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Analysis of QoS in 4G LTE Networks During the Handover Process

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Abstract

This study analyzed Quality of Service (QoS) in 4G LTE networks during the handover process, focusing on the parameters RSSI, RSRQ, SINR, and throughput. We conducted data collection through a drive test using the G-NetTrack Pro application in the morning, afternoon, and evening. The measurement results showed a Handover Success Rate (HOSR) of 96.6%, slightly below Telkomsel's mobility KPI target (>98%). The majority of RSSI and SINR values were in the good to very good category, although there were cases of significant signal quality degradation after handover with a throughput reduction of up to 1.28 Mbps. Factors causing the decline in performance included high user density in the destination cell (BTS 2), interference, and physical environmental conditions such as buildings and trees. This study displayed the importance of considering signal quality parameters (RSRQ and SINR) in addition to signal strength (RSRP) in cell selection logic to improve handover success.

Keywords:
4G LTE, QoS, Handover, RSSI, RSRQ, SINR

1. Introduction

The rapid growth of mobile broadband usage has increased the demand for seamless connectivity, especially in 4G LTE networks. One of the critical challenges is maintaining service quality during handover, the process of transferring an ongoing connection from one cell to another. Previous research in Palembang showed that although Telkomsel's 4G network supports stable connections, handover issues still occur in areas with high mobility, affecting Quality of Service (QoS) parameters such as throughput and delay [1]. This demonstrates that while LTE technology is robust, the optimization of handover processes remains an open challenge.

Optimization of LTE handover is crucial since the handover process directly impacts the user experience in high-demand applications such as video calls and streaming. Drive test analysis on 4G LTE has proven effective for detecting weak coverage and handover interruptions, where significant degradations in QoS parameters were observed when users moved across cell boundaries [3]. These findings suggest that a more systematic analysis of QoS during handover is required to understand its reliability in real-world scenarios.

Studies on earlier 3G networks revealed that improper handover implementation often resulted in call drops and increased packet loss [4]. Similar issues persist in LTE, especially in dense urban environments where interference and overlapping cell coverage are common. Research has shown that handover quality is not only dependent on signal strength but also on factors like user movement speed and environmental conditions, which complicate the design of efficient mobility management strategies [6].

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Electrical tilt adjustments on base station antennas have been investigated as a method to optimize LTE handovers. While such techniques improved signal coverage and reduced interference in certain areas, drive test results showed that improper tilt configuration could still cause handover failures [5]. This indicates the need for adaptive and context-aware handover strategies rather than static optimization methods.

QoS evaluation is especially relevant for real-time applications such as video streaming. Research on WLAN-based streaming demonstrated that codec efficiency, such as the use of H.265, significantly influences user experience under varying network conditions [7]. By analogy, similar QoS constraints are observed in LTE networks, where handover interruptions may lead to video buffering or call quality degradation. Thus, analyzing QoS during LTE handovers is essential for supporting multimedia services.

Recent work has focused on measuring network quality in open and urban environments, revealing that base transceiver station (BTS) distance and terrain conditions directly affect handover reliability [9]. In addition, comparative studies of LTE operators showed that handover performance varied significantly between providers, with some achieving smoother transitions while others experienced frequent packet loss [14]. This indicates that operator-specific infrastructure design plays a major role in determining QoS during handovers.

Several studies have directly examined LTE handover quality using drive test parameters such as RSRP, RSRQ, and SINR. For instance, analysis on the Padang-Pariaman railway line showed fluctuating handover quality due to varying terrain and mobility speeds [10]. Similarly, studies on video call communication in LTE networks reported QoS deterioration during handovers, especially when network load was high [11]. These results emphasize the necessity of continuous monitoring and optimization of handover processes.

Comparative evaluations of packet scheduling strategies further demonstrated that handover performance could differ significantly depending on scheduling algorithms such as Round Robin and Proportional Fair [13]. Although both methods maintained basic connectivity, Proportional Fair achieved a better balance in throughput and delay during handover. These findings highlight that improving QoS during LTE handovers requires not only optimizing radio parameters but also integrating advanced scheduling and mobility management techniques.

2. Related Works

Afwan et al. analyzed the performance of Telkomsel’s 4G LTE network in Palembang using drive test measurements. Their results showed that while the network generally provided acceptable service, handover delays were evident in areas with dense traffic and building obstructions. The study concluded that approximately 78% of observed handovers were successful, while the remaining 22% experienced service degradation, such as temporary call drops and reduced throughput. This indicates that the optimization of handover parameters is crucial in maintaining Quality of Service (QoS) [1]. Daffa et al. investigated LTE network performance in the XYZ building using the drive test method. The results indicated that signal strength and quality significantly fluctuated inside the building, with handover success rates dropping by nearly 30% in indoor environments compared to outdoor areas. These findings demonstrate that environmental conditions such as walls and closed spaces contribute to reduced handover performance, underscoring the importance of designing indoor coverage solutions [3].

Fatmi et al. conducted a study on 3G network handover performance in Mataram using TEMS and G-NetTrack tools. Although based on 3G technology, the study highlighted common problems relevant to LTE, such as poor handover decisions caused by weak signal strength. Their results showed that only 65% of handovers were executed without significant packet loss, while the rest suffered from interrupted services. This reinforces that seamless handover remains a significant challenge when transitioning between cells [4].

Fajar and Devia applied the electrical tilt method to optimize 4G LTE networks. The results indicated that adjusting antenna tilt improved signal strength and reduced interference, thereby increasing handover reliability. The study reported a 15% improvement in successful handover rates after tilt optimization. However, it also emphasized that improper tilt settings could worsen coverage overlaps, proving that optimization must be carefully calibrated for each environment [5].

Firqad Ilfan et al. examined the impact of user movement speed on LTE handover quality. Their analysis showed that handover failures increased as user speeds exceeded 80 km/h, especially in overlapping coverage areas. The study found that at lower speeds (<40 km/h), handover success rates were above 90%, but at high mobility conditions, success dropped to 70%. This demonstrates that mobility is a critical factor in LTE handover performance, particularly for transportation scenarios [6].

Rosyada et al. analyzed handover performance on the Padang–Pariaman railway line using drive test parameters such as RSRP and RSRQ. The study revealed that QoS degraded significantly during high-speed train movements, with average throughput decreasing by 25% during handover events. Despite these challenges, the researchers noted that the LTE system was still able to maintain connectivity, although with reduced quality. This highlights the importance of optimizing LTE networks in high-speed rail environments [10].

Setiadi et al. studied handover quality in video call communication using LTE drive test data in Ketapang City. The results demonstrated that voice and video quality dropped during handovers, with jitter increasing by 18% and packet loss by 12% during transitions between cells. Despite these degradations, LTE was still able to support video calls, though with noticeable delays. The study emphasized the necessity of fine-tuning handover thresholds to reduce interruptions in real-time services [11].

Yuhanef et al. compared LTE handover performance among three operators using drive test methods in Central Pariaman Beach. Their findings showed significant variation in handover quality across providers: Operator A achieved a 92% handover success rate, Operator B achieved 85%, while Operator C lagged at 78%. The study concluded that network infrastructure quality and optimization strategies strongly influence handover performance, making operator-specific tuning essential for ensuring high QoS [14].

Afwan, Nasron, and Suroso examined Telkomsel's 4G LTE network handover performance in Palembang using drive test data. They observed that approximately 78 % of handovers succeed smoothly, while the remaining 22 % suffer temporary disruptions like throughput drops or call interruptions, particularly in areas with dense traffic or building obstructions. Their conclusions signify that fine-tuning handover parameters remains critical for maintaining QoS in metropolitan environments [1].

Ilfan, Hertiana, and Usman analyzed the impact of user velocity on LTE handover reliability, finding that mobile speeds below 40 km/h maintain over 90 % handover success. However, above 80 km/h—common in transport scenarios, with success dropping to around 70 %. These results highlight the challenge of preserving QoS amid high user mobility and point toward the need for dynamic or predictive handover strategies [6]. Meanwhile, Adhitama et al. compared packet scheduling algorithms, showing that Proportional Fair scheduling ensures better throughput balance and reduced delay during handover, outperforming Round Robin approaches under the same handover conditions [13]. On operational environments like railways, Rosyada, Zurnawita, and Chandra observed a 25 % throughput reduction during handovers along the Padang–Pariaman line, revealing the need for specialized handover mechanisms tailored to high-speed movement and varying topologies [10]. Other real-world testing in Ketapang by Setiadi et al. noted jitter rises of 18 % and packet loss by 12 % during video calls in handover events, indicating degraded user experience for real-time services despite maintained connectivity [11].

Building upon these empirical findings, several advanced methods have been proposed. Khan and Portmann designed an SDN-based combined QoS control and handover optimization framework. Their NS-3 simulations demonstrate throughput improvements of roughly 6 % across all users and 23 % for edge users, showing that centralizing optimization across access and backhaul layers can significantly enhance QoS during transitions [15]. Gu, Voigt, and Rost introduced a deep reinforcement learning (DRL) approach using proximal policy optimization to reduce ping-pong effects in handovers, increasing average data rates and lowering radio link failures compared to standardized protocols that implying that machine learning can dynamically adapt to mobility patterns for improved QoS [16].

Another method proposed by Kumar et al. in a 5G context uses deep reinforcement learning for advanced handover optimization, achieving higher protocol performance and better QoS outcomes in dense deployments [17]. Hakkou, Mazri, and Hmina developed a new algorithm activating 3GPP A1/A3 events based on RSRQ thresholds for handover decisions, using NS-3 simulation and demonstrating effectiveness in raising throughput and SINR while reducing latency relative to standard thresholds [18]. Lastly, models incorporating fuzzy logic and neural-fuzzy frameworks, for example, combining PSO with ANFIS that have shown promise in proactively predicting vertical handovers between LTE and LTE-A, improving decision accuracy, and reducing handover latency and power consumption [19].

3. Proposed Method

In this study, we calculate four key performance indicators—Received Signal Strength Indicator (RSSI), Signal-to-Interference-plus-Noise Ratio (SINR), Bit Error Rate (BER), and throughput—to provide a comprehensive evaluation of Quality of Service (QoS) in 4G LTE networks during the handover process. RSSI serves as a fundamental measure of the received power from the serving and neighboring cells, directly influencing the decision to trigger handovers. SINR reflects the quality of the radio link by accounting for both signal strength and interference, thereby determining the reliability of data transmission. BER quantifies the rate of errors in received bits, which is critical for assessing the accuracy and stability of communication under varying channel conditions. Throughput, representing the actual data rate experienced by the user, integrates the effects of RSSI, SINR, and BER into a tangible measure of end-user performance. By analyzing these parameters together, we capture both the physical-layer and user-level impacts of handovers, allowing us to assess how effectively the network maintains service continuity and QoS in dynamic mobility scenarios.

We utilized several tools to support the process of collecting, processing, and analyzing cellular network quality data. Samsung A24 was used as the main device for field data collection because it is capable of running network measurement applications and recording technical parameters such as RSSI, RSRP, RSRQ, and SINR in *real-time*. Measurements were carried out with the help of the *G-NetTrack Pro* application, which functions to record technical network parameters, record GPS coordinates, and store measurement logs for further analysis. In addition, the *OpenSignal* application was also used to test network performance, such as download and upload speeds and latency, as well as to display a map estimating the location of the nearest BTS. The measurement data was processed using Microsoft Excel to perform statistical calculations, data grouping, and the creation of distribution and cumulative percentage graphs. *Google Earth Pro* was used to visualize the measurement points on a satellite map, facilitating spatial analysis and documentation of the research results. The entire analysis process was carried out using a laptop as the center for data processing, graphing, and research report preparation. Fig. 3 depicts the system model of this study.

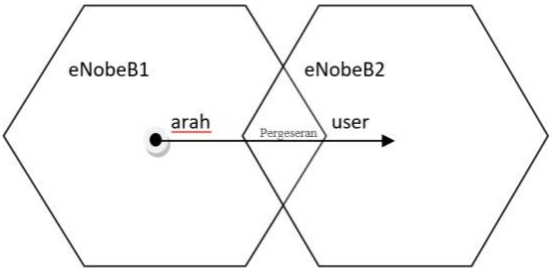

Fig. 3 System Model

In this *handover* simulation, a hexagonal cell *coverage* model is used, with two adjacent cells being observed. eNobeB1 represents the coverage area of Cell 1 as the sender before the handover occurs, while eNobeB2 represents the coverage area of Cell 2 as the receiver after the handover occurs, as shown in

1. Measurements were taken using the *G-NetTrack Pro* app. Data measurements were taken during peak hours from 7:00 a.m. to 8:30 a.m., 12:00 p.m. to 1:00 p.m., and 4:00 p.m. to 5:00 p.m. Western Indonesian Time.
2. Calculation of the data obtained from the measurements will enable the calculation of RSSI, SINR, BER, *throughput*, and distance parameters. Data calculation was performed using *Excel*.
    1. *Throughput* is the effective data *transfer* rate, measured in bps *(bits per second)*. *Throughput* is the total number of successful packet arrivals observed at the destination during *a* specific time *interval* divided by the duration *of* that time *interval*. *Throughput* is the number of bits successfully transmitted over a network [7].

    $$Accepted\ Data \frac{Throughput}{Time\ Analysis} \qquad (1)$$

    2. *Free Space Loss* (FSL) is the attenuation that occurs due to signal propagation from the transmitter to the receiver through empty space. *Free Space Loss* is influenced by distance and frequency. In the space along the transmitter and receiver antenna, there should be no obstacles, as the transmission itself is *Line of Sight* (LOS) [2]. Similarly, it does not take into account the type and characteristics or advantages of a particular antenna. The FSL equation used is [9]:

    $$\text{FSL} = 32.44 + 20 \log d \text{ (km)} + 20 \log(MHz) \qquad (2)$$

Table 1. Free Space Loss Propagation Model

Notation	Description
FSL	$Free\ Space\ Los\ (dB)$
d	$Jarak$
f	frequency (MHz)

3. RSSI (*Received Signal Strength Indicator)* is a parameter used in cellular communications to measure the strength of the signal received by the receiver or the receiver device. RSSI indicates the amount of signal power received by the receiver antenna from the cellular transmitter [12].

Table 2. RSSI Value Range

RSSI Value Range	Description
≥ -70 dBm	Very Good
-70 dBm to -85dBm	Good
-86 dBm to -100 dBm	Fair

4. RSRQ (*Reference Signal Received Quality*) is the quality of the reference signal received by the device. Table 3 describes the RSRQ value range.

Table 3 RSRQ value range

RSRQ Value Range	Description
≥ -10 dB	Very Good
-10 dB to -15 dB	Good
-15 dBm to -20 dB	Fair
≤ -20 dB	Poor

5. SINR (*Signal-to-Interference-Plus-Noise Ratio*) is a measure of how clean and strong the received signal is compared to interference (interference from other cells) [8]. Table 4 describes the SINR Value Range

Table 4. SINR Value Range

SINR Value Range	Description
≥ 20 dB	Very Good
13 dB to 20 dB	Good
0 dB to -13 dB	Fair
≤ - 0 dB	Poor

6. Drive test or walk test are terms often used in the telecommunications industry to describe work in which a person walks indoors or uses a vehicle while taking

4. Experimental Setup

1. Dataset

To conduct this study, we determined the following research locations, which are located at BTS 1 and BTS 2. BTS Provider Point 1 Telkomsel: Dasan Agung, Mataram City (NTB) Coordinates: 8˚34’59.25 “S - 116˚05’51. 14” E. BTS Provider Point 2 Telkomsel: Jl. Irigasi 2, Mataram City (NTB) Coordinates: 8˚35’18.19 “S -116˚05’04. 30” E.

Fig. 1 Research Location

Then, the handover point location can be seen in Fig. 2, where the two red circles represent the BTS coverage area and the small circle on the north right represents the intersection where the handover occurs. Data collection was only carried out at one point on Jalan Pendidikan, Mataram, as shown in Fig. 2

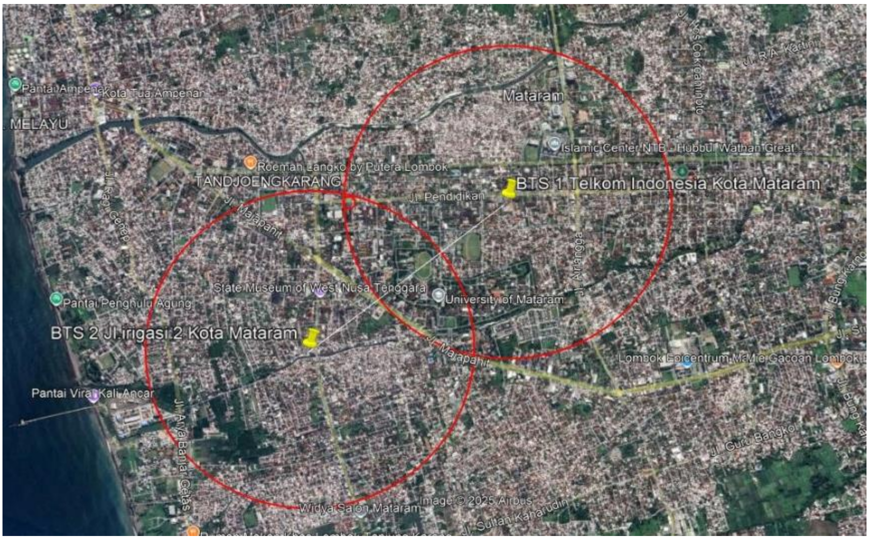

Fig. 2 Point where *the handover* occurs

Observation is a technique or approach to obtain primary data by directly observing the data object. In this study, the author collected data at the eNodeB on Jl. Dasan Agung to obtain *drive test* performance in handling *handover,* starting with preparing the necessary equipment to observe the performance of the eNodeB.To conduct data gathering, the *drive test* data collection was conducted from November 22, 2024, to December 13, 2024. *The* *drive test* was only conducted on Jalan Pendidikan in Mataram City using a motorcycle traveling at a speed of 18 km/h to 26 km/h. The large red circle represents the BTS coverage area, while the small red circle represents the *handover* point, where data was only collected on Jalan Pendidikan in Mataram City. The *drive test* measurement device used *a* Samsung Galaxy A24s *smartphone* with the *G-NetTrack Pro* application installed. The *drive test* results were then viewed on the *G-NetTrack Pro* application, which was *plotted* on the *Google Earth Pro* application. Measurements began at the BTS 1 location on Jalan Pendidikan , Mataram City, and ended on Jalan Irigasi 2, Mataram City. The drive test data collection route is shown in Fig. 4.

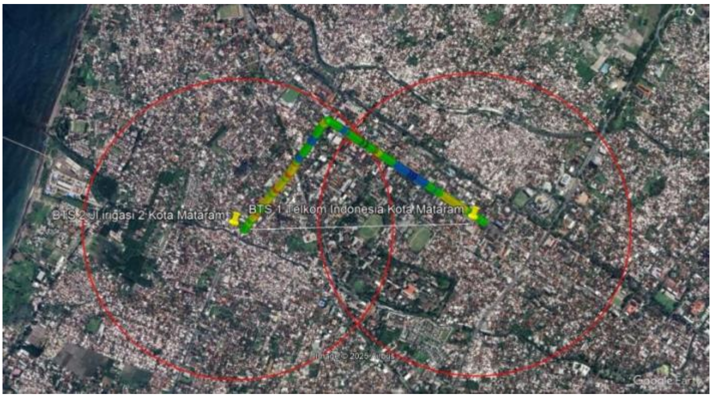

Fig. 4 Google Earth pinpoint on the Drive test route

The results of data collection using the *drive test* method with the *G-NetTrack Pro* application aim to determine network quality. This quality can be determined based on the RSSI, RSRQ, SINR, and *Throughput* parameters. This study uses a Telkomsel *provider* SIM card, which supports the frequency license allocation composition of 2.1 GHz. Fig. 5 depicts data display on the G-NetTrack Pro application.

07.31

G-NetTrack Pro v32.4

Operator: Telkomsel

MCC: 510 MNC: 10 TAC: 8038 Type: 4G
eNB: 497258 CID: 23 PCI: 383 TA:
ARFCN: 500 BAND: L40 BW:
F DL: 2160.0 MHz F UL: 1970.0 MHz
RSRP: -85 RSRQ: -12 SNR: 0.0 CQI: - RSSI: -73
Longitude: 116.085337 Latitude: -8.588075
Speed: 12 km/h Hdg: 187° S GPS Acc: 1m
Height: 46m Altitude: 46m Ground: 0m
UL: 0 kbps DL: 0 kbps
Data: Telkomsel IDLE
Serving time: 18s

TIME	EVENT	AC	CELLID	CI	ARFCN	LEVEL	QUAL	TYPE	SERV
07:24:13		8038	497031-36	221	39092	-81	-8	4G	72
07:25:26	CR4G4G	8038	497031-34	221	38750	-85	-10	4G	48
07:26:14	CR4G4G	8038	497228-14	395	38750	-100	-8	4G	54
07:27:08	CR4G4G	8038	497022-13	288	500	-90	-14	4G	2
07:27:10	CR4G4G	8038	497031-34	221	38750	-101	-10	4G	2
07:27:12	HD4G4G	8038	497228-14	395	38750	-96	-9	4G	3
07:27:16	CR4G4G	8038	497022-13	288	500	-89	-13	4G	1
07:27:17	CR4G4G	8038	497031-34	221	38750	-103	-14	4G	26
07:27:43	CR4G4G	8038	497022-21	290	1850	-74	-11	4G	24
07:28:07	CR4G4G	8038	497256-11	418	1850	-84	-15	4G	45
07:28:52	HD4G4G	8038	497256-13	418	500	-340	-	4G	49
07:29:42	CR4G4G	8038	497256-23	419	500	-77	-10	4G	29
07:30:11	CR4G4G	8038	497256-21	419	1850	-73	-9	4G	28
07:30:39	CR4G4G	8038	497258-11	381	1850	-72	-13	4G	14
07:30:53	CR4G4G	8038	497258-13	381	500	-80	-12	4G	2
07:30:55	HD4G4G	8038	497129-14	184	38750	-90	-12	4G	18
07:31:13	CR4G4G	8038	497258-23	383	500	-85	-12	4G	

Fig. 5 Data display on the *G-NetTrack Pro* application

Fig. 5 measured 4G *LTE* signal quality using the *drive test* method with *G-Net Track Pro software*. *G-Net Track Pro* is an Android-based application for monitoring and *logging* using cellular network parameters. The main display on the *G-NetTrack Pro* application is used to view *events* on the network during *drive tests* while measurements are being taken. The 4G LTE network quality parameters used are RSSI, RSRQ, and SINR during measurement. The values of these 4G network quality parameters will later be entered into categories according to KPI (*Key Performance Indicator)* standards. The KPI used in this study is the KPI from *the* Telkomsel *provider*.

5. Results and Analysis

1.1 Handover Data

The *handover* data shows that the number of *handover attempts* is 30 times, as can be seen in the data results table 4.1, which shows the RSSI values before and after *the handover*. Then, there were 29 *successful* handovers and 1 failed handover. Table 5 depicts handover results.

Table 5. Handover Results

Event	Number
Handover Attempt	30
Handover Failure	1
Handover Success Rate	29

$$Handover\ Success\ Rate\ (SR) = \frac{Handover\ Success}{Handover\ Attempts}$$

Thus:
If Handover Success = 29, *Handover Attempt* = 30

Calculation result:

$$Handover\ Success\ Rate\ (SR) = \frac{Handover\ Success}{Handover\ Attempts}$$

$$Handover\ Success\ Rate\ (SR) = \frac{29}{30} = 96{,}6\ \%$$

Therefore, *the Handover SR* has a value of 96.6%, which is quite good compared to the target KPI *mobility* value for the LTE network, which is >98% for excellent performance. Based on the analysis of RSSI, RSRQ, SINR, and *Handover* SR calculations for Telkomsel obtained from *drive test* results, it is known that the *handover* quality for the LTE network on Jalan Pendidikan in Mataram is good, with 29 out of 30 research data meeting the mobility KPI target value, namely *a handover* SR of >96.6%, which is categorized as good.

1.2 RSSI values before and after *handover*

Based on field measurement data from 30 samples, RSSI values were grouped into four range categories, namely (-100 to -120), (-86 to -100), (-71 to -85), and (-70 to -50) dBm.

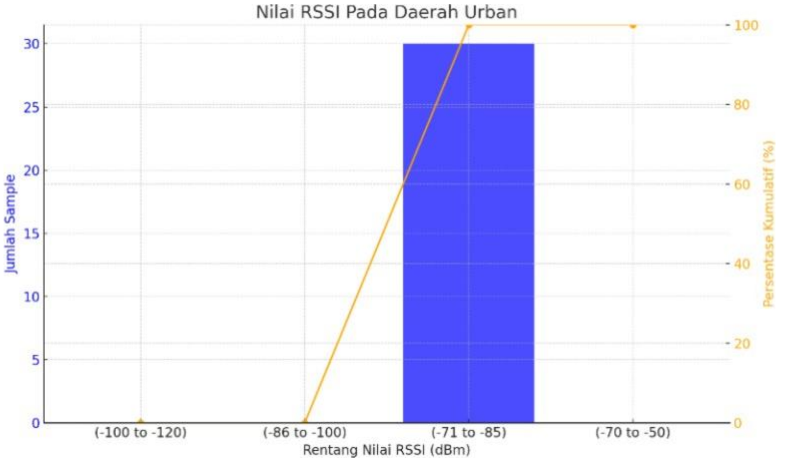

Fig. 6 RSSI graph before *handover*

Based on the graph in Fig. 6, the RSSI value data before *handover* shows that the signal strength (RSSI) is generally still within an acceptable range. Based on the RSSI value, most of the data is in the range of -85 dBm to -71 dBm. This indicates that before handover occurs, the device is still able to receive a strong enough signal to maintain a stable connection, even though it is not in optimal conditions. This range is an indicator that the network can still be used with adequate service quality. Meanwhile, no data was found in the very weak signal range (-120 dBm to -100 dBm). There is sufficient data in the range of -100 dBm to -86 dBm. Conversely, there is almost no data in the very good signal range (-70 dBm to -50 dBm). Therefore, it can be said that the RSSI value before the *handover* was successful *(*good). The value after the *handover* can be seen in Fig.7.

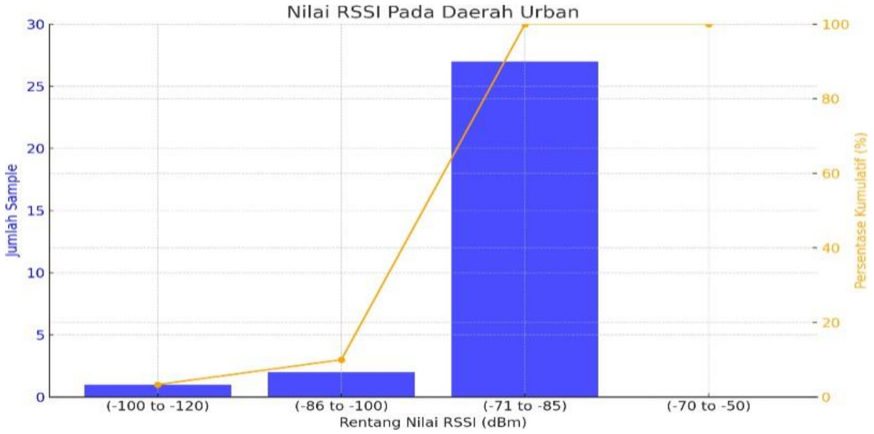

Fig. 7 RSSI after *handover*

Based on Fig. 7, which shows the RSSI values after *handover* in urban areas, it can be seen that most RSSI values are in the range of -85 dBm to -71 dBm, , which indicates the highest number of samples. This indicates that the signal quality in urban areas tends to be quite good, although there are several samples with lower RSSI values, such as in the range of -100 dBm to -120 dBm, which reflects weak signal conditions or failed *handover,* which may occur due to obstruction by tall buildings and other interference. The cumulative distribution after *handover* shows that *handover* failure occurred only once, and the samples had better RSSI values, meaning that the network after *handover* in urban areas is still stable enough for everyday use.

However, the presence of several very low RSSI values after *handover* indicates the existence of zones with poor signal coverage, which may occur in areas with dense buildings or locations with high interference. Overall, the signal quality after *handover* in urban areas is still relatively good, with most samples showing RSSI values sufficient to support stable communication and internet usage at the research location on Jalan Pendidikan in Mataram. However, improvements to network infrastructure in areas with weak signals are still needed to enhance the overall user experience.

1.3 RSRQ values before and after handover

The following is a graph comparing RSRQ before and after *handover*, where the data was collected 30 times, with 1 failure in the 17th data collection and 29 successful data collections.

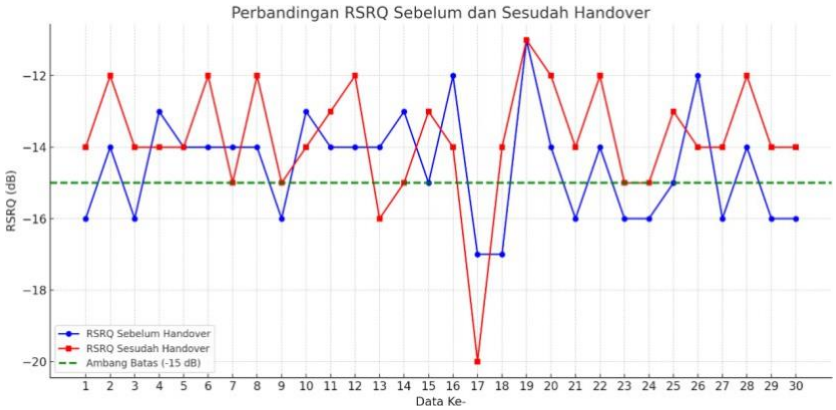

Fig. 8 Graph Comparing RSRQ Before and After *Handover*

Based on Fig. 8, the change in RSRQ (*Reference Signal Received Quality*) shows a tendency for signal quality to decrease after the *handover* process. This can be seen from the large number of negative RSRQ values, indicating that the RSRQ value after *handover* is less than optimal compared to before *handover*. Visually, more than half of the data experienced a decline in quality, and some of them experienced significant degradation. This condition indicates that the *handover* does not always transfer to a cell with better signal quality. Technically, a decrease in RSRQ value means an increase in interference from neighboring cell signals to the main signal. This can cause interference in the data *decoding* process, especially in services that require connection stability such as video *streaming.* This inefficiency could be caused by *handover* logic that only considers RSRP (signal strength) without taking into account the actual signal quality. Therefore, this graph reinforces the need to include RSRQ as a key parameter in *handover* decision-making*,* so that the cell-to-cell handover process is not only based on signal strength, but also takes into account signal quality to ensure service continuity and quality for users.

1.4 Comparison of SINR and *Throughput* before and after *handover*

Overall (30 data points) for *the provider* (Telkomsel) at the measurement point, the results show that 29 data points were successfully optimized, while 1 data point was not successfully optimized. This can be seen in Fig. 9

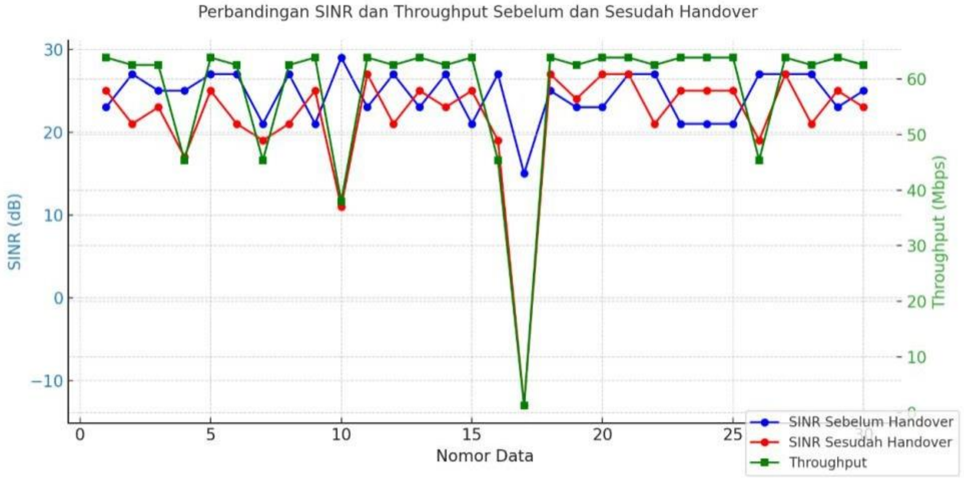

Fig. 9 Graph Comparing SINR and Throughput Before and After Handover

Based on Fig. 9, the results of Signal to Interference plus Noise Ratio (SINR) measurements before and after handover show a relatively stable pattern at most observation points, but with some significant data. In general, SINR values range from 15 dB to 29 dB, which, according to LTE signal quality standards, is classified as good to very good, thus capable of supporting high throughput services. These high SINR values contribute to throughput in the range of 45.36 Mbps to 63.84 Mbps at most points, indicating optimal connection quality. However, there are several data points that show a significant decrease in SINR after handover. The most striking example occurred in the 17th data point, where the SINR value after handover dropped dramatically to -13 dB from the pre-handover value of 15 dB. This extreme decline directly resulted in a throughput reduction to 1.28 Mbps, which is classified as very poor and unsuitable for supporting services with high bandwidth requirements. This phenomenon indicates the possibility of a failed handover to the target cell with suboptimal signal conditions, or the potential for significant interference in the destination cell.

There are also cases where the SINR value after handover increased compared to before handover, such as in data points 1, 9, and 15. At these points, the increase in SINR had a positive impact on throughput stability, which remained in the optimal range of around 63.84 Mbps. This shows that the handover mechanism in the network can work effectively in most conditions, by selecting a target cell that has signal quality equivalent to or better than the source cell. Thus, the graph provides visual evidence that the handover process is not yet fully optimal. In some cases, users are transferred to cells with poorer signal quality, resulting in a significant decline in performance.

1.5 Data results during the day and the afternoon

Table 6 describes measurement and calculation data for RSSI, RSRQ, SINR, and *Throughput* during the day

Table 6. Measurement and Calculation Data for RSSI, RSRQ, SINR, and *Throughput* during the day

Daytime

NO	RSSI		RSRQ		SINR	(dB)	
	Before handover (Cell ID)	After handover (Cell ID)	Before handover	After handover	Before handover	After handover	RESULT
1	-79 11	-81 21	-12	-15	23.0	25.0	Successful
2	-79 13	-79 23	-12	-12	27.0	21.0	Successful
3	-79 13	-113 23	-15	-20	25.0	-13.0	failed

Based on the measurement results of signal quality parameters before and after *handover*, it can be seen that the success of the *handover* process is greatly influenced by the stability of RSSI, RSRQ, and SINR values in the destination cell. In the first experiment, although RSSI decreased slightly from -79 dBm to -81 dBm and RSRQ decreased from -12 dB to -15 dB, the SINR value actually increased from 23 dB to 25 dB, allowing *the handover* to proceed smoothly. A similar thing happened in the second experiment, where RSSI and RSRQ remained stable at -79 dBm and -12 dB, even though there was a decrease in SINR from 27 dB to 21 dB, but the value was still in the very good category so that the connection was maintained. Conversely, in the third experiment, *the handover* failed due to a significant decrease in signal quality. RSSI dropped dramatically from -79 dBm to -113 dBm, RSRQ decreased from -15 dB to -20 dB, and SINR changed from 25 dB to -13 dB. These conditions indicate that the signal in the destination cell was very weak. The afternoon data can be seen in Table 4.5 below.

Table 7. Data on RSSI, RSRQ, SINR *Throughput* Measurement and Calculation Results in the Afternoon

AFTERNOON

NO	RSSI		RSRQ		SINR	(dB)	
	Before handover (Cell ID)	After handover (Cell ID)	Before handover	After handover	Before handover	After handover	RESULT
1	-79 11	-81 21	-12	-15	23.0	25.0	Successful
2	-79 13	-79 23	-12	-12	27.0	21.0	Success
3	-79 13	-113 23	-15	-20	25.0	-13.0	failed

Based on Table 4.5, during the first afternoon measurement, the *handover* process failed due to a decrease in signal quality. RSSI dropped from -73 dBm to -113 dBm, RSRQ decreased from -13 dB to -20 dB, and SINR changed from 23 dB to -13 dB. These values indicate that the signal at the destination cell was in the very weak category, accompanied by a high level of interference, so the connection could not be maintained. In the morning testing, it can be seen from the data results that the average handover failure always occurs in the target cell eNobeB2, which can cause the failure because the measurement location is on Jalan Pendidikan, Mataram City, where BTS 1 is located in Dasan Agung, Mataram City, and BTS 2 is located on Jalan Irigasi 2, Mataram City. The second BTS location has a higher user density (users) due to the densely populated area ( ) of residents or network users. As a result, BTS 2 is not strong enough to control users accessing the cell, causing the receiving BTS to experience dropped calls

6. Conclusion

This study obtains LTE network parameters through a drive test, which collects real-time field data to evaluate network performance with RSSI, RSRQ, SINR, and throughput. The analysis of LTE QoS on Jalan Pendidikan, Mataram City, from November 22, 2024, to December 13, 2024, shows that network quality before and after handover generally falls within the good to very good category across all parameters. The Handover Success Rate (HOSR) reaches 96.6%, reflecting stable performance, although slightly below Telkomsel's KPI target of >98%. Several measurement points reveal signal degradation after handover, primarily in destination cells affected by high traffic load, interference, and environmental obstacles such as buildings and trees. The findings also indicate that optimal throughput, averaging ±63.84 Mbps, correlates with SINR values above 20 dB, whereas severe SINR degradation (e.g., –13 dB) reduces throughput drastically to below 2 Mbps. These results confirm that successful handovers depend not only on signal strength (RSRP), but also on signal quality factors such as RSRQ and SINR to ensure service continuity. For future work, researchers should investigate advanced mobility management techniques, interference mitigation strategies, and machine learning–based predictive models to enhance handover decision-making and achieve higher QoS in dense urban environments.

References

[1] Afwan, M. I., Nasron, and Suroso, "Analysis of Telkomsel 4G Network Handover in Palembang at PT. Metro Global Service," *Proc. Nat. Seminar on Innovation and Technology Applications in Industry (SENIATI)*, vol. 5, no. 3, pp. 162–166, 2019.

[2] Budi, W. A. C., *Design and Construction of a Navigation Aid for the Blind Based on an Arduino Microcontroller Integrated with an Android Smartphone*, Doctoral dissertation, Universitas Nasional, 2022.

[3] Daffa, R., Saedudin, R. R., and Fathinuddin, M., "Analysis of 4G LTE Network Performance Using the Drive Test Method in the XYZ Building," *JIPI (Scientific Journal of Informatics Research and Learning)*, vol. 9, no. 2, pp. 548–557, 2024.

[4] Fatmi, Y. Y., Zainuddin, A., and Sasongko, S. M. A., "Analysis of Handover Quality in 3G Networks Based on Drive Test Data Using G-NetTrack and TEMS Mobile Insight Software in the Mataram Area (Case Study of PT. Indosat Tbk)," *Dielektrika*, vol. 5, no. 2, pp. 82–90, 2018.

[5] Fajar, A. N., and Devia, E., "Analysis and Optimization of 4G LTE Networks Using the Electrical Tilt Method Based on Drive Test," *Jurnal Jiifor*, vol. 1, no. 1, pp. 78–87, 2017.

[6] Ilfan, F., Hertiana, S. N., and Usman, U. K., "Analysis of Overlapping Coverage Requirements in Handover Cases on LTE Due to the Influence of User Movement Speed," 2021.

[7] Hakimah, P., "Analysis of QoS (Quality of Service) for Video Streaming Services with Codec H.265 on WLAN Networks in the Public Facility Building of the Sriwijaya State Polytechnic," *Momentum Journal*, vol. 21, no. 1, pp. 26–33, 2019.

[8] Teltonika Networks, "Mobile Signal Strength Recommendations," Available: https://wiki-teltonika-networks.com/view/Mobile_Signal_Strength_Recommendations. [Accessed: 2023].

[9] Laila, T. W. N., “Measurement and Analysis of Determining the Distance Between Base Transceiver Stations and Mobile Stations in Urban Areas with Open Area Conditions,” Mataram University, 2023.

[10] Rosyada, A., Zurnawita, Z., and Chandra, D., “Analysis of 4G LTE Handover Quality Based on Drive Test Parameters on the Padang-Pariaman Railway Line,” *TESLA: Journal of Electrical Engineering*, vol. 24, no. 1, p. 56, 2022. doi: 10.24912/tesla.v24i1.17753.

[11] Setiadi, K. A., Tjahjamooniarsih, N., Marpaung, J., and Imansyah, F., “Analysis of Handover Quality on Video Call Communication in 4G LTE Networks Based on Drive Test Data in Ketapang City,” *Journal of Electrical Engineering, Energy, and Information Technology (J3EIT)*, vol. 9, no. 1, 2020.

[12] Shojaifar, A., *Evaluation and Improvement of the RSSI-based Localization Algorithm*, Blekinge Institute of Technology, pp. 1–109, 2015.

[13] Adhitama, C. Y., Trisnawan, P. H., and Siregar, R. A., “Comparison and Influence of Handover on the Performance of Round Robin and Proportional Fair Packet Scheduling in LTE Networks,” *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer*, vol. 3, no. 3, pp. 2711–2716, 2019. Available: http://j-ptiik.ub.ac.id.

[14] Yuhanef, A., Aulia, S., and Yaseva, O. P., “Comparison of 4G LTE Network Quality Among Three Operators Using the Drive Test Method in Central Pariaman Beach,” *JIKO (Journal of Informatics and Computer Science)*, vol. 7, no. 2, p. 301, 2023. doi: 10.26798/jiko.v7i2.886.

[15] F. H. Khan and M. Portmann, “Joint QoS-control and Handover Optimization in Backhaul-aware SDN-based LTE Networks,” *Wireless Networks*, 2019.

[16] P. J. Gu, J. Voigt, and P. M. Rost, “A Deep Reinforcement Learning-based Approach for Adaptive Handover Protocols in Mobile Networks,” arXiv preprint, 2024.

[17] T. S. Kumar, M. Roslee, J. Jayapradha et al., “Advanced Handover Optimization (AHO) using Deep Reinforcement Learning in 5G Networks,” *J. King Saud Univ. Comput. Inf. Sci.*, 2025.

[18] S. Hakkou, T. Mazri, and N. Hmina, “Improvement of the LTE Handover Algorithms in Terms of Quality of Service,” *Indonesian J. Electr. Eng. Comput. Sci.*, DOI:10.11591/ijeecs.v28.i3.pp1720-1729, 2020.

[19] W. Benaatou, A. Latif, and V. Pla, “A Predictive Algorithm for Handover Decisions between LTE and LTE-A Networks,” *JTDE*, vol. 9, no. 4, 2021.