

VoLTE and ViLTE Quality Measurement for LTE Over IMS Technology

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Abstract—Video conferencing has become a widely adopted solution for meetings involving remote participants and rapid communication. This service must comply with the required Quality of Service (QoS) parameters to meet user expectations. The primary purpose of this work is to assess the energy consumption and jitter of a real-time testbed for Video over LTE (ViLTE) and Voice over LTE (VoLTE) over an IP Multimedia Subsystem (IMS). Modern technology is deployed to recreate the best feasible scenario for this goal. Based on the results of our test experiments, VoLTE can drain the battery faster than ViLTE, which consumes up to 112% of the battery while using the LTE B7 band. Our study provides an analysis of jitter evaluation for video conversations, evaluates power usage for ViLTE and VoLTE services, and quantifies jitter values.

Index Terms—VoLTE, ViLTE, IMS, Battery Consumption, Jitter.

I. INTRODUCTION

Mobile communications technology is known for its exponential growth. However, legacy technologies are still in constant use in many countries. Additionally, despite the rise of New Radio (NR), which offers new services with Quality Of Services (QoS), regions such as Brazil and other developing nations have only recently started implementing services through IP-based networks. These solutions include

voice, video, text, and other technologies that utilize the IP Multimedia Subsystem (IMS) network.

Regarding emergent market trends, voice and video are the most extensively used methods for communication among people. VoLTE and ViLTE services, powered by the IMS, are among the most utilized communication methods. These services represent an essential network that employs Long-Term Evolution (LTE) as the radio communication method to deliver high-quality services with reduced latency and optimized battery usage in User Equipment (UE) compared to legacy technologies [1].

Within IP-based communication services, various key performance metrics are used to assess the effectiveness and efficiency of these services. One such metric is jitter, which plays a significant role in LTE's Quality of Service (QoS) standards. Jitter is crucial for managing network performance across data, voice calls, and video services over IP networks [2]. While these high-quality services enhance the overall user experience, they can also lead to unintended consequences, such as increased battery consumption in User Equipment (UE). This trade-off between service quality and device power consumption is an important consideration in modern mobile communication systems.

According to [3], millions of dollars are spent annually on electricity bills to fully charge User Equipment (UE). Furthermore, as new communication services emerge, they imply varying energy demands, highlighting the need to understand the trade-offs between power consumption in user devices and the type of communication services used by end-users.

This work aims to develop a testbed that evaluates battery consumption metrics for VoLTE and ViLTE services while analyzing the differences in QoS standards related to jitter for voice and video calls within an IMS-powered LTE network.

This article is organized as follows: Section II presents related works, while Section III covers the necessary background on mobile telecommunications, including LTE, IMS, VoLTE, ViLTE. Section IV describes the methodology and setup for analyzing battery consumption during voice and video transmissions. Section V provides the results of our analysis, and Section VI concludes with key findings.

II. RELATED WORKS

According to the research [4], the authors studied the battery consumption and jitter of a high-performance device under VoLTE and Voice over NR (VoNR) services over IMS technology. Furthermore, the work demonstrated that New

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Radio (NR) technology is more efficient in terms of battery consumption and packet delivery rate. Nevertheless, the research did not consider video calling service, such as ViLTE or ViNR. Additionally, the battery consumption results of NR and LTE technologies were extremely high, indicating a lack of concern for maintaining a stable test scenario. For instance, there is no evidence to suggest that the transmission power of the device remained stable throughout the tests.

The study in [5] provides a thorough examination of the voice quality performance of VoLTE and ViLTE across various measurement settings. It offers important tests to assess how Quality of Service (QoS) factors at different network tiers affect the QoE of ViLTE services. Nonetheless, a critical aspect not addressed in these works is the influence of service quality on battery consumption. This is particularly important because improved service quality can have a direct impact on the power consumption of User Equipment (UE).

In [6], the authors investigate the difference in power consumption for voice and video services on LTE and NR networks, finding significant differences based on device state (idle, connected, airplane mode). Their results indicated that NR consumed considerably less energy than LTE — 27.77% less during video calls and 14.86% in idle mode. However, the study did not include QoS parameters to evaluate whether the reported improvements in efficiency were achieved while maintaining acceptable service quality for end users.

III. KEY CONCEPTS AND THEORETICAL BACKGROUND

A. LTE and IMS Architecture

In the LTE architecture, there are several layers in the service process between the UE and the network. The UE connects the users to the LTE network, starting at the first layer [7]. In the second layer, the Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) is responsible for the radio communication services between the UE and the Evolved Packet Core (EPC) using evolved NodeBs (eNBs). The Home Subscriber Server (HSS) stores the subscriber data, while the Mobility Management Entity (MME) handles access control, protection, and roaming of the UE. Finally, the Packet Data Network Gateway (PGW) connects the UE to other mobile wireless networks by providing Internet Protocol (IP) addresses, managing IP packet transmission and ensuring a simple and efficient data experience.

On the packet side, data must go through all the entities of the core for successful communication and data exchange. Due to the network's design, there is a possibility of data accumulation process delay and errors occurring along the way.

Voice, video, conference, and instant messaging are a few examples of the IP-based multimedia services provided by the IMS architecture. This architecture consists of several layers and protocols including the Proxy-Call Session Control Function (P-CSCF), Session Border Controller (SBC), Interrogating-Call Session Control Function (I-CSCF), Break-out Gateway Control Function (BGCF), Serving-Call Session Control Function (S-CSCF), and HSS, as illustrated in Fig. 1.

Similar to the data packets transmitted through the EPC in the LTE network, data in the IMS design must adhere to

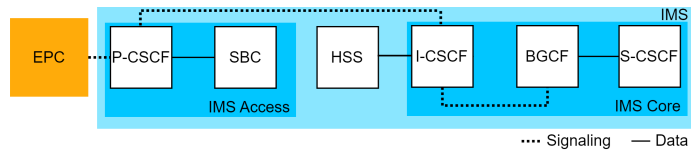


Fig. 1. The Essential Architecture of IMS

the rules of the IMS core. The P-CSCF is responsible for providing an interface between the UE and the IMS network, serving as a session control proxy that routes communication sessions between the user's terminal and the IMS network [8]. Additionally, the SBC controls and manages streaming media traffic between the IMS network and the Internet [9]. To access the IMS network, the I-CSCF acts as a gateway for the UEs [8]. Similarly, the BGCF is essential for controlling and managing call routing among IMS networks and other networks [9], as well as managing communication session between the UE and IMS networks and providing services such as forwarding, rejecting, and transferring calls. According to LTE, the HSS is a database that maintains user information, including user profiles, service settings, and authentication data. It is also the database used by IMS network session control components to authenticate and authorize users [10].

B. Voice and Video Over LTE (VoLTE and ViLTE)

During a voice call, VoLTE maintains both control and data sessions simultaneously. The signaling messages that initiate the call flow through the control plane, utilizing Session Initiation Protocol (SIP) to govern the call. Voice packets are encoded using the Adaptive Multi-Rate Wide Band (AMR-WB) codec and transmitted across the data plane using the Real-time Transport Protocol (RTP) [11].

VoLTE is projected to provide benefits to both network operators and end users. For carriers, it offers increased efficiency in network resources and spectrum efficiency, along with seamless worldwide roaming. From the user's perspective, the most noticeable advantage is improved speech quality, as VoLTE employs a wideband codec to enable clearer and more natural voice communication compared to traditional technologies. Additionally, VoLTE benefits from the use of a dedicated bearer, which ensures Quality of Service (QoS) for voice transmission. Prior to VoLTE, all application data, including voice, was delivered across a default carrier without any QoS guarantees [12].

ViLTE services include full-duplex phone calls and simplex or full-duplex video media with synchronization between the component streams. To enable interoperability for high-quality IMS-based conversational video service over LTE, ViLTE is specified in GSMA standards as a fundamental set of necessary characteristics that wireless devices and the network itself must possess. These features are also outlined in [11].

In ViLTE signaling, messages must be sent through the IMS platform to activate the dedicated bearers, which transmit video and audio RTP data to establish a ViLTE session. A detailed description of the signaling procedures for initiating a ViLTE call can be found in [11], [12], [13].

Similarly to a VoLTE request, the UE connects to the LTE network through an eNodeB and sends a ViLTE service request using the IMS signaling protocol SIP. Then, the CSCF transmits the request to the IMS network, which requires the Policy and Charging Rules Function (PCRF) to allocate bearer resources for the appropriate media. After processing the network signals, the CSCF re-transmits them to the Application Servers (ASs) in the EPC. Consequently, the AS completes the service based on the data provided by CSCF. To assign resource and configure the ViLTE call bearers, the PCRF informs the PGW and the Serving Gateway (SGW). When it comes to VoLTE, ViLTE services require the UE's video capabilities to be transferred to the LTE network [11], [12], [13].

It is crucial to remember that each service must be assigned an identifier. For IMS services, this is known as QoS Class Identifier (QCI), which serves as a scalar reference to specific packet forwarding behaviors, such as packet loss rate or packet delay to be provided to a service data flow [14]. In the case of ViLTE service, the PGW and SGW establish two separate service bearers, often both Guaranteed Bit Rate (GBR), one for the video and other for audio. The corresponding QCI for video traffic is 2, while for voice traffic, it is 1 [11], [12], [13].

A ViLTE session can be established by supplementing an existing VoLTE conversation with a video media flow or by initiating a parallel IMS session that includes both voice and video. If the GBR bearer allocated for video fails to establish or is lost during the session, the network may either continue the call in voice-only mode—by terminating the video SIP dialog—or completely terminate the related SIP session for the GBR bearer [11].

IV. METHODOLOGY

On the network environment side, various advanced technologies and equipment have been employed to set up a test environment and provide optimal conditions for conducting and analyzing the tests and results, as illustrated in Fig. 2. The Keysight UXM 5G E7515B was used to configure the radio communication test station by simulating both the 4G Core (4GC) and IMS network features for the DUT (3). To collect UE voltage data, the Low Voltage Monsoon Power Monitor FTA22D was utilized. Additionally, the FTA22D is essential for replacing and accurately evaluating the battery consumption of the DUT (2). A laptop was required to record battery consumption information using the PowerTool software, which is the property of the FTA22D equipment, to access the test results (1). Furthermore, jitter related to VoLTE and ViLTE communication services was analyzed using Wireshark's free and open-source network protocol analyzer.

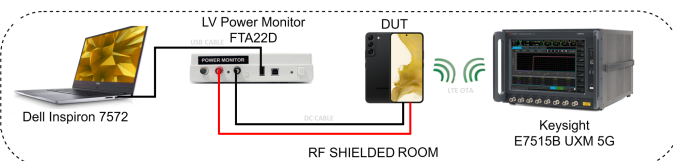


Fig. 2. Design for the high-level LTE setup

To develop the testbed on the UE side, a high-end Device Under Test (DUT) was utilized. The DUT featured a battery capacity of 3700 mAh, powered by the Snapdragon 8 Gen 1 processor and modem-RF Snapdragon X65 5G components. It ran One UI 4.1 with Android 12 as its operating system.

In addition to ensuring accurate measurements by avoiding external interference, all experiments were conducted in an RF-shielded room. This controlled environment provides a radio frequency quiet space essential for precise testing in mobile wireless technology.

A high-performance test environment has been established based on the settings provided in Fig. 2. Additionally, according to [4], the parameters and configurations such as Band, Modulation, Frequency, Sub-Carrier Spacing (SCS), Bandwidth, Power Tx and the main functions for this work, including the Physical Uplink Shared Channel (PUSCH), which controls the power data traffic in the uplink channel, are described in Table I.

TABLE I
SETUP PARAMETERS

	LTE scenario configuration	
Band	B7 (2600 MHz)	B28 (700 MHz)
BW	20 MHz	20 MHz
SCS	15 kHz	15 kHz
Power TX	-18 dBm	-18 dBm
PUSCH Power	-11 dBm	-12 dBm
Modulation	64 QAM	64 QAM

To ensure that the measurements of the current related to battery consumption were as accurate as possible, the PUSCH was controlled and fixed within a specific range for both bands. Regarding jitter, Enhanced Voice Services (EVS), a super-wideband speech audio codec developed by 3GPP for audio, and Advanced Video Coding (AVC), also known as ITU-T H.264, a standard for video compression that can provide excellent video quality with significantly lower bit rates, were analyzed [15].

To evaluate the impact of different frequencies on services based on QoS metrics such as jitter, two Frequency Division Duplex (FDD) bands (B28 and B7) were used. The center frequency of B7 is 2600 MHz, while for B28, it is 700 MHz. Using these bands allows for data collection on how high and low frequency impacts the services.

An important point is that the structured sampling technique is a crucial component of the testbed: 20 samples were selected for the VoLTE service and 20 for the ViLTE service, with each sample containing approximately 6,000 data points. This technique enabled multiple rounds of testing for both services, resulting in statistically significant and uniform findings.

To accurately assess battery usage, a four-step process was created and consistently implemented. The procedure began with a battery bypass setup, which connected the Device Under Test (DUT) to a DC power analyzer. Initially, the DUT was set to airplane mode for 20 seconds to record its baseline energy consumption. Afterwards, airplane mode was turned off to reconnect with the mobile network and enable IMS-based audio or video communication. A 40 seconds stabilization phase was then observed to ensure that the network and system were ready for data collection. Finally, a VoLTE or ViLTE call was established and maintained for 60 seconds. Each trial

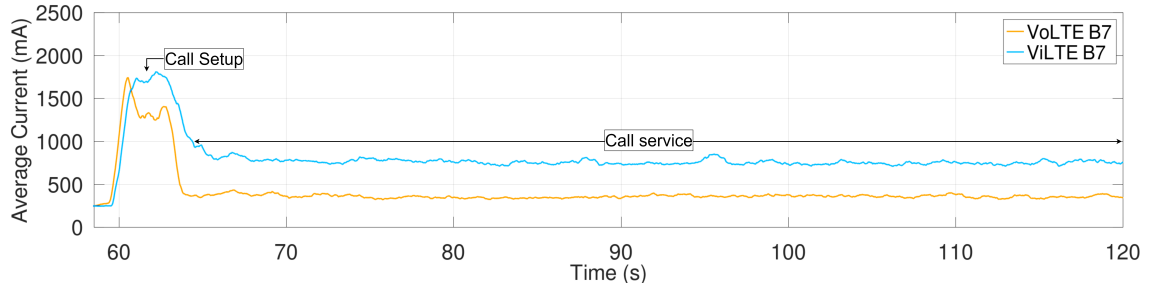


Fig. 3. Average current consumption comparison between VoLTE and ViLTE services over IMS at band B7 (2600 MHz)

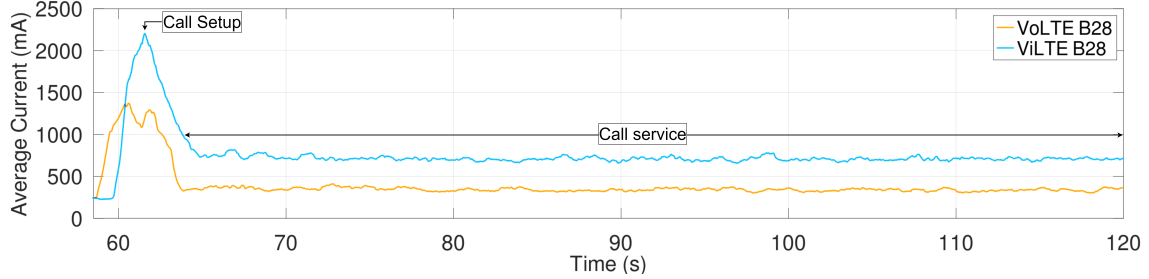


Fig. 4. Average current consumption comparison between VoLTE and ViLTE services over IMS at BAND B28 (700 MHz)

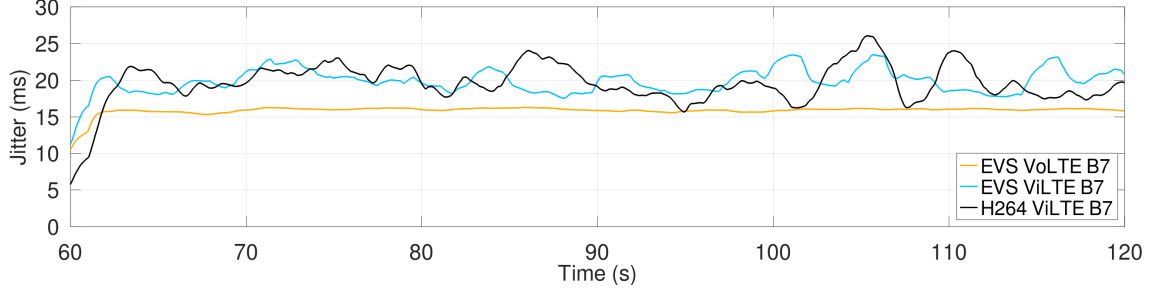


Fig. 5. Jitter comparison between VoLTE and ViLTE services over IMS at band B7 (2600 MHz)

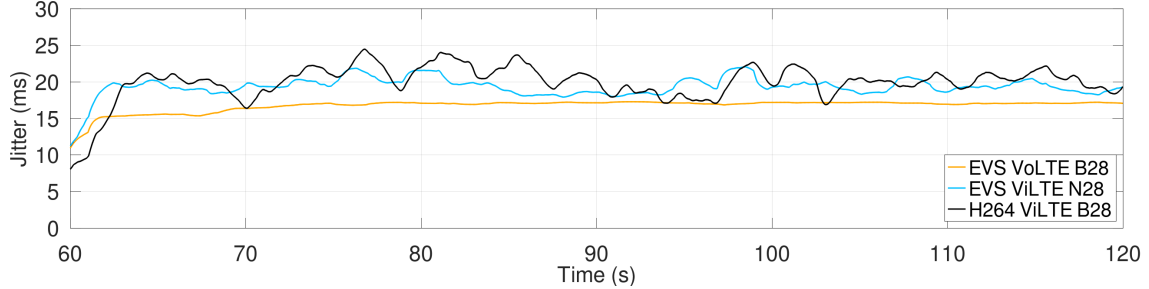


Fig. 6. Jitter comparison between VoLTE and ViLTE services over IMS at band B28 (700 MHz)

lasted 120 seconds, including all preparatory and measurement steps.

V. RESULTS

The comparisons between VoLTE and ViLTE for the B7 and B28 consumption test scenarios are shown in Figs. 3 and 4, respectively, while the jitter scenarios are depicted in Figs. 5 and 6. All results consider the test scenario outlined in the preceding sections. In all cases, the outcomes will be presented in terms of current usage and delay in milliseconds. These results can be compared to the current voice call usage displayed in the analysis in the [4]. The results presented in Figs 3 and 4 only take into account the moment when the services are being provided to the UE. Our measurements indicate that VoLTE

generally consumes less current than ViLTE, considering the 120 seconds average measurement duration. Nevertheless, this pattern varies in certain instances. In airplane mode, the device exhibits similar energy usage for both services, as no services are active and the device is disconnected from the network. As expected, power consumption was lowest and most consistent across all groups in this state.

When the airplane mode is switched off, the DUT connects to the network and remains in idle mode for a few seconds. This same behavior is observed for both VoLTE and ViLTE services. However, after the video call setup is completed, the call stabilizes at a significantly higher current consumption level compared to other intervals, and the consumption trend for ViLTE is noticeably larger than that for VoLTE throughout

the call duration. Therefore, Table II presents the average call setup and call service results for each service.

TABLE II
CONSUMPTION COMPARISON FOR VoLTE AND ViLTE

		Average consumption (mA)	
		VoLTE	ViLTE
B7	Setup	1018.314	1369.509
	Service	360.569	760.855
B28	Setup	955.486	1342.399
	Service	343.907	712.601
AirPlane mode		93.056	

The analysis indicates that during the call setup phase, ViLTE deployments on Bands B7 and B28 exhibited higher current consumption compared to VoLTE: specifically, a 34.49% increase for B7 and 40.49% for B28. Similarly, in the call service stage for both B7 and B28, ViLTE deployments showed substantial increases (111.02% and 107.21%, respectively) over VoLTE. Collectively, these findings demonstrate that VoLTE, as expected, results in lower current consumption than its video service, ViLTE, across all tested bands.

The jitter scenario highlights the impact of the video channel on voice quality. Voice jitter in ViLTE mirrored video jitter (as shown in Figs. 5 and 6), with EVS ViLTE achieving an average jitter of 19.836ms for B7 and 19.345ms for B28, compared to 19.588ms and 19.953ms for H.264. In contrast, VoLTE exhibited consistent jitter results for the EVS codec on both bands (15.859ms for B7 and 16.744ms for B28). This represents a reduction of 20.05% and 13.45% compared to EVS in ViLTE. Detailed jitter measurements are presented in Table III.

TABLE III
JITTER COMPARISON FOR VoLTE AND ViLTE SERVICES

		Jitter (ms)	
		VoLTE	ViLTE
B7	EVS	15.859	19.836
	H.264	-	19.588
B28	EVS	16.744	19.345
	H.264	-	19.953

VI. CONCLUSION

The main goal of this work was to assess how much energy commercial devices currently consume and how each communication service affects the energy usage of these UEs use when utilizing services on the LTE network powered by IMS. As predicted, ViLTE consumes more energy than VoLTE. When considering the difference during the service time, ViLTE in the B7 band exhibited a 111.02% increase in consumption compared to VoLTE. The B28 band showed similar results, with ViLTE usage reaching 107.21% during the video call service stage, presenting highly pertinent findings and demonstrating that the data flow more than doubles current consumption due to the requirement for an additional data channel for video. Additionally, the EVS jitter values for VoLTE and ViLTE services followed the same behavior: VoLTE jitter had an average value of approximately 15.859 milliseconds for band B7 and 16.744 milliseconds for band

B28, while ViLTE jitter reached around 19.836 milliseconds for band B7 and 19.345 milliseconds for band B28. This represents a 20.05% and 13.45% increase for ViLTE compared to VoLTE. Despite the need to adjust EVS jitter to accommodate the H.264 video codec, the VoLTE service did not significantly increase packet latency compared to ViLTE, suggesting comparable Quality of Service (QoS) in terms of jitter, even with the added data flow.

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VII. BIOGRAPHY SECTION



Jackeline D. da Silva received a B.Sc. in Electrical Engineering in 2018 from the Statal University of Amazonas (UEA), with an MBA in project management (2023) in (UEA). Has experience in the field of Electrical Engineering, with emphasis on Renewable Energies, Analog Electronics, Digital Electronics, and has worked directly with hardware development. Currently, works on investigating problems in models that support 5G technology in the area of protocol with communication processors from Qualcomm and UNISOC, but already worked with LSI and Mediatek chipset, applying requirements of the Latin American region. Helps verify the implementation of 4G and 5G requirements in Samsung devices and works on development and research in topics related to 4G and 5G technologies.



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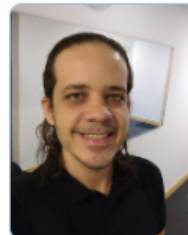
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