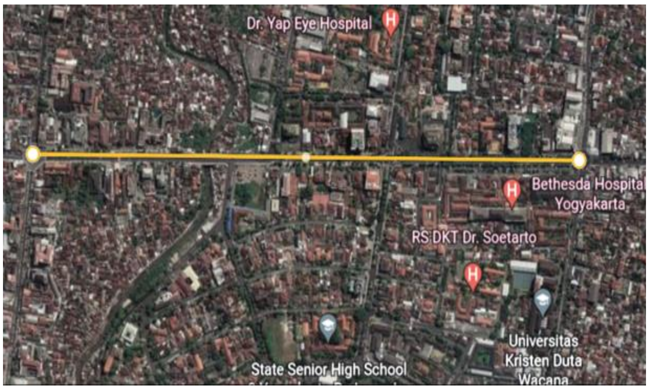


Fig. 4. Sudirman Road Yogyakarta

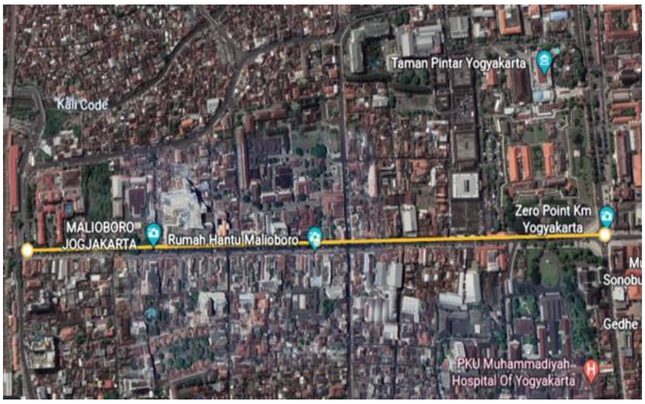


Fig. 5. Malioboro Road Yogyakarta

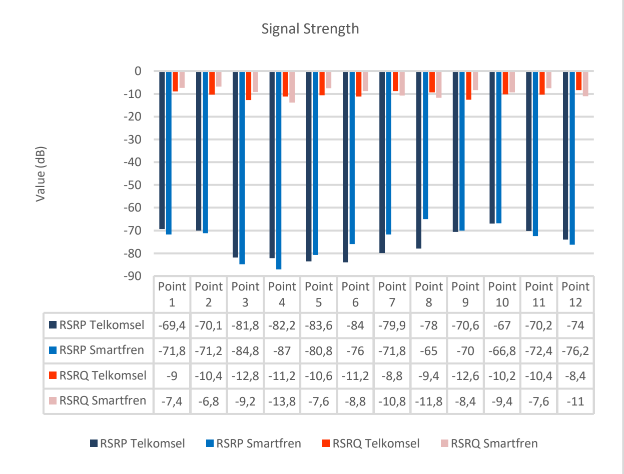
Based on Figure 3.1 and Figure 3.2 above, this study has two main locations for drive test measurement to obtain and to collect data, namely Sudirman Road and Malioboro Road in the City of Yogyakarta. Both two locations, approximately 3 km long, are famous for tourist's point of interest in Yogyakarta where there are many shopping centers, restaurants, and café. These places already have LTE-Advanced network services from Telkomsel and Smartfren network operators to serve the user's data communications need in the area.

IV. Result and Discussion

A. *Comparison of Drive Test Results for Sudirman Road, Yogyakarta*

Comparison results of Signal strength and Quality of Service (QoS) parameters between Smartfren and Telkomsel from the drive test measurements data are depicted in Fig.6 and Fig.7 below. In this study, the analysis was carried out by comparing the average results in a total of 12 data collection points for 5 days data acquisitions which consists of three days at day time, and two days at night.

1. *Signal Strength*

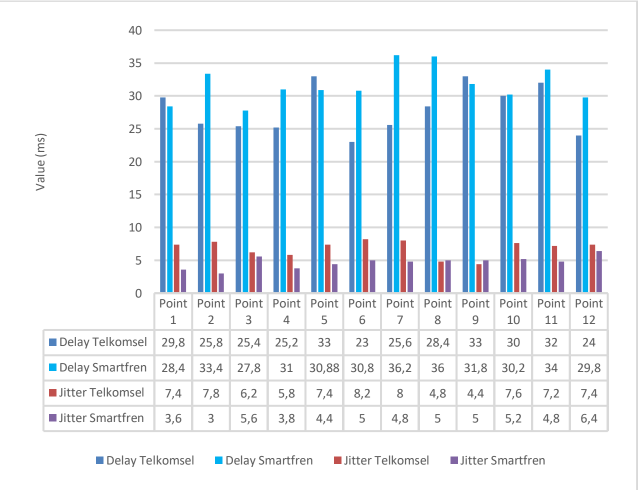


	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	Point 11	Point 12
RSRP Telkomsel	-69,4	-70,1	-81,8	-82,2	-83,6	-84	-79,9	-78	-70,6	-67	-70,2	-74
RSRP Smartfren	-71,8	-71,2	-84,8	-87	-80,8	-76	-71,8	-65	-70	-66,8	-72,4	-76,2
RSRQ Telkomsel	-9	-10,4	-12,8	-11,2	-10,6	-11,2	-8,8	-9,4	-12,6	-10,2	-10,4	-8,4
RSRQ Smartfren	-7,4	-6,8	-9,2	-13,8	-7,6	-8,8	-10,8	-11,8	-8,4	-9,4	-7,6	-11

Fig. 6 Signal Strength Comparison

A comparison of the RSRQ data from the drive test for Telkomsel and Smartfren operators shows that at 9 out of 12 points tested or almost 70% Smartfren has better RSRQ value compared to Telkomsel. Thus, it can be concluded that the quality of RSRQ value of Smartfren is more superior to Telkomsel because the user's received signal has better and higher value. For detail comparison data results of Signal Strength measurement can be shown in Fig.6 above. It can be seen from the result also that the average RSRP value for Telkomsel and Smartfren does not have significant differences, except at points 7 & 8, Smartfren has much better RSRP's value than Telkomsel.

2. *Quality of Service (QoS)*



	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	Point 11	Point 12
Delay Telkomsel	29,8	25,8	25,4	25,2	33	23	25,6	28,4	33	30	32	24
Delay Smartfren	28,4	33,4	27,8	31	30,88	30,8	36,2	36	31,8	30,2	34	29,8
Jitter Telkomsel	7,4	7,8	6,2	5,8	7,4	8,2	8	4,8	4,4	7,6	7,2	7,4
Jitter Smartfren	3,6	3	5,6	3,8	4,4	5	4,8	5	5	5,2	4,8	6,4

Fig. 7 QoS Comparison

The smaller the value of delay, the better networks performance will be. From the Fig.7 above, it can be shown that 9 of the 12 points data collections or almost 70%, Telkomsel has a better average delay parameter. In this study, it can be concluded that Telkomsel's delay parameter is better than Smartfren. The delay parameter can determine the quality of the network because if the delay value is small, it can be used as compensation when the jitter value is high. However, if the delay value is bigger, the quality of the network is certainly poor. For jitter parameter, 10 of the 12 points studied or more than 70% of Smartfren's jitter values are slightly better than Telkomsel with a difference between 2 ms to 4 ms, while at other points the jitter comparison is tends to be the similar. Low jitter value indicates that the delay variation during data transmission is small. The jitter value is directly proportional to the traffic of a network, meaning that the higher the traffic load of a network, the higher the jitter value, and vice versa. Thus, the jitter is influenced mainly by the network traffic load. In some cases, higher jitter value can be compensated with low delay value, so that the jitter value does not really affect the quality of the network performance.

B. Comparison of Drive Test Results for Malioboro Road, Yogyakarta

Comparison results of Signal strength and Qality of Service (QoS) parameters between Smartfren and Telkomsel from the drive test measurements data are depicted in Fig.8 and Fig.9 below. In this study, the analysis was carried out by comparing the average results in a total of 12 data collection points for 5 days data acquisitions which consists of three days at day time, and two days at night.

1. *Signal Strength*

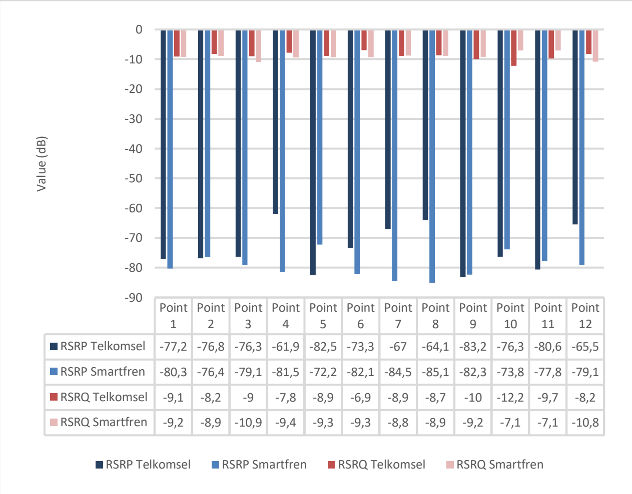


Fig. 8 Signal Strength Comparison

From the Fig. 8, comparison of RSRQ data from drive test measurements between Telkomsel and Smartfren operators shows that almost 80% RSRQ of Telkomsel has better value compared to Smartfren. Thus, it can be concluded that the quality of RSRQ value of Telkomsel is more superior to Smartfren because the user's received signal has better and higher value. For detail comparison data results of Signal Strength measurements can be shown in Fig.8. 8 of the 12 points measured or almost 80% of the average Telkomsel's RSRP value are more superior as compared to Smartfren.

2. *Quality of Service*

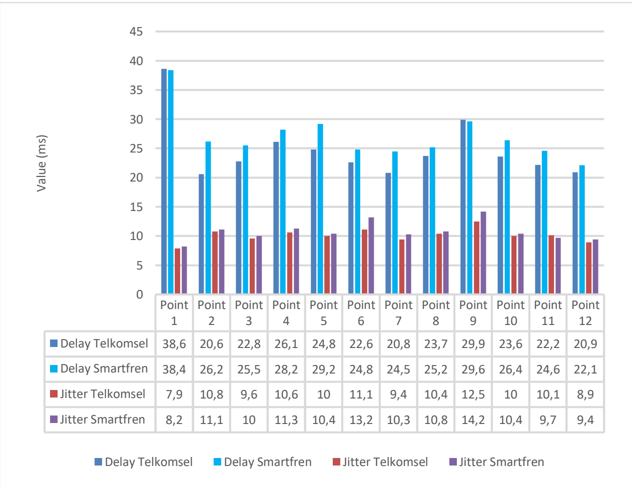


Fig. 9 QoS Comparison

From the Fig.9 above, it can be seen that in 10 of the 12 points data or almost 90%, Telkomsel has a better average delay value. Thus, in this study, it can be concluded that Telkomsel's delay value is better than Smartfren. The delay parameter can determine the quality of the network because if the delay value is small, it can be used as compensation when the jitter value is high. However, if the delay value is bigger, the quality of the network is certainly poord. For jitter parameter, 11 of the 12 points data or more than 90% of Telkomsel's jitter values are better than Smartfren. Low jitter value indicates that the delay variation during data transmission is small. The jitter value is directly proportional to the traffic of a network, meaning that the higher the traffic load of a network, the higher the jitter value, and vice versa. Thus, the jitter is influenced mainly by the network traffic load. In some cases, higher jitter value can be compensated with low delay value, so that the jitter value does not really affect the quality of the network performance.

V. Conclusion

This study provides valuable insights into the performance of Smartfren and Telkomsel's LTE-Advanced networks.

In Sudirman Road, both operators exhibit better RSRP value, with Smartfren boasting slightly better RSRQ values. Along Malioboro Road, both demonstrate robust RSRP values, with Smartfren leading slightly. Regarding quality of service, both operators deliver low latency or delay and acceptable jitter, ensuring smooth user experiences. While Telkomsel generally outperforms Smartfren in delay, Smartfren excels in jitter at specific points in Sudirman Road. However, at Malioboro Road, Telkomsel surpasses Smartfren in both delay and jitter.

These findings offer actionable insights for network optimization, aiding both operators in enhancing service quality for users in Yogyakarta.

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