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Analysis Of Quality Of Service (Qos) For Xl's 4g Lte Network In Padang Panjang City

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ABSTRACT

The rapid advancement of telecommunications necessitates continuous improve ment in service quality, including 4G LTE networks. Padang Panjang's mountainous geography presents specific challenges, requiring a Quality of Service (QoS) analysis to evaluate public service levels. This study aims to measure and analyze the QoS of XL's 4G LTE network in Padang Panjang based on latency, jitter, packet loss, and throughput.The research employed an experimental method, conducting drive tests on planned routes. Data was collected using a smartphone with the TEMS Pocket application to measure parameters and Wireshark to analyze packet data. Results were processed using TEMS Discovery to assess performance against QoS standards.Findings showed an average throughput of 6.46 Kbps, latency of 0.000358 ms, jitter of 0.000356 ms, and packet loss of 0.3%. According to the TIPHON QoS standard, latency, jitter, and packet loss fall into the excellent category. However, throughput is classified as very poor. This indicates that while the XL 4G LTE network in Padang Panjang is stable and capable of supporting real-time services like VoIP and video conferencing, its data transfer speed performance remains severely inadequate. The study concludes that significant improvement in throughput is needed to meet overall service quality expectations.

INTRODUCTION

The swift evolution of information and communication technology, especially in mobile telecommunications, has positioned 4G LTE as a standard for high-speed data access. LTE technology is designed to offer peak download speeds of up to 100 Mbps and upload speeds of 50 Mbps, facilitating various data-intensive applications (Muna, Priyanto, & Puryono, 2023). In Indonesia, the proliferation of 4G LTE services demands that network operators not only ensure widespread coverage but also maintain high service quality to meet user expectations.

Padang Panjang City, located in a mountainous region of West Sumatra, presents a distinct geographical challenge for cellular network deployment. Topographical features such as hills and valleys can cause signal attenuation, shadow areas, and interference, potentially degrading network performance (Sari, 2022). Consequently, continuous network performance evaluation is crucial for operators like XL Axiata to identify service gaps and optimize their infrastructure.

Quality of Service (QoS) is a fundamental metric for assessing network performance from the user's perspective. Key QoS parameters include throughput (data transfer rate), latency (delay), jitter (delay variation), and packet loss (Aprianto Budiman, Duskarnaen, & Ajie, 2020). Regular measurement and analysis of these parameters provide objective data on network health and its ability to support various applications, from web browsing to real-time voice and video services.

While several studies have evaluated 4G LTE QoS in urban areas, limited research focuses on the performance in geographically challenging regions like Padang Panjang. Most existing studies prioritize throughput measurement but often provide limited simultaneous analysis of latency, jitter, and packet loss, which are critical for real-time applications. This study aims to fill this gap by conducting a comprehensive, multi-parameter QoS analysis.

Therefore, this research focuses on measuring and analyzing the QoS of XL's 4G LTE network in Padang Panjang City. The primary objectives are: (1) to measure the network's QoS parameters (throughput, latency, jitter, and packet loss) using the drive test method; (2) to analyze the measurement results based on standard QoS benchmarks (TIPHON); and (3) to provide an overview of the network's suitability for supporting modern data services. The findings are expected to contribute valuable insights for network operators in planning optimization and expansion, ultimately improving the quality of telecommunications services for the community in geographically constrained areas.

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LITERATURE REVIEW

Quality of Service (QoS) in telecommunications refers to the overall performance of a network as perceived by the end-user, often measured through specific technical parameters. For 4G LTE networks, key performance indicators (KPIs) include throughput, latency, jitter, and packet loss. Throughput measures the actual data transfer rate, crucial for user experience in data-heavy applications (Aprianto Budiman et al., 2020). Latency, or delay, is the time taken for a packet to travel from source to destination, critically impacting interactive services (Mikola & Sari, 2022). Jitter, the variation in latency, can degrade real-time audio and video, while packet loss indicates data packets that fail to reach their destination, often due to congestion or poor signal (Farras et al., 2025).

The drive test method is a standard technique for collecting real-world network performance data. Tools like TEMS Pocket are widely used for field measurements, capturing data on signal strength and throughput (Rahmat, 2022). Complementary software like Wireshark is employed for deep packet analysis to extract parameters like latency and packet loss (Luthfansa & Rosiani, 2021). The combined use of drive test tools and packet analyzers provides a holistic view of network QoS.

Previous studies have applied these methods in various geographical contexts. Research in dense urban areas often reports high throughput but may face latency issues due to user congestion (Yuhanef, Chandra, & Isnurisi, 2023). In contrast, studies in areas with challenging topography highlight different problems. For instance, research in **mountainous regions** has identified **signal attenuation and coverage gaps as primary causes of degraded throughput**, even when other parameters remain stable (Sari, 2022). A study focusing specifically on **operator XL** in a suburban setting also reported **suboptimal throughput performance** linked to capacity and interference issues (Perdana Sari & Eka Tassia, 2024). However, many of these studies tend to focus on a limited set of parameters, such as throughput and signal coverage, without providing a **simultaneous and comprehensive analysis of all four critical QoS parameters (throughput, latency, jitter, and packet loss)** in a singular geographically constrained environment.

This study aims to address this gap. It builds upon the existing body of work but distinguishes itself by conducting a **comprehensive, multi-parameter QoS evaluation** specifically in the **mountainous terrain of Padang Panjang**. By employing a combined methodology of drive tests (TEMS Pocket) and in-depth packet analysis (Wireshark/TEMS Discovery) on a **single operator's (XL) network**, this research provides a detailed and holistic assessment of network performance, offering insights that are specifically relevant to service provisioning in topographically challenging regions.

METHOD

In This study employed an experimental research design with a case study approach, focusing on the XL 4G LTE network in Padang Panjang City. The primary method for data collection was the **drive test**, which is a standard technique for assessing real-world network performance by collecting data along a planned route **(Perdana Sari & Eka Tassia, 2024; Rahmat, 2022)**. The selection of measurement tools, including the **TEMS Pocket** application for field measurement and **Wireshark** for packet analysis, was based on their established reliability and widespread use in similar network QoS studies **(Luthfansa & Rosiani, 2021; Yuhanef et al., 2023)**. The research flow, illustrated in Figure 1, consisted of several systematic stages: literature study, test planning, data collection, data processing, and analysis.

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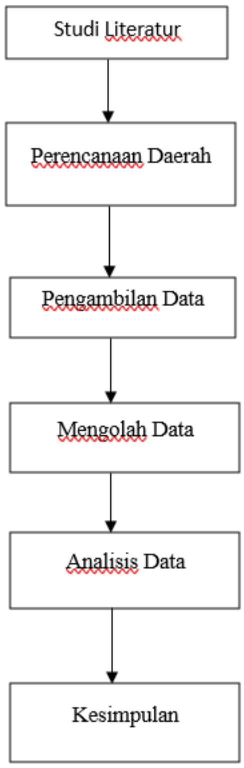

Figure 1. Research Methodology Workflow

The initial stage involved a comprehensive literature review to establish the theoretical foundation concerning LTE technology, QoS parameters, and drive test methodologies. Subsequently, the test area and route were planned. Using Google Earth, a representative route covering major roads and public areas within Padang Panjang City was designed to capture diverse network conditions. The selected route aimed to provide a snapshot of user experience across different parts of the city.

Data collection was executed using the drive test method. A Samsung smartphone equipped with the TEMS Pocket application was used as the primary measurement tool. The phone was configured with an active XL SIM card and set to lock onto the 1800 MHz frequency (Band 3). The TEMS Pocket application recorded network parameters in real-time while the researcher traversed the planned route. Simultaneously, to capture packet-level data for latency, jitter, and packet loss analysis, a voice call was initiated from the test phone to a fixed endpoint, and the traffic was captured using Wireshark software running on a connected laptop (see Figure 2 for a sample capture). This setup allowed for the correlation of RF measurements with core QoS parameters.

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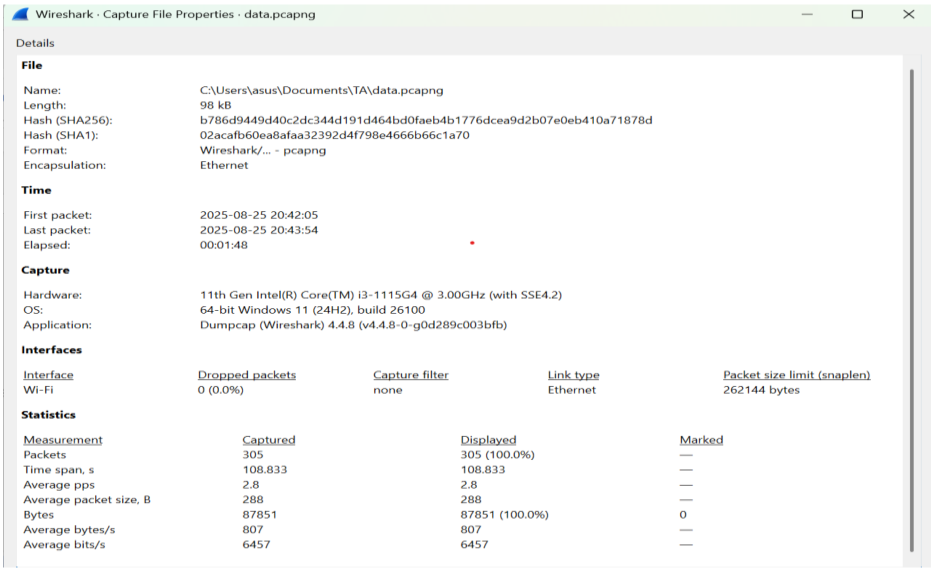

Figure 2. Data retrieval Wireshark

The collected data was then processed and analyzed. The drive test log files from TEMS Pocket were imported into TEMS Discovery software. This software processed the geographical and parametric data to generate visualizations, such as maps and graphs, specifically for throughput analysis (PDSCH Throughput). The packet capture files from Wireshark were exported and analyzed in spreadsheet software (Microsoft Excel). Key parameters were calculated using standardized formulas **(Aprianto Budiman et al., 2020)**:

Parameter Drive Test 4G

Latency : is a parameter that measures the duration required for data transmission from the starting point of sending to the final destination in a computer system, based on the Round-Trip Time (RTT) of the LTE network as received by the user equipment (Aprianto Budiman et al., 2020).

Table 1. Standar Latency

Kategori	**Legend**	**Latency (ms)**
Very good		0
Good		$0 \leq 75$
Fair		$75 \leq 125$
Poor		$125 \leq 225$

The formula for calculating the Latency value is:

$$\text{rata} - \text{rata delay} = \frac{\text{Total delay}}{\text{Total paket yang diterima}}$$

Jitter : is the variation in latency or delay between when a signal is transmitted and when it is received. It refers to small, intermittent delays during data transfer (Aprianto Budiman et al., 2020).

Table 2. Standar Jitter

Kategori	**Legend**	***Jitter* (ms)**
Very good		0
Good		$0 \leq 75$
Fair		$75 \leq 125$
Poor		$125 \leq 225$

The formula for calculating the Jitter value is:

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$$rata - rata\ jitter = \frac{Total\ variasi\ delay}{(Total\ paket\ yang\ diterima - 1)}$$

Throughput : is the effective data transfer rate, measured in bps (bits per second). It is the total number of successful packet arrivals observed at the destination during a specific time interval divided by the duration of that interval. Throughput represents the number of bits successfully transmitted in a network (Aprianto Budiman et al., 2020).

Table 3. Standar Throughput

Kategori	Legend	Throughput (kbps)
Excellent		≥ 2100
Very Good		≥ 1200 THP <2100
Good		≥ 700 THP <1999
Fair		≥ 400 THP <699
Poor		<339

The formula for calculating the Throughput value is:

$$Throughput = \frac{Paket\ data\ yang\ diterima}{Lama\ pengamatan}$$

Pocket Loss : is a parameter that describes a condition indicating the number of packets lost due to collision and congestion in a network. The failure of these packets is caused by several possibilities such as overload traffic, errors in the physical media, receiver-side failure, and path congestion(Aprianto Budiman et al., 2020).

Table 4. Standar Pocket loss

Kategori	Warna	Packet Loss (%)
Very good		0 – 2
Good		3 – 14
Fair		15 – 24
Poor		>25

The formula for calculating the Pocket Loss value is:

$$Packet\ loss = \frac{(Paket\ data\ dikirim - paket\ data\ diterima)}{Paket\ data\ dikirim}\ x\ 100\%$$

RESULT

In The drive test and subsequent data analysis yielded specific results for each of the four QoS parameters under investigation. The overall network performance is summarized in Table 1.

Table 5. network performance is summarized

No	PARAMETER	SATUAN	HASIL PENGUJIAN	KETERANGAN
1	Throughput	kbps	6,46 Kbps	Very Poor
2	Delay	ms	0.000358	**Excellent**
3	Jitter	ms	0,000356829503	Excellent
4	Packet Loss	%	0,3 %	Excellent

The table clearly illustrates the paradoxical nature of the network performance: while three parameters (latency, jitter, and packet loss) demonstrate excellent performance suitable for real-time applications, the throughput parameter shows critically poor performance that severely limits data-intensive applications. This combination of results provides the basis for the technical analysis and discussion presented in the following section.

Throughput: The downlink throughput measurement using the TEMS Pocket application revealed significant performance limitations. The average throughput calculated from the packet analysis was **6.46 Kbps**, which falls within the "Very Poor" category according to the TIPHON QoS standard (see Table 2.3 in Literature Review). Spatial analysis using TEMS Discovery software showed that this low throughput was not an isolated incident but a pervasive condition

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throughout the test area. As shown in Figure 3, **96.18%** of the sampled measurement points recorded throughput values in the lowest category (0-399 Kbps). Only minimal areas, representing approximately 2.53% of samples, showed throughput above 2100 Kbps ("Excellent" category). This distribution indicates a widespread challenge in achieving adequate data transfer speeds across Padang Panjang.

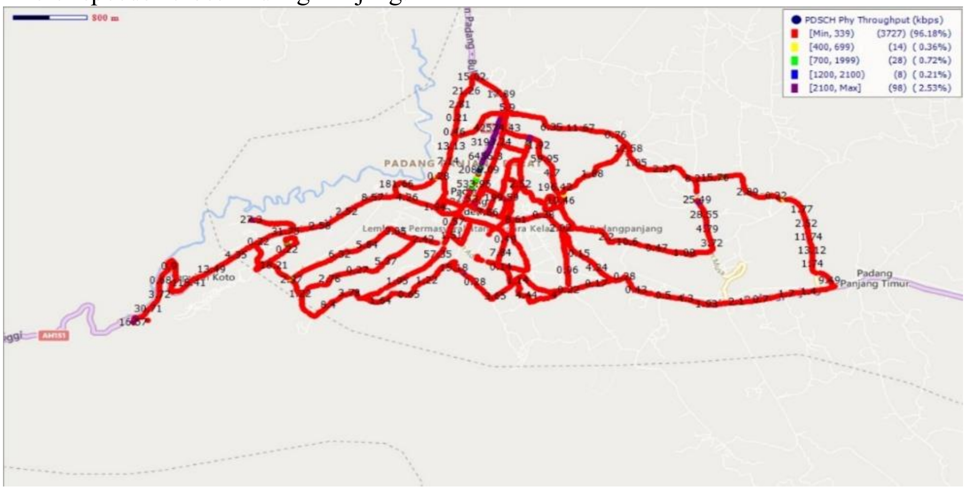

Figure 3. Throughput Measurement Map of XL Network in Padang Panjang

This figure illustrates the results of cellular network testing in the Padang Panjang City area. The route marked by a meandering red line indicates the measurement path, meaning that the tester traveled through various main and branch roads in the city. Each small point along the path represents a sampling area where PDSCH throughput (LTE/4G physical download speed) was recorded.

The legend on the right side shows color categories for the measured throughput, ranging from very low (0–399 kbps) to high (>2100 kbps). However, based on the percentages listed in the legend, almost all measured points (96.18%) fall into the lowest category, i.e., 0–399 kbps. The percentages for better throughput categories are minimal—even the high-speed rate above 2100 kbps is only about 2.53%, while the categories 400–699 kbps to 1200–2100 kbps are each less than 1%.

The map shows a distribution of color points dominated by dark blue (the lowest category), indicating that overall, most areas of the city experience poor downlink performance. The city center area, which has a higher number of measurements, also shows the same pattern, meaning that not only the suburban areas face problems. Points with higher throughput appear very rare and are randomly distributed, indicating that good connectivity is only present in specific locations, likely close to the eNodeB or areas with better signal and less interference.

Latency (delay) : The latency analysis from Wireshark packet capture demonstrated exceptional performance. The average latency calculated was 0.000358 ms (0.358 microseconds), which is far below the 150 ms threshold for "Very Good" category according to TIPHON standards (Table 2.1). The time-sequence analysis of packet delays, as visualized in Figure 4, showed remarkably consistent values with only minor fluctuations. The maximum observed latency reached approximately 0.02 ms at sample point 166, but this peak value remains negligible for practical applications. These results indicate that the network's packet delivery timing is highly consistent and responsive.

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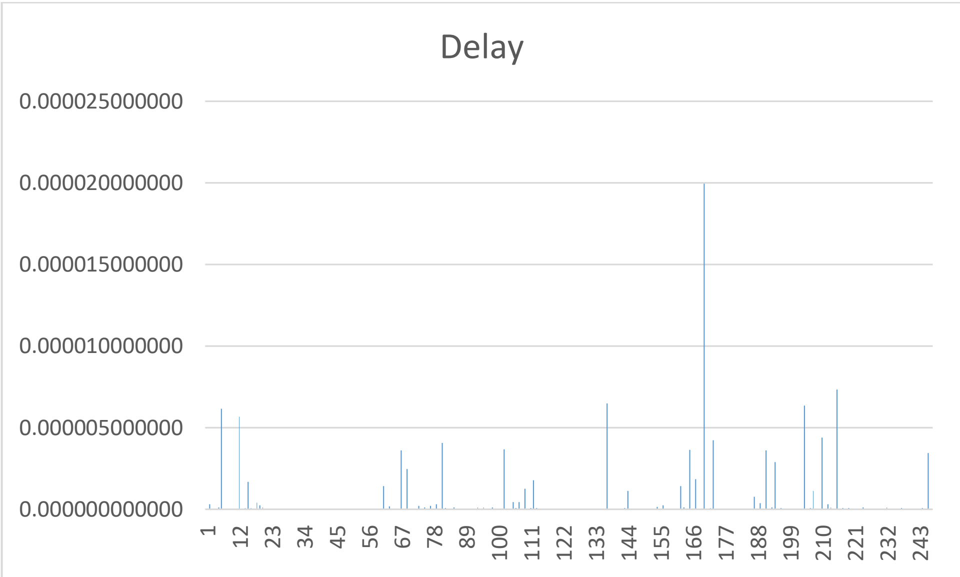

Figure 4. Data Latency (delay)

Jitter : Jitter, representing the variation in packet arrival times, also showed excellent performance. The calculated average jitter was 0.000356 ms (0.356 microseconds), which is well within the "Very Good" category (0 ms) per TIPHON standards (Table 2.2). As shown in Figure 5, the jitter values remained consistently close to zero throughout the measurement period, with only minimal positive and negative variations ranging between -0.00003 to 0.00005 seconds. This low jitter indicates stable packet delivery intervals, which is crucial for real-time communication services.

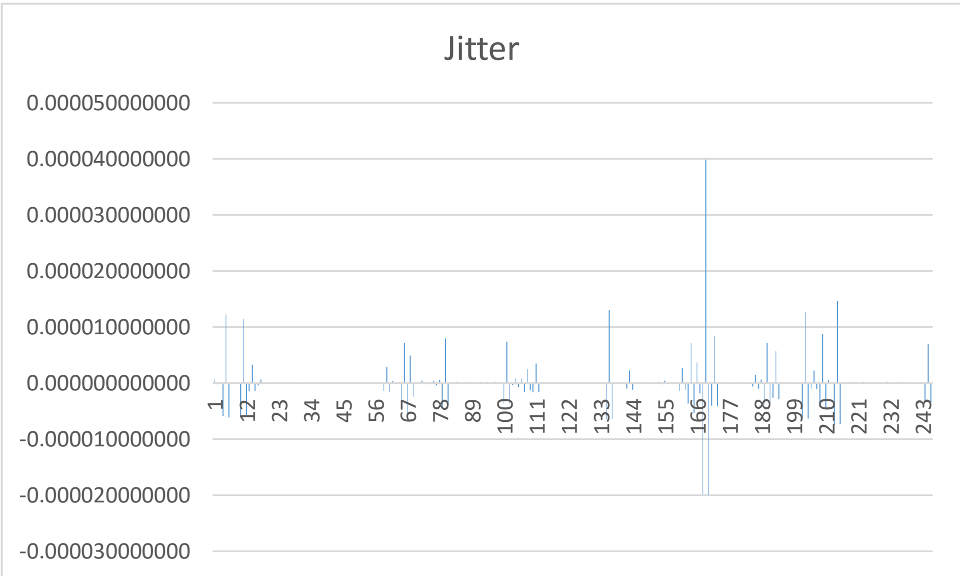

Figure 5. Data Jitter

Pocket Loss : The packet loss analysis revealed minimal data loss during transmission. The calculated packet loss rate was 0.3%, which falls within the "Very Good" category (0-2%) according to TIPHON standards (Table 2.4). Out of 305 packets sent during the measurement session, only 1 packet was lost, as confirmed by the Wireshark analysis shown in Figure 6. This low packet loss rate indicates reliable data delivery despite the challenging geographical conditions of Padang Panjang.

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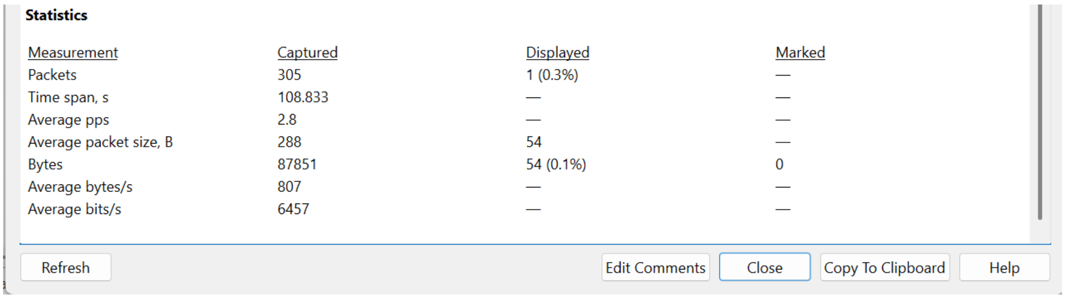

Statistics

Measurement	Captured	Displayed	Marked
Packets	305	1 (0.3%)	—
Time span, s	108.833	—	—
Average pps	2.8	—	—
Average packet size, B	288	54	—
Bytes	87851	54 (0.1%)	0
Average bytes/s	807	—	—
Average bits/s	6457	—	—

Figure 6. Data pocket Loss

DISCUSSION

In The results present a paradoxical scenario for the XL 4G LTE network in Padang Panjang. On one hand, the network demonstrates exceptional stability, as evidenced by the excellent scores for latency, jitter, and packet loss. These parameters are crucial for real-time, connection-oriented services. The extremely low latency and jitter indicate that the network's control plane and signaling are highly responsive, and data packets are delivered with remarkable consistency. This makes the network theoretically suitable for high-quality Voice over IP (VoIP), video conferencing, and online gaming, where timing is critical.

On the other hand, the throughput performance of 6.46 Kbps is critically poor and falls far below the expected standards for 4G LTE technology, which typically promises speeds in the Mbps range. This low throughput severely limits the user experience for bandwidth-intensive applications such as video streaming, large file downloads, and modern web browsing. The spatial data (Fig. 3) confirms that this is not an isolated issue but a pervasive condition across most of the tested route.

This disparity can be explained by the geographical and technical context of Padang Panjang. The mountainous terrain likely leads to challenges in radio frequency (RF) propagation, causing weak signal strength (low RSRP) and poor signal-to-interference-plus-noise ratio (SINR) in many areas. While the network may maintain a basic connection (explaining the good latency/jitter), the poor RF conditions drastically reduce the available bandwidth and modulation scheme that can be used, leading to very low throughput. Furthermore, potential network congestion or capacity limitations on the serving cell could also be a contributing factor, where the available radio resources are insufficient to meet user demand, again impacting throughput more directly than latency for connected users.

Comparing these findings with similar studies reveals a common theme. Research in other non-urban or topographically challenging areas often reports satisfactory latency and packet loss but significantly degraded throughput (Perdana Sari & Eka Tassia, 2024). This study corroborates that pattern, emphasizing that in such environments, coverage and capacity for high data rates become the primary constraints rather than network responsiveness.

A limitation of this study is its focus on a single operator (XL) and a specific, predefined route. Network performance can vary with time of day, user load, and exact location. Furthermore, the test was conducted using a dedicated data session; performance under mixed traffic loads (voice, video, data) might differ.

CONCLUSION

This study successfully measured and analyzed the Quality of Service (QoS) of XL's 4G LTE network in Padang Panjang City. The analysis leads to three main conclusions. First, the methodology combining drive tests with TEMS Pocket for field measurement and Wireshark for packet analysis proved effective for a comprehensive, multi-parameter QoS evaluation. Second, the results revealed a significant performance dichotomy: the network excels in time-sensitive parameters—exhibiting excellent latency (0.000358 ms), jitter (0.000356 ms), and packet loss (0.3%)—but fails dramatically in delivering adequate data speed, with an average throughput of only 6.46 Kbps, classified as very poor. Third, this indicates that while the XL network infrastructure in Padang Panjang is fundamentally stable and capable of supporting real-time communication services with high quality, its capacity for data transfer is severely limited, likely due to geographical challenges affecting radio signal quality and potentially limited cell capacity.

Based on these findings, it is recommended that the operator, XL Axiata, focus on network optimization and capacity enhancement in the Padang Panjang area. Technical strategies could include optimizing antenna tilt and azimuth to improve signal distribution, adding new cell sites or deploying small cells in high-demand areas to increase capacity, and implementing advanced radio features like carrier aggregation if supported. For researchers, future work should involve comparative studies with other operators, measurements at different times to assess network load impact, and the inclusion of additional parameters like RSRP and SINR to directly correlate RF conditions with the observed QoS results.

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