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Practical QoS measurement and analyzes on a 5G non-standalone architecture

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Abstract

Fifth Generation (5G) networks are becoming the standard in the global telecommunications industry and are becoming a permanent part of everyday life. As mobile network operators have commenced to publicize the implementations of their 5G networks, measurements are not frequently used to demonstrate the actual aspects of these networks' capabilities. This article presents an actual 5G architecture based on the 5G Option 3x reference model, together with findings from Quality of Service (QoS) testing. The outcomes are compared to our actual hands-on measurements of the 4G network in addition to being compared to the expectations for the 5G network. Based on examination of the 5G testbed results, 5G performed much better than 4G in all fundamental QoS, including up- and downlink throughput, latency, packet error rate and jitter. Additionally, practical measurement results on this non-standalone 5G architecture demonstrate that latency and jitter are not greatly impacted by the load on the cell or the core network provided traffic preferences are set up correctly. The study of QoS and a first performance assessment of 5G, along with the identification of application-level performance concerns, are the paper's main conclusions. These results underline the necessity of validating and testing generic 5G services and applications through fair benchmarking approaches.

Introduction

The 5G is the newest mobile network being deployed worldwide. As it was stated 5G Network can provide high throughput, high reliability, low latency, increased capacity, availability and connectivity, and dynamic bandwidth allocation and in general better performance. In fact, it is expected that the 5G performance will span over the three extremes of bandwidth, latency, and capacity requirements, which enable enhanced Mobile Broadband (eMBB), Ultra Reliable and Low Latency Communication (URLLC), and massive Machine Type Communication (mMTC), respectively [1].

The 3rd Generation Partnership Project (3GPP) has regulated two primary 5G deployment modes in Release 15 (Rel-15), termed Non-Standalone (NSA) and Standalone (SA), to meet these requirements [2]. The main difference is that whereas 5G NSA uses the current 4G core network to handle the control plane, 5G SA uses its own 5G core and so operates independently of the 4G network (Figure 1). Both of these modes need a 5G New Radio (NR) Radio Access Network (RAN) made up of Next Generation Node Bs (gNBs), which are the 5G equivalent of 4G E-UTRAN Node Bs (eNBs).

The majority of Mobile Network Operators (MNOs) have chosen to use the NSA mode throughout the current stages of 5G implementation because it is an easier and less expensive option. However, 4G/5G co-dependence in the NSA presents a variety of setup, operational, and performance challenges that need for more research and analysis. Actual 5G networks claims include 20Gbps data throughput, 1ms latency, 1 million devices=km^2, and 10 times less energy usage (than 4G UE), although their combined effects on the network are not yet completely understood.

Analysis of the performance of an 5G network and service can also be done using a variety of techniques and technologies. Regardless of the fact that 5G networks can benefit from the same network and service validation systems now in use, considerable tool upgrades will be required for thorough validation and verification of 5G goals.

Recently, there has been significant research related to the 5G performance evaluation, however, these are not tested on live network, so it cannot be known which will fulfill the expectations. For examples, the authors in [3] had evaluated the performance of an NSA 5G architecture. They observed that if the traffic preferences are properly set, the load on the cell or the core network (CN) has no effect on latency and jitter. As well, the authors examined the performance of SA and NSA 5G new radio (NR) installations in terms of coverage, network capabilities, and deployment cost based on simulations in [4]. In more recent works, the effectiveness of NSA 5G networks has also been assessed; for examples, see [5] and [6].

In this paper, we present a testbed measurement study on 5G experimental mid-band NSA networks of Vodafone Albania. To the best of our knowledge, this work constitutes the first effort toward empirically studying deployment, coverage, and performance aspects of 5G NSA deployments in QoS terms, as well as providing insights with regard to future 5G version updates.

5G testbed proposed and design.

The testbed we employed is a defined architecture called "Option 3X," which stands for "migration path to Non-Standalone Next Generation Radio with LTE aided mode coupled to Evolved Packet Core" (Figure 1). The EPC is responsible for AAA functions, service mobility management, besides, it ensures connectivity with the IP network. Another key part of the 5G architecture is gNB, which is responsible for the radio attachment between UEs and the Core network's interfaces in case of 5G media. For the basic understanding, Figure 4 on [2] depicts the generic 5G architecture, where the main elements are also defined.

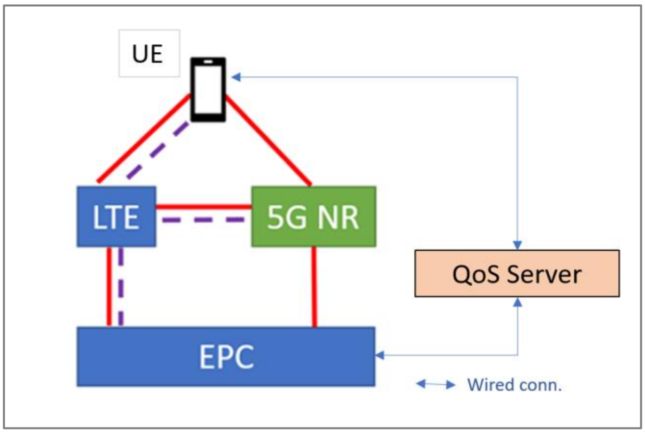

Figure.1 5G testbed NSA Option 3X

In our testbed, we use a dedicated server, where we have installed different tools like iPerf3, Speedtest by Ookla, SolarWinds. The 5G NR is simulated using Amarisoft Callbox Advanced, which is a self-contained 5G base station deployed in an indoor environment.

QoS parameters and Expectations

In the 5G networks, Quality of Service (QoS) model is based on the QoS Flows. Each QoS flow has a unique identifier called QoS Flow Identifier (QoI). There are always two types of bearer flows GBR (Guaranteed bit rate) QoS flows and NGBR(Non-Guaranteed bit rate) QoS flows. GBR bearers are used for real-time services such as rich voice and video services which occur in real-time. A GBR bearer has a minimum amount of bandwidth that is always reserved by the network. Non-GBR bearers do not have specific bandwidth allocation e.g., file downloads, email, internet access, etc.

There are different parameters to evaluate QoS in 5G networks, in this paper we will present some of the most important that end users and applications are affected.

Throughput: 5G throughput performance is one of the most important indicators of user experience. Increasing bandwidth, utilizing various coding techniques, and improving modulation all result in higher data transmission rates. Even 100 MHz of bandwidth can be employed in the downlink direction, and 1.5 Gbps is the maximum theoretical capacity. Naturally, the quantity of receiver and transceiver antennas can also be used to tune the transmission rate.

Latency: One of the main promises of 5G is the dramatic reduction of latency from the levels experienced with 4G to approximately 1 ms. In particular, latency can be maintained at a low level even when the network is experiencing significant traffic loads.

Packet Error Rate (PER): It defines an upper bound for the rate of PDUs (e.g., IP packets) that have been processed by the sender of a link layer protocol (e.g., RLC in RAN of a 3GPP access) but that are not successfully delivered by the corresponding receiver to the upper layer (e.g., PDCP in RAN of a 3GPP access).

Maximum Packet Loss Rate: The Maximum Packet Loss Rate (UL, DL) indicates the maximum rate for lost packets of the QoS Flow that can be tolerated in the uplink and downlink direction.

Measurement and results

In our setup, the 5G network is operating with real live 4G network creating the perspective NSA network. Server is connected directly to EU and EPC, we are using several tools for timing synchronization and valuating the QoS mentions parameters. For better understanding these parameters are depicted in Figures 2-5.

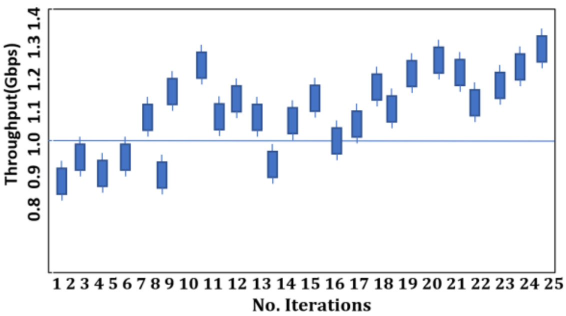

Figure 2. Throughput in 100MHz bandwidth

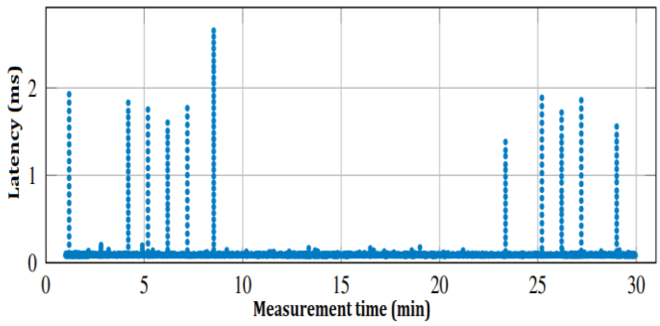

Figure 3. Latency in 30 min with light traffic

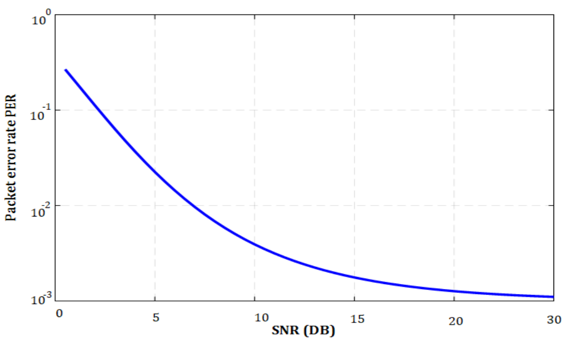

Figure 4. Packet error rate PER vs SNR

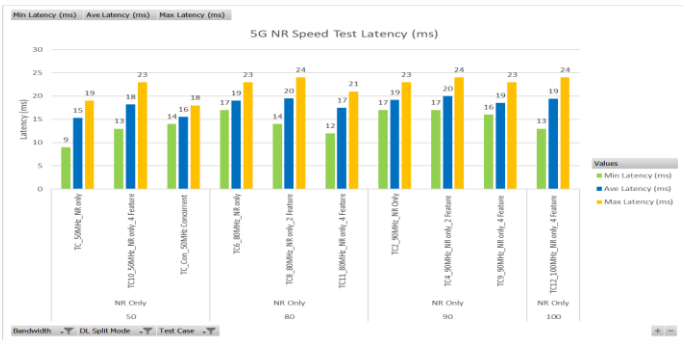

Figure 5. Latency vs bandwidth with heavy traffic

Conclusion

This paper aims to provide some comprehensive measurements and validating real-world 5G Quality of Service capabilities. As expected, 5G data latency is significantly lower than it is for 4G -although for heave traffic require further tune. Moreover, in the tested, real-world 5G network testbed, latency and jitter statistics do not dramatically rise with traffic load. On the throughput parameters it is observed that almost the theoretical limit is reached in the basic band of 100MHz. It is necessary to research more in cases of network loading with different types of traffic, as in these cases the tested data showed an increase of the latency.

References

1. ITU-R M.2083-0. IMT Vision-Framework and Overall Objectives of the Future Development of IMT for 2020 and Beyond; ITU: Geneva, Switzerland, 2015.
2. 3GPP (2018). Summary of Rel-15 Work Items, TR 21.915 version 0.5.0 Release 15. 3GPP, Version 15, 2018-12.
3. Soós, G., Ficzere, D., Varga, P., & Szalay, Z. (2020, April). Practical 5G KPI measurement results on a non-standalone architecture. In *Noms 2020-2020 IEEE/IFIP network operations and management symposium* (pp. 1-5). IEEE.

4. Liu, G., Huang, Y., Chen, Z., Liu, L., Wang, Q., & Li, N. (2020). 5G deployment: Standalone vs. non-standalone from the operator perspective. *IEEE Communications Magazine*, *58*(11), 83-89.
5. Heimann, K., Gorczak, P., Bektas, C., Girke, F., & Wietfeld, C. (2019, April). Software–defined end–to–end evaluation platform for quality of service in non–standalone 5G systems. In *2019 IEEE International Systems Conference (SysCon)* (pp. 1-8). IEEE.
6. Giordani, M., Polese, M., Roy, A., Castor, D., & Zorzi, M. (2019). Standalone and non-standalone beam management for 3GPP NR at mmWaves. *IEEE Communications Magazine*, *57*(4), 123-129.