A testbed and methodology for initial 5G NSA mobile deployment to provide voice services over IMS using SDR

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***Abstract*—This work presents a testbed for simulating an initial 5G NSA (Non Standalone) network to provide VoLTE (Voice over LTE) calls. The configuration testbed relies on using open-source projects as well as the Kamailio server for real-time communication and signaling messages using the SIP (Session Initiation Protocol) of the IMS (IP Multimedia Subsystem) network. In addition, the Open5GS open source project is used to implement a 4G EPC (Evolved Packet Core) and 5G network functions that were developed using a C language software. A BTS (Base Transceiver Station), composed of a SDR (Software Defined Radio) equipment i.e. USRP (Universal Software Radio Peripheral) complete the testbed setup. The jitter and throughput values are also presented. The contribution of this work is to present a relatively low-cost alternative VoLTE testbed, as well as the availability of an experimental environment for teaching and research within universities.**

***Index Terms*—5G, VoLTE, IMS, SDR.**

I. Introduction

When observing the evolution of wireless communication, two main subjects come to the fore: internet and mobile telephony. In the case of mobile telephony, the idea behind its conception was precisely the promise of ubiquitous access from the telephony industry, that is, the provision of telephony and Internet access regardless of location. In the past, voice calls were designed as circuit-switched networks, in which, with the initiation of a telephone call, the network establishes a direct connection between two parties that, inefficiently, is only used for the connection in question. In recent years, mobile telephony has evolved to the point of providing voice calls through IP (Internet Protocol) packet switching over the 4G LTE (Long Term Evolution) with IMS networks [1]. Currently, the first 5G NR (New Radio) networks are being implemented worldwide, initially as NSA networks, introducing new network elements and using the 4G core, significantly increasing throughput and decreasing latency [2]. In this circumstance, when it comes to enabling telephony services on smartphones, there is an effort by both smartphone manufacturers and operators to develop software and hardware support for the service in question, especially due to high priced test equipment. In this context, in regards to the core network cell generation, it becomes practical to use a SDR device such as the USRP [2] because of the simple configuration of its RF and digital interfaces through srsRAN open source software [3], which combined with 4G and 5G virtualized elements in Open5GS open source software provide a complete private LTE network. The MD8475A signaling tester is one of the tools commonly used by smartphone manufacturers to perform VoLTE tests and call processing. According [4], although the MD8475a signaling tester is more robust and is able to generate multiple network cells simultaneously, USRP is a device of considerable low cost intended for single cell network research and development, costing up to 21 times less than the MD8475a, which makes it a viable option for validation of VoLTE calls. The present work aims to present and test a hardware and software system that employs low-cost hardware to generate a network cell and configure it, making it possible to validate voice over LTE services in an initial 5G NSA option 3 network [2].

II. Methodology

Figure 1 presents a general schematic of the system architecture, with the blocks of elements enumerated according to the sequence described below. There are two interfaces: digital (related to the mobile network elements) and analog (related to the SDR USRP and RF stage).

(1) IMS Kamailio Server: The open source SIP Kamailio server was used as the core IMS network [5], whose main elements are the Call Session Control Functions (CSCFs),

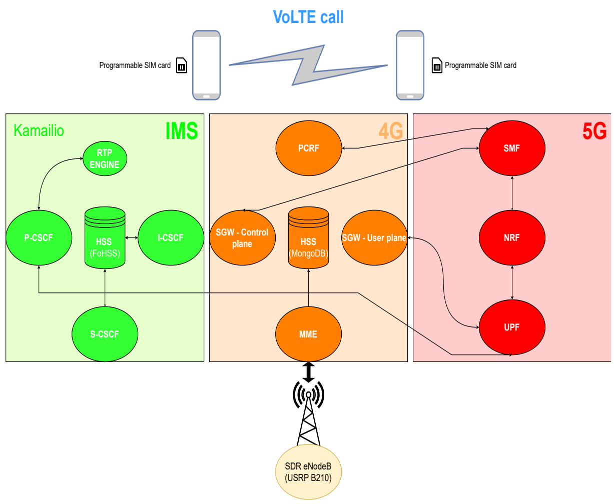

Fig. 1. Testbed architecture.

divided into P-CSCF (Proxy CSCF), I-CSCF (Interrogating CSCF) and S-CSCF (Serving CSCF). In a simplified way, the Real-time Transport Protocol Engine (RTPEngine) manages the transmission of packets in real time between the UE and CSCF elements, directing it to a suitable database. After consulting the Home Subscriber Server (HSS), the subscriber has its data validated and is then registered on the IMS network [6].

(2) eNodeB (USRP): The SDR device USRP [2] was used on the RF interface, in which the base radio of the open source project srsRAN [3] was implemented. The 4G and 5G virtualized interfaces are based on the Open5GS project [7].

(3) 4G Interface: Initially there is the Mobile Management Entity (MME), which authenticates the device and manages the bearer, a connection tunnel with the Packet Data Network (PDN). The Serving Gateway (S-GW) acts as a bridge between the eNB and the P-GW. In turn, P-GW manages the IPs and addresses of connected devices, directing and routing them. Finally, the HSS database holds subscriber information, then the Policy and Charging Resource Function (PCRF) performs the QoS (Quality of Service) control [6].

4) 5G Interface: This interface is at an early stage and implements some elements of the 5G NSA network. The elements considered are the Session Management Function (SMF), which manages the PDU (Protocol Data Unit) associated with a given subscriber; the User Plane Function (UPF), involved with user plane traffic and responsible for ensuring that data is routed in the correct downlink QoS flow; after that, the Network Repository Function (NRF), that has the main function of discovering services, and responds to requests by informing the categories of functions, addresses and list of services [1].

(5) Smartphones: The devices were configured to support IMS and VoLTE technologies. Along with them, programmable SIM cards are used to set security parameters, encryption and identification of operators e.g. PLMN (Public Land Mobile Network) [6].

III. Results

Considering the configuration setup presented in Fig. 1, the throughput and jitter values are presented for a VoLTE call between two users. Fig. 2 shows the throughput value for the mobile users during the VoLTE call. The highest throughput values is approximately 100Kbps. Fig. 3 shows the evaluation of the jitter value; User 1 and user 2 satisfy the minimum requirement value which is 20 ms, as explained in [8].

IV. Conclusion

In this work, an SDR (RF interface) platform was presented for validation of VoLTE calls in a 4G and 5G architecture option 3 (initial stage) implemented in the computer (digital interface). Through laboratory tests, it was possible to make VoLTE calls of up to 5 minutes in duration between two users (smartphones) connected to the SDR BTS which satisfied the requirement value of 20 ms, characterizing a VoLTE call of acceptable quality. As future work, it is suggested to carry

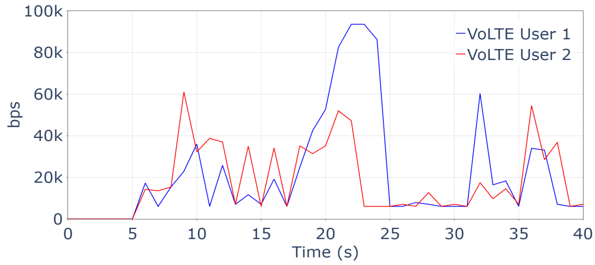

Fig. 2. VoLTE Call throughput

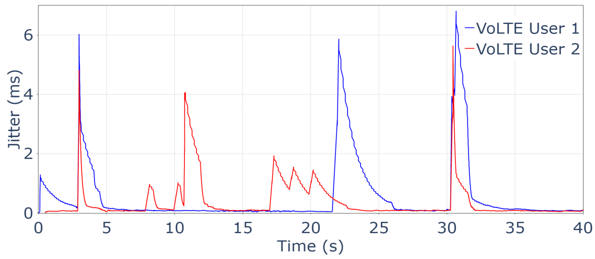

Fig. 3. VoLTE Call jitter

out tests with ViLTE (Video over LTE) calls and evaluate SIP (Session Initiation Protocol) messages in comparison to a VoLTE call using packet analyzer software. The contribution of the work is to present a proposal that can be used as an alternative testing platform and solution in cellular networks for smartphone manufacturers; in addition, to encourage investments in universities to develop practical classes with mobile telephony and provide a supportive environment for scientific research.

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