5G Implementation: Major Issues and Challenges

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***Abstract*—Fifth generation networks have been introduced in response to the need for exponential growth of mobile data traffic and the provision of new generation of services. The ability to provide such services with high flexibility requires the use of new technologies and the extensive changes to existing mobile networks. This paper examines the most important challenges in the implementation of 5G from the technology aspects including mmWave communications, backhaul technology, Technology maturity, energy consumption, EMF and business aspects including business models, ecosystem maturity, Coordination of industry verticals and regulation aspects including spectrum management and fragmentation. Moreover, for some of them solutions suggested by vendor reports and academic works are discussed and analyzed in this article.**

Keywords—5G, Spectrum Fragmentation, mmWave, Business Models

I. INTRODUCTION

With the development of the Internet of Things and the widespread use of wireless telecommunications in a variety of areas, such as transport and transportation, healthcare, intelligent building and industrial automation, new numbers and types of subscribers will emerge. These subscribers will have different requirements such as higher bandwidth and reliability, less latency and higher energy efficiency [1]. On the other hand, new services such as Augmented Reality, Virtual Reality and online presentation of high quality 3D movies that require very high data exchange rates are also becoming more and more important. Regarding to the mentioned requirement for service provisioning, International Telecommunication Union (ITU) has introduced the IMT2020 document in 2015 as a vision for the fifth generation of network [2]. According to this, the services provided in the telecommunications meet the requirements of the three categories of High Data Rate (eMBB) Services, High Reliability and Very Low Delay (uRLLC) Services and They are divided by very high connection capacity (mMTC). From the type of users for each three service categories, the fifth generation services can be provided to individuals or to private and public organizations and organizations.

To achieve all the goals of the services specified in the IMT-2020 in the 5G network, it requires a high frequency spectrum. In this case, the frequency spectrum has been presented in bands below 1 GHz, frequency bands in the range of 1-6 GHz and frequency bands in excess of 6GHz, while in 4G only frequency bands less than 1GHz and 1-6GHz be used. Each of these bands has features that make it suitable for particular applications.

On the other hand, to provide diverse fifth generation services with unique features, fundamental changes to the structure and technologies used in various parts of the network, including the radio, core and transport. In the RAN part, heterogeneous access types are available [3-4]and other technologies such as D2D technology, carrier integration technology, multiple access technology, new coding, Massive MIMO have been proposed for increasing RAN capacity [5].

In the transmission network, by considering capability to transmit large volumes of data to the core network in a flexible and accessible mode with low latency, at the same time imposing low costs as well as managed a heterogeneous environment , SDN technology has been proposed [6]. In this case, integrated resource control over the network can be achieved using SDN. This integration is achieved by separating the network control component from the data segment. With SDN, the forwarding equipment on the network will no longer make distributed decisions, and different decisions about the network will be made by the SDN controller.

In the core of the network, NFV technology is used to optimize resource utilization and to implement different service delivery scenarios flexibly. This approach significantly reduces costs such as network management and energy efficiency. In this case, VNF software must be implemented to add new functionality to the network.

To allow different parts of the network to be automatically configured and optimized, SON technology has been introduced. This capability is especially important given the expansion of small cells. The prospect of automated network management extends across all parts of the network from radio access to Core Network. The benefits of SON are the reduction of human intervention and the costs of network operation [7]. The most important feature of the 5G network is the slicing. Using Slicing, you can have a dynamic network with high scalability. Slicing technology in the network enables different services to be used by different resources to meet the needs of that service and optimize the use of resources.

Regarding to new technologies and concepts that they have been proposed in 5G era, there are challenges for implementation. In this paper, the most important challenges in the implementation of 5G from the technology aspects, business aspects and regulation have been discussed. In the next section 5G enablers are introduced. The section III proposes challenges and issues in 5G implementation and finally in the last section a conclusion is presented.

II. 5G ENABLERS

As already discussed, for the implementation of 5G, new technologies and solutions have been proposed to provide next generation services. These technologies as enabler are spread in different parts of network, including RAN, Core and transport part. In this section, the 5G enablers have been presented.

The focus of RAN enablers is to improve system capacity by increasing bandwidth and spectral efficiency against the demands of high traffic and special service requirements [8]. The main technologies used in this part are mmWave communication, massive MIMO, beamforming, modulation (e.g. 1024 QAM for downlink-3GPP R 15) and new coding methods (e.g. The LDPC code for the data channel and the Polar code for the control channels), carrier aggregation (integration of bands below 6 GHz with mmWave), device-to-device (D2D) communication.

Traditional network implementation models cannot provide all the requirements for 5G scenarios implementation. This needs a network reconstruction, which is being considered as Network Functionality Virtualization (NFV), Software Defined Network (SDN) and cloudRAN (C-RAN) as enablers in 5G era [9].

NFV is a concept of network architecture that allows for virtualizing the node functionalities and so the separation of network functions from the hardware infrastructure. Using NFV, operators expect the systems to be agile and service deployments faster while reducing operational costs (OpEx) and lower capital costs (CapEx).

SDN is used to reduce network costs while increasing efficiency by utilizing programmable switches. By using SDN technology, the forwarding traffic is separated from the control traffic and equipment in the network will no longer make decisions, in such that the different decisions about the network traffic is made by the SDN controller [10]. By utilizing SDN, we can manage data (user traffic, network traffic: e.g. VMs that should be migrated and transferred in the network) in the network, centrally. Moreover, It helps in providing different isolated transport network to implement the slicing concept for different service types.

In C-RAN as a technical solution, multiple sites are connected to a central data center, and radio signals are sent through the front-haul to perform basedband processes [11]. It can facilitate complex management as well as coordination of radio resources in the radio access network.

5G network slicing as an enabler provides different isolated virtual networks for different types of services. SDN and NFV technologies allow slicing in mobile networks to be implemented [12]. In the architecture presented by 5GPPP, network slices are created at the network level to support various network services and can be configured in a control plane. Network slices are end-to-end which includes access, transmission and core network and are managed by an e2e service orchestrator

III. CHALLENGES AND ISSUES

There are many challenges in implementing 5G networks. If we want to group them, they are divided into technical and non-technical including business continuity and social challenges and regulation issues.

A. Technical issues

The Technical challenges in 5G implementation have been categorized in mmWave, D2D communications, Backhaul, Technology maturity, Security challenges and EMF and *Technology Maturity*.

mmWave communications

mmWave communications have been proposed to be an important part of the 5G mobile network to provide eMBB services such as VR, AR and ultra-high definition video (UHDV) [13], [14]. It can support the requirements of high growth of mobile traffic demand and reduce the bottleneck effects of wireless bandwidth that it is a key problem of 5G networks. However, blockage of electromagnetic signals and designing integrated circuits are the challenges of mmWave communications. These waves in the 60 GHz band are sensible to blockage by barriers (e.g., humans and furniture). E.g. penalizing 20-30 dB due to blocking by a person). In this regards, in reference [15] emission statement of mmWave by considering human activities has been presented and shown that a channel may be blocked 1 to 2 percent on average by 1 to 5 people. Moreover, the probability of blocking increases linearly as the user device moves toward the edge of the service cell. As mentioned, another issue is the design of integrated circuits and a high frequency carrier system for wide bandwidths that have challenges in designing circuit components and mmWave communication antennas [16] [17].

D2D communications

There are two main issues for D2D communications in 5G era. The first one is controlling and limiting interference among D2D devices and microcell users because there is no operator control as a central body for direct communications, interference management, and resource allocation. Another issue is security and privacy in D2D communication because of routing users' data through other users' devices [18].

Backhaul

To meet the anticipated capacity of the 5G network, vendors and players need to develop new technologies in telecommunications [19-20]. Transmitting this volume of traffic, the backhaul network is responsible. Backhaul (backhaul network or backbone or transport), in cellular networks, is defined as a network that connects the access network (e.g. eNB) to the core network and is composed of fiber, copper, microwaves and sometimes satellite [21]. In this environment, deploying backhaul networks for small cells - to support high data rates and low latency - is one of the major challenges facing operators due to the lack of adequate fiber networks in many different areas. This, as has been said, has created a new bottleneck in the backhaul. Because it requires the backhaul and fronthaul for transfer the heavy traffic of the high-dense cells with capacity constraints such as delay and delay.

There is no one unique solution to address 5g backhaul requirements. Future 5G backhaul can be designed by utilizing existing transmission networks such as xPON and new technologies such as mmWave. In this regards, authors in [22] have suggested that technology adoption such as SDNs can help in the evolution of 5G backhaul to facilitate backhaul management in a heterogeneous environment.

Security challenges

5G Network uses new technologies such as Virtualization and Software Defined Networking (SDN) / Network Function Virtualization (NFV) for infrastructure to provide services and use cases. On the other hand, service security cannot be provided unless the network infrastructure is secure. In traditional networks, elements are isolated from each other, however in 5G, the functions are virtualized and their infrastructure resources are shared. In this environment, different virtual network slices are defined which require distinct security capabilities. Moreover, security heterogeneity in 5G network is a new issue that should be considered. According to ITU service framework, 5G support different services with various requirements including mMTC, URLLC and eMBB [22]. Each of them has different security requirements. For example, IoT services need light security while URLLC services such as industrial services require high efficient security. In this environment, a multi-level architecture security framework is needed to dynamically support policies and threats detection and mitigation.

EMF level

In the implementation of 5G, the EMF level should be in the normal level due to networks and devices while we have the necessary capacity. Because the level of EMF in the environment may be increased by adding 5G networks through new 5G radios and deploying smaller cells (near sites)[23].

Technology Maturity

Currently, operators have started 5G service with eMBB cases and other service types e.g. URLLC are not available in near future due to lack of technology maturity. Despite the presenting architecture and some implementation, however, a maturity level to propose different services is required for used technologies in 5G era. Because the growth of 5G requires the development of enablers such as SDN, orchestration and NFV and RAN technologies. The maturity in technology requires concentration on specific one and avoiding fragmentation in technology [24]. For example, instead of focusing on specific one such as NFV, each vendor works individually. This could delay the maturity of the NFV implementation and therefore limit us in providing different service types (e.g. URLLC) in the 5G domain.

B. *Non-Technical issues*

None-technical challenges in 5G implementation have been categorized including Business continuity and social issues. Business continuity has been analyzed in terms of business models and investment costs.

Business models

One of the major challenges in the ICT industry is finding topics and areas that can generate added profit and value. In 5G era, the important issue is what opportunities for stakeholders such as vendors, operators and verticals will be created by 5G business cases? [25]. Mobile operators as actors who implements 5G believe that the new business model is needed to address economic aspects and earn a balanced benefit and sustainable investment in infrastructure. For example, the implementation of microcells to support 5G mmWave services has a high cost and if the issue of interest is ignored, the investment in the 5G development may be limited [26].

In this era, in comparing with past mobile networks that the service has been provided for customers, the 5G opportunity provides new generation services mainly to enterprise sections. In other words, a huge part of the market for 5G operators is anticipated is the enterprise segments. Moreover, in the 5G perspective, it is anticipated that the market is focused on not only users but also "things". Therefore, in this regards, the operators should have agenda for providing the proposed service category (e.g. eMBB) by considering different market types by utilizing new business models.

Investment costs

In the 5G network, supporting customized slicing demands requires reconstruction of radio and core networks in terms of utilizing new technologies such as SDN, NFV and Microcells [24]. For example, rolling up a small dense network in an urban area requires a lot of capex. On the other hand, deploying microcell networks in rural areas due to the high cost of capex may not have sufficient income. Moreover, OPEX of the current network adds to these costs. At the same time, for the development of backhaul, there is a need to invest in fiber implementation, which adds to the cost of previous one. In this regards, investment should be considered and analyzed for implementation of 5G.

Culture and digital literacy

Lack of digital literacy in the use of new services offered by 5G can pose challenges to the use of 5G services which can affect 5G adoption as well as operator revenue. The process of education to accelerate emotional, cognitive and behavioral responses in the digital environment can provide opportunities. In that case, it could hopefully create new markets from operators which provides new services[26].

C. Regulation issues

None-technical challenges in 5G implementation have been categorized including Spectrum management and spectrum fragmentation.

Spectrum Management

Despite the potential of microcells to facilitate entry by local and specialized providers, it is unclear whether the implementing 5G will create new opportunities in rural areas, or strengthen existing incumbent monopolies or oligopolies. Micro licensees might have to pay high charges to incumbent competitors in their area for backhaul or middle mile connectivity. Some jurisdictions may not allow micro licenses and other licenses for new entrants. In addition, if the spectrum is auctioned, the result may perpetuate the dominance of incumbents. As with other services, key issues involve access to 5G technology and services, and affordability for rural users. [27]

Spectrum fragmentation

Sub 6GHz spectrum including 3400–3800 MHz band is proposed for 5G. Fragmentation of the spectrum is a challenge that it may cause interoperability problems among vendors and mobile operators and reduces the impact of 5G efforts. This should be considered in the market approach (e.g. spectrum trading) and controlled by regulators of spectrum licenses for new 5G spectrum releases to achieve a harmonized 5G spectrum [28]. The fragmentation of the spectrum can even cause issues in the development of 5G commercial services that repacking can relax it and introduces the mobile services in the vacated spectrum (e.g. assignment the TVs stations to new channel) [29].

IV. CONCLUSION

Regarding to service requirements presented by IUT in IMT-2020, many researches and works have been done in 5G development by focusing on new technologies and enablers. However, there are some major challenges and issues that should be considered in 5G implementation. This paper has presented the most important challenges in the implementation of 5G from the technology aspects, business aspects and regulation. Moreover, for some of them solutions suggested by vendor reports and academic works are discussed and analyzed.

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