5G Dilemma of Supporting Contrasting Narrowband and Broadband Services

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Abstract. The 5th generation of cellular technology (5G), also known as IMT-2020, is seen as a game changer in mobile communication. One key characteristic of 5G is its consumer oriented emphasis, where the mobile user or user equipment is given utmost priority compared to previous generations. Its ongoing standardization is a result of the rapid growth of connected devices worldwide, an increased design complexity. Moreover, 5G has the vocation of providing wireless communication with almost no limitation, hence enhanced mobile broadband, but it also aims at enabling other applications such as IoT for which narrowband is used. This paper aims at investigating the challenges of accommodating both 5G broadband and 5G narrowband services in the same network.

Keywords: Narrowband · Broadband · Mobility · Internet of things Data rates

1 Introduction

The aim of the 3rd Generation Partnership Project's (3GPP) 5G is to bring new developments including the support for enhanced mobile broadband, ultra-reliable and low latency communication, and support for connecting a massive number of machine type communication, resolving the limitation of 4G networks. However, the targeted services by 5G networks can be separated to both Narrowband and broadband services. Where enhanced mobile broadband services can be categorised as 5G broadband services, while ultra-reliable and low latency communications, and massive machine type communications can be classified as 5G narrowband services. 5G Narrowband services are seen as enablers of self-driven cars, mission critical application, industry automation and smart cities. 5G broadband services are targeting applications such as 3D video, ultra-high definition screens and cloud based game/work. However, the standardization is still ongoing and many issues are still being investigated by 3GPP. This paper aims at investigating the challenges of accommodating both 5G broadband and

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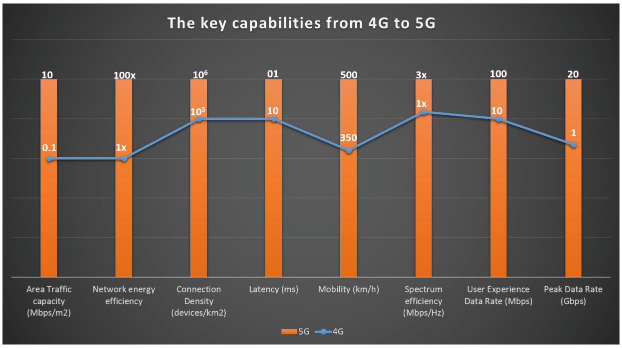

Fig. 1. The key capabilities between 4G and 5G networks [1].

5G narrowband services in the same network in terms of connectivity requirement, spectrum demand, and architecture requirement for 5G Radio Access Network.

The rest of the paper is organised as follows: Sect. 2 will give an overview of the requirements for realizing 5G and Sect. 3 presents the enabling technologies for the realization of a converged narrowband and broadband 5G network. Section 4 presents the current challenges encountered by the developers of 5G systems and will be followed by a conclusion in Sect. 5.

2 Requirements for Realizing 5G Systems

The aim of 4G was to increase support for broadband services. Networks beyond 4G are expected to further increase support for broadband services, by enhancing the peak data rate to multi-gigabits per second [2]. In addition to increased peak data rate, 5G also aims at increasing the user experience data rate, spectrum efficiency, mobility, latency, connection density, network energy efficiency and area traffic capacity as seen in Fig. 1. The following subsections will discuss the targets by 5G and their importance relevancy with respect to both narrowband and broadband services.

2.1 Enhanced Data Rates

The 3GPP standards beyond the current 4G standards will be expected to provide better throughput (average data rate) per connection as compared to its predecessors in order to meet the requirements of broadband services. There are three types of data rates: peak data rate, cell-edge and user experience data rate. Peak data rate is experienced on the base station, which refers to the highest theoretically achievable data rate in an error-free conditions and assignable to only one user-equipment (EU) when all the radio resource are utilized for the corresponding link. The peak data rates are expected to be in the range of 10–50 Gbps for user device at low speeds regardless of a user's location [3]. This is expected to solve the 4G cell edge problem of undesirable data rates. However, the equal improvement of data rate regardless of the UE location is what 5G aims to achieve [3].

2.2 Ultra-reliable and Low Latency

The latency requirement aims to reduce the time delay between the base station and the UE. 4G systems can achieve end-to-end latency of 50 ms and over-the-air latency of 10 ms. However, 5G systems are aiming to achieve an expected to end-to-end latency of 5 ms and over-the-air latency of 1 ms. Both services require low latency [4].

2.3 Very High Bandwidth Density

One of the envisioned 5G network improvement from its predecessor, is its ability to achieve wide coverage, while managing heavy traffic at a rate of 1000 fold of the system capacity per given area. The aim in the high bandwidth density is to achieve high area traffic capacity and high spectrum efficiency [6]. Conventionally, 3GPP broadband based networks are deployed in exclusively licensed spectrum, which has been shown to results to a minimum spectrum utility [5]. In response to this realization, the U.S. has adopted the use of the spectrum access system (SAS), which is a three-tier model between a permanent user, licensed opportunistic user and license-exempt users. A similar system is employed in the UK, which is a two-tier model [5].

2.4 Very High Connection Density

The introduction of 5G narrowband services is associated with a massive number of connected devices, which transmit sporadic and small amounts of data. The expectation is that these devices would be invisible and have less complexity, implying the need for lightweight radio-module design and efficient communication modes. The devices supporting 5G narrowband services should achieve a connection density of 10^6 [7].

2.5 Very High Mobility

5G will be required to support various high mobility environments, including trains, cars and airplanes, implying that most use case scenarios in 5G systems will require high mobility. This requirement is for both broadband and narrowband services.

2.6 Evolution or Revolution in the RAN

The architecture of 5G will be determined by the enabling technologies that will be adopted in the standard, which is still in its development as mentioned above. 5G will be a cornerstone for all broadband and narrowband based services

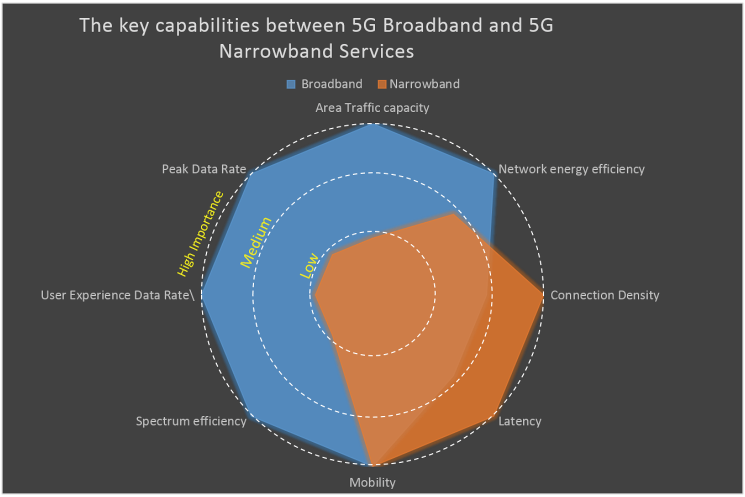

Fig. 2. The key capabilities between 5G's narrowband and broadband services.

and the definition of technologies that will be adopted in 5G will be concluded around 2020. These technologies will determine its fitting characterization as either evolution or revolution standard. 5G might therefore require the radio access network (RAN) and architectural level to be revolutionised. Moreover, the drastic change in the RAN will enforce a change in end-user devices [8].

3 Enabling Technologies for Broadband and Narrowband

In order for 5G systems to meet the services requirements as shown in Fig. 2, the following are the potential enabling technologies of such envisioned network or system: small cell deployment, utilization of the millimetre-wave band, M-MIMO, and beamforming.

3.1 Small Cells and Millimetre-Wave Band

With the anticipated increase in the rate of broadband services, network densification through the use of small cell networks seems to be an inevitable solution for 5G systems. Small cells are necessary for offloading traffic from macrocells. Their deployment can either be indoors or outdoors, which is associated with cost-effective solution to network capacity issues resulting from the massive growth in mobile traffic [8]. Smalls cells will definitely be part of the 5G networks, especially when considering that the World Radio Communications in 2015 conference made the spectrum at the 6-GHz band available [9] for use in mobile communication. Where it is understood that the coverage of millimeter-wave band will force the use of small cells. Millimetre-wave technology is investigated because of its wider bands provision and the saturation in lower bands. Still more spectrum is recommended to be allocated for 5G networks as shown in Fig. 3.

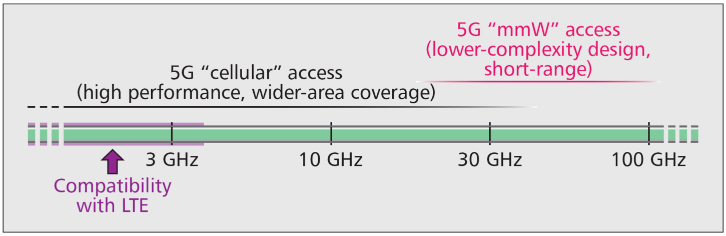

Fig. 3. The millimeter-wave band as a potential spectrum for 5G networks [7].

3.2 Massive Multiple-Input, Multiple-Output and Beamforming

Massive multiple-input, multiple-output (M-MIMO) is achieved by integration of advanced antennas with massive numbers of elements. M-MIMO is a useful technique for minimizing the intensity of RF imperfections and mitigate interference distribution. In addition, M-MIMO can be used to enhance the coverage for high-data-rate, especially given the number of narrowband devices anticipated. On the other hand, beamforming, which is achieved when multiple antenna elements are used to form narrow beams, is another vital technique for both 5G narrowband and broadband services.

4 Current Development and Challenges

4.1 Current Development

Current networks are able to provide data rates of more than 200 Mbps. SK Telecom in South Korea has heavily invested in 5G research and has about 29 million customers. This trial will heavily depend on M-MIMO use [10]. KT cooperation is preparing to launch its 5G trial service during the PyeongChang's Olympic Winter Games. KT's 5G network is based on the 28 GHz spectrum, different than SK telecom [11]. Furthermore, Fujitsu has managed to develop a millimetre-wave prototype receiver, achieving data rates at around 20-Gbps. In addition, Nokia has employed the 73-GHz carrier with 2-GHz bandwidth to achieve data rates of 10 Gbps, corresponding to a latency around of 1 ms [11].

4.2 Challenges Toward 5G Realization

Network planning and traffic management is vital in addressing the issue of adopting small cell and managing coordination between the different cells. Especially, given that network operators will be able to optimize the organization of macrocells and picocells. However, femtocells are self-organizing type of small cells. Moreover, there will be lot of handover taking place in 5G network if not well planned. The complication of the design will be escalated by the difficulty to estimate indoor network capacity.

M-MIMO have their own challenges, when deploying a number of RF chains is not realizable. Furthermore, the energy efficiency of M-MIMO, decreases with the increase in the number of RF chains, leading to the need for the development of channel estimation and beamforming algorithms that considers the limitation on the number of RF chains [12].

5 Conclusion

5G will increase efficiency, capacity, adaptability, innovation, and its ability to support narrowband and broadband services will provide access to information and sharing of data anywhere and anytime for anyone and anything. However, it will be a challenging task given the contrasting requirements between the two services. The evolution/revolution future network is necessary to meet the demands posed by the ever grown user equipment. This paper has shown the requirements of such networks and their enabling technologies with the associated challenges that still need to be addressed for its realization.

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