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Comparative Analysis of Voice Call Service Quality Between CSFB and VoLTE Technologies

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***Abstract*— This study compares the quality of voice services between Circuit Switched Fallback (CSFB) and Voice over LTE (VoLTE) technologies. Background: With the advancement of mobile networks and the shift from 4G to 5G, ensuring high-quality voice services remains critical. CSFB and VoLTE are two key technologies supporting voice calls on LTE networks. Objective: This research aims to evaluate and compare the performance of these technologies in terms of Key Performance Indicators (KPIs) and Quality of Service (QoS) metrics. Methods: The study was conducted through drive tests in East Padang using Tems Pocket software to measure RSRP, SINR, throughput, call setup success, and other relevant metrics. Results: VoLTE shows superior performance in several aspects. It offers better throughput, reaching an average of 7503.6 kbps compared to CSFB's 116.25 kbps. VoLTE also has faster call setup times, averaging 7084 ms, while CSFB requires 7600.5 ms. However, both technologies maintain a high retainability rate, achieving 100% with no call drops recorded. Conclusion: VoLTE outperforms CSFB in terms of throughput, call setup time, and overall service integrity, making it more suitable for delivering high-quality voice services over LTE networks. CSFB, while functional, is limited by its reliance on 2G/3G networks during voice calls, which results in longer delays and reduced throughput. Consequently, VoLTE proves to be a more efficient solution for modern voice services.**

Keywords—VoLTE, CSFB, LTE, KPI, GSM

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I. INTRODUCTION

The rapid advancement of cellular network technology continues to grow as cellular communication remains a necessity. Higher frequency bands exhibit distinct characteristics, and data is transmitted via radio waves divided into frequency bands. In Indonesia, the telecommunication industry has progressed to the fifth generation, or 5G, with operators striving to enhance service quality. Despite uneven distribution, voice services have remained a key component from the early days of mobile technology to the current 5G era. However, 4G LTE has achieved widespread coverage across the country. Unlike earlier generations, 4G LTE supports only Packet-Switched (PS) technology, meaning voice services that previously relied on Circuit-Switched (CS) technology must adapt. One adaptation is Circuit-Switched Fall Back (CSFB), allowing operators to deliver voice services over 4G. However, CSFB has limitations; it does not allow simultaneous data and voice use, as the network switches to CS for calls, pausing data sessions. To overcome this, Voice over Long Term Evolution (VoLTE) was introduced. VoLTE enables voice and messaging services over 4G LTE via the IP Multimedia Subsystem (IMS), allowing for full IP transmission of these services. Both CSFB and VoLTE are crucial in the transition from 4G to 5G voice services in Indonesia. Voice quality is typically measured using the Mean Opinion Score (MOS), while Key Performance Indicators (KPIs) are used to assess overall service quality. A 2013 study by Bautista J analyzed CSFB performance from LTE to UMTS. It found that in an optimized LTE Rel8 network, Mobile Originated (MO) and Mobile Terminated (MT) CSFB calls experience around a 1-second delay in call setup compared to CS calls on UMTS. LTE Rel9 networks reduced this delay to approximately 0.5 seconds. Additionally, switching back to LTE after a CSFB call took around 10 seconds using inter-RAT re-selection, or as little as 0.5 seconds with UMTS-to-LTE switching

II. LITERATURE REVIEW

The evolution of voice communication technologies in mobile networks has seen a transition from Circuit Switched (CS) technology to more advanced solutions like Voice over LTE (VoLTE). The Circuit Switched Fallback (CSFB) mechanism has been used as a temporary solution for delivering voice services in LTE networks. CSFB forces the network to revert to 2G/3G technologies for voice calls, which, although functional, presents several limitations, such as increased call setup time and the inability to simultaneously use data and voice services (Bautista et al., 2013). A study by Wardhana et al. (2014) discusses the impact of signal strength (RSRP) and signal quality (SINR) on the user experience in LTE networks. They conclude that poor SINR values lead to significant degradation in call quality, an issue often encountered in CSFB due to the switch from LTE to GSM. Further analysis by Barazzetta et al. (2020) compares VoLTE's ability to deliver high-quality voice services with minimal latency, highlighting VoLTE's superiority over CSFB due to its full-IP architecture.Febriana (2019) investigates the Single Radio Voice Call Continuity (SRVCC) method, which allows smoother transitions between LTE and legacy networks, particularly useful for voice services like VoLTE. VoLTE is noted for its low latency and higher data throughput, allowing for a better user experience, especially in high-traffic scenarios. Previous research suggests that although CSFB is still used in some regions due to lack of full LTE coverage, VoLTE is generally preferred for delivering superior voice quality and service reliability, thanks to its seamless handover capabilities and IP-based nature. Krasniqi et al. (2019) reinforce the notion that key performance indicators (KPIs) such as Call Setup Success Rate and Call Drop Rate are significantly improved with VoLTE, particularly in environments with strong LTE signal strength.

III. METHOD

A. Research Flow

This research was conducted in the form of a comparative analysis of voice service quality between VoLTE technology and CSFB technology on cellular networks in the East Padang area, Padang City, West Sumatra. This research uses non-participative observational qualitative methods, namely by comparing voice service quality parameters between each voice service technology. The following research flow is in Figure 1.

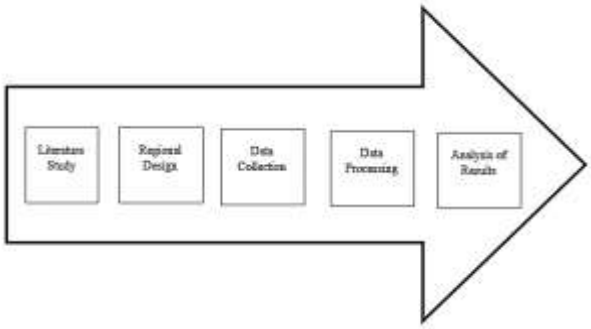

Figure 1. Research Flow

B. Research Data Flowchart

The process of analyzing the quality of voice services is generally divided into several stages, including initial problem analysis, planning, data collection, analyzing service quality measurement data and writing reports. In measuring service quality, it should be noted that the East Padang area already has a cellular network that supports VoLTE and CSFB technology. The service measurement is carried out using the drive test method. In general, the research methodology is shown in the flowchart in Figure 2.

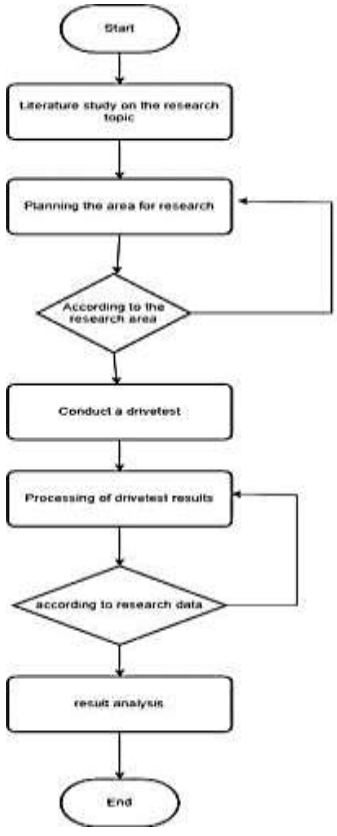

Figure 2. Research Data Flowchart

IV. RESULT AND DISCUSSION

A. Measurement Data Based on Key Performance Indicators

1) Reference Signal Received Power (RSRP) and Rx Level

The assessment of voice service quality using VoLTE technology begins with evaluating the power received by the user from the eNode B, commonly known as RSRP [7], as illustrated in Figure 3.

Figure 3. RSRP VoLTE Measurement

The figure shows the power quality received by the user when using VoLTE technology is dominant in the range of -100 dBm to -85 dBm with a total sample of 1082 samples, and in the range of -85 dBm to -75 dBm with a total sample of 476 samples. This shows the quality of power received by users when using VoLTE technology using LTE network is in good power quality. In accordance with the diagram in Figure 4 which shows the quality by users when using VoLTE technology using LTE network is in good power quality. In accordance with the diagram in Figure 4 which shows the quality of received power is quite constant in the range of -100 dBm to 70 dBm.

Figure 4. RSRP Diagram

While measuring the power quality for CSFB services, using the Rx Level parameter, because when using CSFB the cellular network service will move from LTE to GSM.

Figure 5. Rx Level Measurement CSFB

Based on Figure 5, it can be seen that the power received by users when using CSFB technology is quite good because the dominant receiving area is blue and green. The blue color indicates very good power quality or is in the range of -70 dBm to 0 dBm, while the green color indicates good power quality or is in the range of -80 dBm to -70 dBm. This is consistent with the power diagram received by the user when using CSFB technology in Figure 6.

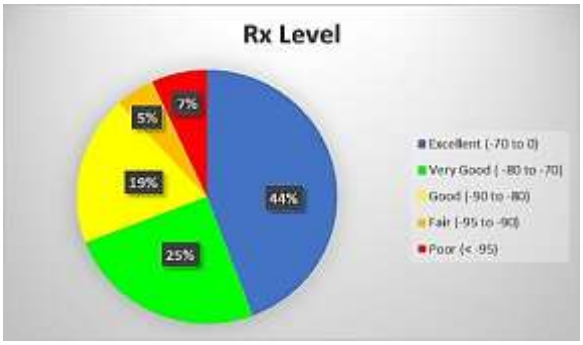

Figure 6. Rx Level Diagram

TABLE I
COMPARE THE AVERAGE POWER RECEIVED BY USER

Teknologi	Avr RSRP no call (dBm)	Avr RSRP on Call (dBm)	Avr Rx Lev on Call (dBm)
VoLTE	-89,76	-87,62	
CSFB	-87,53		-74,02

In measuring voice service quality with CSFB and VoLTE, RSRP is categorized as good (-90 dBm to -70 dBm), normal (-110 dBm to -91 dBm), and bad (-130 dBm to -110 dBm) (Wardhana Lingga et al., 2014). For Rx Level, poor is below -95 dBm, fair is -95 dBm to -90 dBm, good is -90 dBm to -80 dBm, very good is -80 dBm to -70 dBm, and excellent is -70 dBm to 0 dBm [8].

Before a call using CSFB, the average signal quality was -87.53 dBm, while for VoLTE, it was -89.76 dBm, indicating good 4G coverage. During VoLTE calls, the average RSRP was -87.62 dBm, in the good range. In CSFB, there's a handover to the 2G network, where the Rx Level was -74.02 dBm, falling under the excellent range

2) Signal to Interference plus Noise Ratio (SINR) and Rx Qual

The assessment of VoLTE (Voice over LTE) service quality can be performed by analyzing the network conditions that users experience, given that VoLTE operates over the LTE (Long-Term Evolution) network. A key metric for evaluating this quality is the Signal-to-Interference-plus-Noise Ratio (SINR), which measures the quality of the received signal. SINR quantifies the ratio of the strength of the received signal to the combined levels of interference and noise affecting the user.

In a 4G network context, SINR is divided into various quality ranges: a "good" range is defined as having SINR values from 16 dB to 30 dB, indicating high-quality service with minimal issues. The "normal" range, which spans from 1 dB to 15 dB, suggests an adequate level of service, although some users may notice occasional quality dips. Conversely, the "bad" range, encompassing SINR values from -10 dB to 0 dB, generally leads to a poor user experience characterized by frequent disruptions and degraded voice quality.

Figure 7. SINR Measurement VoLTE

In Figure 7, the SINR plot reveals a clear dominance of the red region, which signifies poor network quality characterized by a signal-to-interference-plus-noise ratio (SINR) that falls below 0 dB. This alarming result is represented by a total of 578 samples, indicating that a significant portion of users is experiencing subpar network conditions that can lead to interruptions and degraded service. In contrast, the yellow area of the plot highlights weak service quality, corresponding to SINR values that range from 0 dB to 13 dB. This suggests that, while some users may have slightly better connectivity, it still falls short of optimal performance. Furthermore, this trend is corroborated by the VoLTE SINR diagram presented in Figure 8, where the predominant values are consistently below 15 dB. This further underscores the challenges faced by users in accessing reliable service, as the low SINR values indicate persistent interference and noise, which can significantly impact the overall quality of voice and data transmissions.

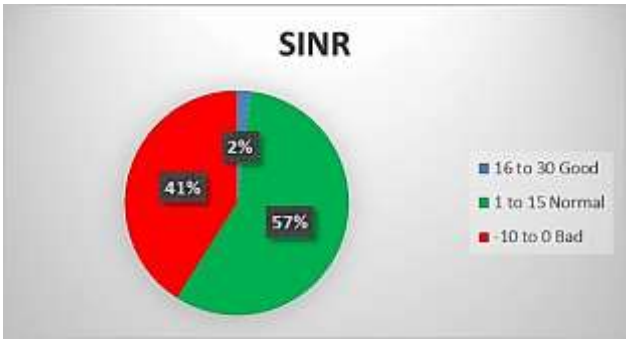

Figure 8. SINR Diagram

While the network quality when using CSFB technology based on Rx Qual parameters as shown in the plot in Figure 9.

Figure 9. Rx Qual Measurement CSFB

In Figure 9, it is illustrated that there are 667 samples marked in red, representing network conditions above 6 dB, which signifies poor quality. Additionally, 184 samples are shown in yellow, indicating weak service quality, while 130 samples in green denote good service. Furthermore, 283 samples in blue represent very good service. Based on this visualization, it is evident that the GSM network service quality experienced by users when utilizing CSFB technology is generally classified as poor, since over half of the samples gathered in the East Padang region fall within the weak and poor categories. This is further demonstrated in the network quality diagram presented in Figure 10.

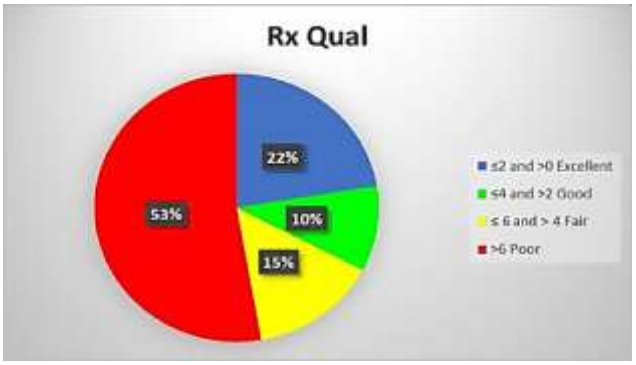

Figure 10. Diagram Rx Qual

When making voice calls using VoLTE technology, which operates over the 4G network, the Signal-to-Interference-plus-Noise Ratio (SINR) is recorded at 2.83 dB. This value places the connection in the "fair" or "weak" SINR category, suggesting that the signal strength is not optimal, and users may experience some degradation in call quality due to interference and noise within the network. VoLTE, while designed for high-quality voice communication over 4G, can still encounter issues when SINR values fall into this range, affecting the overall user experience.

TABLE 2
NETWORK QUALITY COMPARISON

Teknologi	Avr SNR no call (dB)	Avr SNR on Call (dB)	Avr RxQual on Call (dB)
VoLTE	1,27	2,83	
CSFB	4,09		4,38

Based on the signal quality data in Table 2, prior to making a service call, the LTE network shows a normal signal quality with a SINR value of 1.27 dB. This indicates stable performance, with minimal interference. For CSFB technology, which operates on the 2G network, the Rx-Qual value is 4.09 dB, also within the normal range but closer to the weaker end, indicating less robust signal quality.

3) Throughput

Throughput is the actual bandwidth when transferring files of a certain size. With a range of values as in table 3.

Figure 11. Throughput Measurement VoLTE

Throughput when performing VoLTE technology services based on Figure 11 is in the range of 0 kbps to 512 Kbps as many as 501 samples, 512 kbps to 1000 kbps as many as 482 samples, and 1000 kbps to 7000 kbps range as many as 709 samples. Based on Figure 12, the percentage of low and fair is 58%, indicating poor throughput.

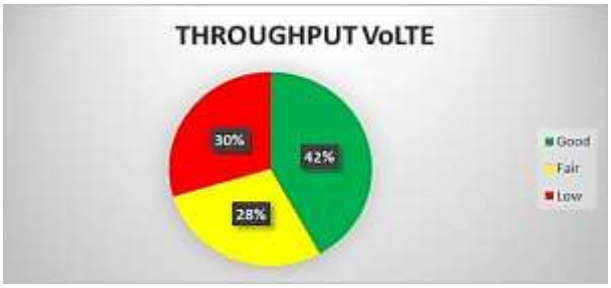

Figure 12. VoLTE Throuput Diagram

Figure 13. Throughput Measurement CSFB

Figure 13 illustrates the throughput for the CSFB (Circuit-Switched Fallback) service, revealing that the data falls within the range of 0 Kbps to 512 Kbps, encompassing a total of 1,300 samples. This indicates that the throughput for CSFB is categorized as low, as further supported by the information presented in Figure 14.

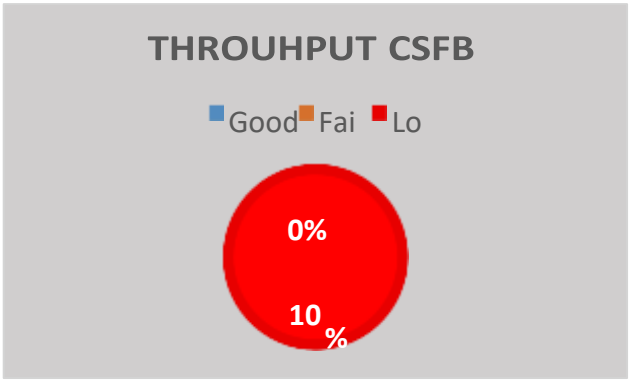

Figure 14. Diagram Throughput CSFB

B. Measurement Data Based on Key Performance Indicator (KPI) QoS

1) Accesibillity

Accesibillity is the ability of users to access the network to start communication [10].

TABLE 3
ACCESSIBILITY MEASUREMENT

Teknologi	*Call Access Success Rate*	*Call Setup Success Rate*	*Call Setup Success Delay*
CSFB	100 %	100 %	50 %
VoLTE	100 %	100 %	25 %

In Table 4, it can be seen that the Call Access Success Rate and Call Setup Success Rate values of VoLTE and CSFB technologies have a value of 100%. However, in Call Setup Success Delay Distributing CSFB has a higher value than VoLTE, with a large percentage of CSFB value of 50% while in VoLTE it is 25%.

2) Service Integrity

Service integrity reflects the quality of service provided to users, influenced by the E-UTRAN network. VoLTE offers better service integrity than CSFB, with higher throughput (7503.6 kbps vs. 116.25 kbps) and lower latency. VoLTE's call setup delay is around 81 ms, significantly faster than CSFB's 142,260.2 ms, due to faster handovers in VoLTE. This makes VoLTE more efficient and reliable compared to CSFB for voice services.

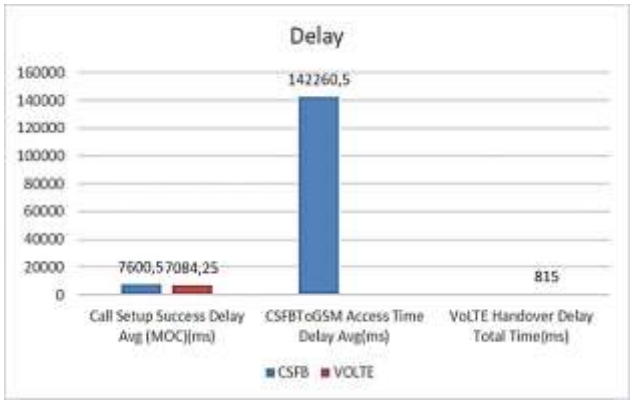

Figure 15. Delay Measurement

3) Mobility

Allows the service to continue while performing handover [11].

TABLE 5
MOBILITY MEASUREMENT

INDIKATOR	CSFB	VOLTE
Inter RAT Redirection To GSM Success Rate (%)	100	
LTE HO Success Rate (%)		100

In Table 5, it can be seen that mobility in CSFB technology occurs Inter RAT service transfer from 4G to GSM with a success percentage of 100%, while in VoLTE technology there is a handover on the LTE network with a success percentage of 100%. Which in CSFB technology occurs Intercell handover with a success percentage of 100% and in VoLTE technology occurs inter e-nodeB handover, intra fequency handover, intra e-nodeB handover with each success percentage of 100%.

4) Retainability

Retainability is the ability of the network to maintain services [10].

TABLE 4
AUDIO PACKET LOST RATE IN CSFB AND VOLTE

INDIKATOR	CSFB	VOLTE
Audio Packet Lost Rate Counter	0	271
CSFB Call Drop Rate (%)	0	
VoLTE Call Drop Rate (%)		0

In VoLTE technology there are 271 audio packet lost samples while in CSFB there are no audio packet lost. In the table it can also be seen that the Call Drop rate of VoLTE and CSFB has a value of 0%. Based on the retainability parameters of the measurement results, it can be seen from the call drop rate that each CSFB and VoLTE technology has the ability to maintain the same good service.

V. CONCLUSION

The difference in service quality is viewed from the key performance indicator (KPI) parameter drive test with good user acceptance conditions and the same weak network quality, but the throughput is greater when using VoLTE technology than when using CSFB technology. With an average throughout VoLTE of 7503.6 kbps and CSFB 116.25 kbps. Based on QoS parameters, VoLTE and CSFB have the same initiation/accessibility capability between VoLTE and CSFB, VoLTE service integrity is better than CSFB. With a delay value of 7600.5 ms on CSFB and 7084 ms on VoLTE. And 100% retainability which is characterized by 0% call drop.

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