5G New Radio Deployment Modes

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Abstract - *5G is the fifth generation of cellular wireless network technology that started extensive deployment in 2019. There are two ways of deploying 5G New Radio (NR). They are the non-standalone (NSA) and the standalone (SA) approach. The NSA approach makes use of the existing LTE systems as its core network along with 4G and 5G Radio Access Network. On the other hand, SA approach makes use of a 5G core network with the 5G Radio Access Network, resulting in an end-to-end 5G service. Both the approaches have their own advantages and disadvantages. This paper discusses and compares both the approaches that are used in deployment of 5G.*

Key Words: 5G, New Radio, Standalone, Non-Standalone, Network Slicing

1. INTRODUCTION

The wireless telecom industry has seen a long way in terms of subscribers and technology. The growth has been drastic in the recent few years with ever increasing number of mobile users and increase in data traffic due to more data intensive activities like streaming, virtual reality, gaming and massive IoT deployments. All major development in the field of the wireless telecom industry has been classified into generations. Each generation has undergone a major change in terms of the architecture and/or the features. The first generation (1G) deals with analog communication and supports voice calls only. With the second generation (2G) came digital technology that brought the short message service (SMS) and low speed data services. The third generation (3G) provides increased capacity and higher data rate which supports multimedia features. The fourth generation (4G) further increases the data rates available to users and reduces the cost of operation. It facilitated services like streaming of high definition services, live television and brought in VoLTE which allows the elimination to depend on circuit switched systems to make calls. The introduction of the fifth generation (5G) aims to provide much higher data rates, high bandwidth and ultra low latency. 5G aims to enable services like massive IoT deployments, real-time critical applications and also aims to reduce operational expenses [1]. Apart from this, 5G aims to virtualize most of its components to make it scalable and also to reduce operational and capital expenses. A major goal of 5G is to satisfy the large kinds of quality of service (QoS) requirements that can arise from various application scenarios [2]. The main types of classes representing the vast QoS requirements has been defined as follows[3,4]: ultra–reliable low latency communication (URLLC) for mission critical communication, massive machine type communication (mMTC) for massive internet of things (IoT) applications, and enhanced mobile broadband (eMBB) for end-user multimedia services. From a user's perspective, 5G systems are expected to provide full connection and reduce the limitations of time and space to create user-centered or service-centric connections between people and things [5].

As mobile data traffic continues to grow, more and more telecom operators are shifting or planning to shift to 5G deployments. It is predicted that the number of mobile-connected devices will be 12.3 billion by 2022 [6]. Mobile data traffic is also expected to increase at a Compound Annual Growth Rate (CAGR) of 46 percent from 2017 to 2022, and will reach 77.5 exabytes per month by 2022 [6]. Currently, 5G offers two modes of deployment, Standalone (SA) and Non-Standalone (NSA) mode of deployment. The NSA mode of deployment uses 5G Radio Access Network (RAN) with the existing LTE core network. The SA mode of deployment uses 5G RAN with a 5G core network [7].

The paper is organized as follows. Section 2 discusses about the 5G concepts required to understand the remainder of the paper. Section 3 discusses about how the resource allocation simulation is performed. Section 4 presents the results of this paper. Section 5 discusses about the conclusion and future prospects of the paper.

2. 5G DEPLOYMENT MODES

2.1 Non-Standalone (NSA)

As mentioned in Fig. 1, the Non-Standalone mode of 5G NR deployment depends on the 4G core network for control plane activities which include session management, resource allocation, handover management, authentication, policy management. The NSA mode benefits from the higher data rates due to the use of the 5G NR but doesn't benefit from all of the 5G goals [8].

This mode of deployment allows operators to provide deployment of 5G using existing 4G setup that facilitates early adoption of 5G [8]. This is why the 3GPP introduced a set of early specifications for NSA before the completion of the complete 5G standard release [9]. NSA uses the concept of dual connectivity in which one of the cells provides the control plane activities; and the cells of both the 4G eNodeB and the 5G gNodeB provide user plane connection. Dual connectivity was introduced for LTE in [10].

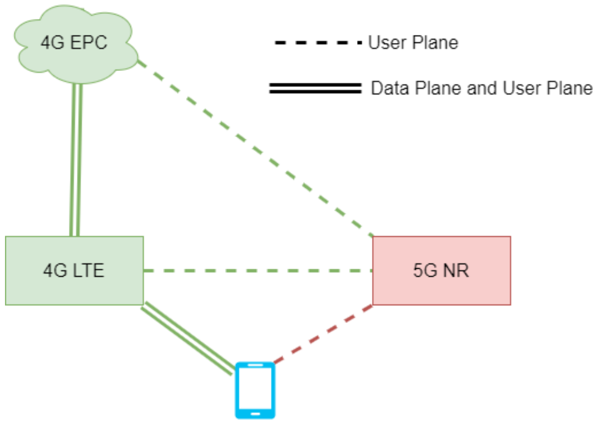

Fig -1: Non-Standalone Mode of Deployment

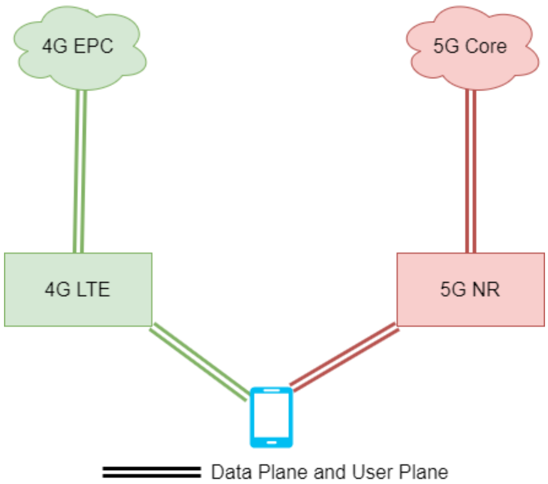

Fig -2: Standalone Mode of Deployment

2.2 Standalone (SA)

As shown in Fig. 2, the Standalone mode of 5G NR deployment separates the 4G and 5G networks. Each of the networks has its own radio access network and core network. This allows in the true realization of the 5G goals and end-to-end 5G connection. 5G allows in having a simpler core network that has lower operational expenses [8].

A new feature in the 5G core network when compared to the 4G core network is the network slicing feature. This allows different kinds of UEs to be placed in different network slices with each having different QoS and policies [11]. This can allow systems of the same capability to handle more UEs efficiently because UEs that have lower resource demands can be put on a different network slice, hence, preventing allocation of extra resources had a single policy been adopted for all kinds of UEs. This is particularly useful in enabling massive IoT deployments. Most IoT devices are sensors which do not require high data rates and in most cases they do not require very low latency, so such UEs can be put in a separate network slice. Critical IoT deployments can be put in another network slice that facilitates low latency. A slice for general internet browsing can differ from a slice of voice call in terms of latency, throughput and reliability. Network slicing allows resources to be more judiciously utilized. The decision making part of network slicing can be rule-based, deterministic algorithms or learning based. Research in this field is ongoing. The concepts of software define networks (SDN) and genetic algorithm [12], game theory [13, 14], support vector machines, K-means clustering [15] and neural networks [16, 17] have been used in the field of network slicing.

In terms of latency, the SA mode of deployment can help realize the goal of ultra low-latency in 5G. This is achieved by the use of the edge computing in the 5G core network which lowers latency as the processing happens closer to the UEs [18]. Introduction of edge computing can help reduce latency, but at the same time it is important to achieve cost effectiveness [19]. However, realization of ultra low latency will not be available in initial existing deployments as the industry needs to shift to a decentralized model [20]. But, the initial SA deployments will offer lower latency than 4G. Ultra-low latency can facilitate applications like self-driving cars, competitive online gaming, and remote medical surgeries on 5G networks. The introduction of edge computing can make the network more fault-tolerant and can facilitate mission critical applications [21].

3. EXPERIMENT

To demonstrate the difference in resource utilization with network slicing, a 5G core network with two network slices are taken. The slices have different policies of resource allocation. In our case, one of the slices allocates half the amount of resources when compared to the other network slice per UE. 500 UEs with high resource requirements and 500 UEs with lower resource requirements have been considered for the simulation. The results are shown in Fig. 3 and 4 which varying levels of network slicing classification accuracy.

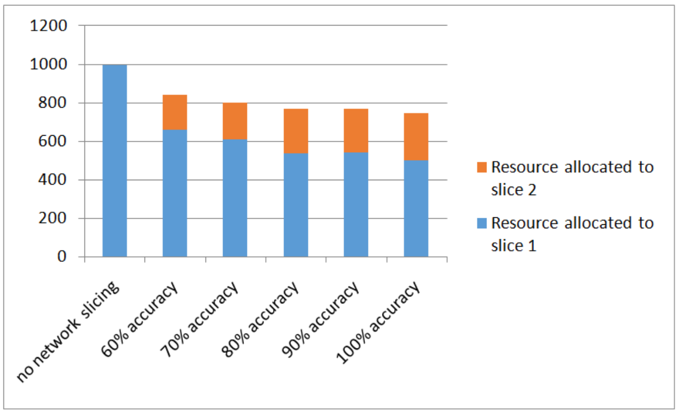

Chart -1: Visualization of the total resources allocated and that in each network slice

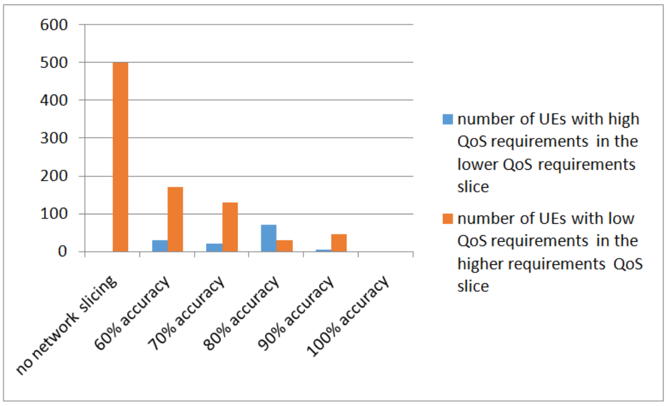

Chart -2: Visualization of the misclassification in selection of network slice

4. RESULT

The results of the simulation in Chart 1 and 2 shows that network slicing can help in better utilization of network resources. Table 1 shows a few differences in the SA and NSA mode of deployment which will be discussed further in the next paragraphs.

Table -1: Comparison of the Non-Standalone and Standalone Mode of Deployment

Criteria	Non-Standalone	Standalone
Core Network	Evolved Packet Core	5G Core
Operational and Capital Expenses	Higher	Lower
Initial Setup Cost	Lower	Higher

NSA deployment facilitates early adoption to 5G as it uses existing 4G setup. In the short run, deployment of 5G on the NSA mode skips the 5G core network setup and is cheaper. However, the 5G core network is much cheaper due to virtualization and cloud technologies which will make running the 5G core cheaper than the existing setups. Deployment of 5G in the SA mode will allow operators to support all use cases of 5G like enhanced mobile broadband (eMBB), ultra-reliable low latency communications (URLLC) and massive machine type communications (mMTC) instead of supporting only enhanced mobile broadband (eMBB). This can allow them to explore new sources of revenue from services like massive IoT deployments, self driving cars to name a few. The 5G core network has several advantages that can outweigh the advantages of using the NSA approach. In the long term, operators in the NSA architecture will have to migrate to the SA mode of deployment. This would result in 5G core deployment, running of NSA and SA for a brief period of time which may result in a higher overall cost than directly adopting SA.

At the end of the day, user experience matters the most, and the deployment of 5G in the SA mode is powered by enhanced mobile broadband (eMBB), ultra-reliable low latency communications (URLLC) and massive machine type communications (mMTC) which will improve user experience. Users are getting more and more sensitive to delay and issues. It also has great market potential due to growing popularity of video streaming, gaming, AR and VR applications on smartphones over mobile data.

5. CONCLUSION AND FUTURE WORK

This paper presents a general comparison between the SA and NSA mode of deployment of 5G with focus on network slicing. Based on the results of the simulation performed, it can be concluded that the SA mode of deployment can help in more judicious usage of the resources. However, it must be kept in mind that the accuracy of classification needs to be high to ensure that the UEs with higher requirements aren't allocated lesser resources. Future work can be directed towards developing techniques that perform network slice selection with high accuracy and to develop deployment techniques for edge computing resources to provide ultra low latency.

In terms of ease of deployment and costs in the long run, the SA deployment is more beneficial. From the perspective of an end user, 5G can result in great user experience and also has great market potential if deployed in the SA mode of deployment. Thus, we conclude that the migration from NSA to SA is necessary for the deployment of 5G in the long run.

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BIOGRAPHIES

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