The vision of 5G and the need for change in mobile spectrum access

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Abstract. This paper discusses the need for change in the regulatory environment to cater for the next generation of mobile technology (5G). It gives particular attention to provisioning of spectrum access for business specific services and applications and to possibilities to improve shared use of spectrum. It is proposed to broaden the market for mobile communication from a mobile operator specific market to a broadened market which is comprised of mobile operators, niche operators and service providers targeting specific business segments and private networks.

Keywords: 5G, spectrum access, sharing, LSA, private networks, unlicensed spectrum.

1 Introduction

The vison of the next generation of mobile communications (5G) that differentiates it from the previous generations of mobile communications was first described by the International Telecommunications Union (ITU) when defining the overall vision and requirements for International Mobile Telecommunications for 2020 and beyond [1].

In the vision of the ITU, IMT-2020 is envisaged to expand and support diverse usage scenarios and applications that go beyond the usage scenarios of existing mobile communications. IMT-2020 is supposed to enable three different classes of usage scenarios:

1. Enhanced Mobile Broadband,
2. Massive Machine Type communications,
3. Ultra-reliable and low latency communications.

Enhanced Mobile Broadband expands the existing Mobile Broadband service offering. It addresses the human-centric use cases for access to multi-media content, services and data. Enhanced Mobile Broadband will improve the user experience in both wide area coverage as well as in hot spots, i.e. areas with high user density, a high traffic demand per user and low mobility compared to wide area coverage.

[1] The opinions expressed do not necessarily reflect the position of the Dutch government.

Massive Machine Type communications addresses the machine-centric use cases characterized by a very large number of connected devices typically transmitting a relatively low volume of non delay sensitive data. Devices are required to be low cost, and have a very long battery life. As such, it is an enabler of the Internet of Things.

Ultra-reliable and low latency communications addresses use cases with stringent requirements for connectivity such as the throughput, latency and availability of the connection. Some examples include wireless control of industrial manufacturing or production processes, remote medical surgery, distribution automation in a smart grid and transportation safety.

This vision of 5G ties in with the trend in modern society with respect to (wireless) connectivity. Mobile connectivity is becoming a necessity for society with strong positive external effects on the economy. Connectivity is becoming a basic need for consumers who rely upon a diverse and affordable range of services. Connectivity is also becoming crucial for businesses for their services and internal business operations. Reliable connectivity is an enabler to strengthen their competitive position through costs savings, increased productivity and development of new applications.

5G is expected to drive industrial and societal transformations and economic growth by offering flexible and versatile mobile connectivity. It provides high-speed, reliable mobile broadband connectivity to enhance the capacity of wireless networks, to support new types of applications, to connect devices and objects in the Internet of Things and to cater for tailored services that fulfill the specific and stringent requirements needed by different industry sectors, also referred to as verticals [2, 3].

The question then is, how this vision of 5G can be realized and what the implications are on the regulatory provisions for spectrum access and spectrum sharing?

2 Providing 5G services

The vision, as given in section 1 above, gives an indication that 5G can be regarded as both an evolution of 4G, as well as a revolution. Many of the use cases build on the services provided by existing infrastructure. The existing mobile network already provides broadband services and IoT capabilities that will remain to be used. 5G will be introduced gradually to enhance the user experience and to provide ubiquitous connectivity for users and devices.

The capabilities that differentiates 5G from the previous generations is that it offers the possibility to tailor mobile data services to the particular characteristics of specific (business) users. Software Defined Networking and network virtualization provide possibilities to support a number of virtual networks over a single physical network. These so-called network slices will provide services to various business segments with performance characteristics such as bit rate, capacity, latency, availability and resilience, tailored for the needs of the specific business segment.

Business specific services may be offered by the existing mobile operators. However, not all business segments will need nationwide or wide area coverage. Many of the specific business needs will be needed in a limited area ranging from a somewhat

larger area, such as a harbor, an airport or an industrial area to an even more limited area of a single factory. This area may even be limited to an indoor environment, e.g. in the case of industrial automation. As a consequence, it remains to be seen if the mobile operator will provide tailored solutions to these specific business segments in limited areas. It will depend on many factors if a mobile operators will serve a particular business segment. Factors that are of relevance are e.g. if there is a need for wide area coverage; how specific the requirements of the business customer are, as some business customers might have a requirement that is too specific or too difficult to meet for a mobile operator; and, how unique the solution is, as an operator is more inclined to offer a specific service if the same type of service can also be offered to other customers as well.

Another point is that the demand side will not have detailed knowledge of mobile connectivity. This will make it very hard for a customer to clearly specify their own requirements in terms of the performance characteristics of mobile connectivity.

This will provide opportunities for two new types of players. First of all, there is a role for a service provider or a Virtual Mobile Network Operators (VMNO) that targets one or more specific business segments. A VMNO that has specific and thorough knowledge of a specific business segment can serve as an intermediary between the mobile operator and the customer to translate the requirements of its customers to a targeted offer.

Secondly, this will provide opportunities for niche players to provide a business propositions for specific industries or factories, e.g. to the petrochemical industry in a harbor area or solutions for industrial automation in a factory or warehouse. There are already niche players active in the field of private mobile radio[2] and fixed wireless access that are in a good position to play a role. These kind of services have historically been delivered through distinct technologies. However, the technologies for these services are now converging. Both fixed wireless access and private mobile radio can make use of the same type of LTE and 5G technology as the mobile operators. Niche operators with a thorough understanding of a business segment can provide specific business services based on local infrastructure that is not easily delivered by mobile operators on their wide area network, e.g. a service that requires very low latency over a wireless connection for real-time control of an industrial process at an industrial plant. A recent study from Harbor Research indicated that the global private LTE network market will grow from $22.1 billion in 2017 to $118.5 billion in 2023 [4].

Other possibilities for niche players are to provide indoor solutions. A large portion of mobile communication needs are indoors and this will continue to be the case in the future. This market is hard to address for a mobile operator with his outdoor mobile network. This will provide opportunities for specific operators to provide indoor coverage with small cell infrastructure to complement the service offering of mobile operators [5].

[2] Private mobile radio means the use of radio communications for business purposes within a company, e.g. a taxi company to have contact between the drivers and the central dispatching unit.

The introduction of niche operators of local private outdoor and indoor networks can be arranged by providing licenses with a limited geographical area of operation. The ability to enter the market, although only on a local level, will make the market more contestable. Licenses for local usage will constrain the market power of the dominant (national) operators by the competitive fringe, which is important because the market for mobile communications tends towards consolidation. The national mobile operators cannot behave as being protected by high entry barriers, but must take the activity of the competitive fringe into consideration. Hence there will be less need for government to regulate the behavior of the dominant national mobile operators [6].

3 Spectrum for 5G

The evolution of mobile communications cannot be decoupled from the availability of "new" spectrum. In Europe, the step from the first analogue systems to the second generation digital system (GSM) was made through the harmonized designation of the 900 MHz band, later followed by the 1800 MHz band. The third generation (UMTS) was developed in the 2100 MHz band.[3] The introduction of the 4th generation (LTE) started with the designation of the 2600 MHz band and later the 800 MHz bands. Nowadays, the different bands for mobile communication services are used for all generations of mobile technology with the introduction of UMTS and especially LTE in other bands to provide both coverage and capacity to the end user based on the requirements of the users and the actual spectrum holdings of the mobile operators.

To fulfill the requirements of 5G there is a need for additional spectrum. The Radio Spectrum Policy Group (RSPG), a high level group of Member States that advices the European Commission, has identified three bands for the introduction of 5G [3]:

1. The 3.6 GHz (3400 – 3800 MHz) band is seen as the primary band for the introduction of 5G services.
2. The 26 GHz (24.25-27.5 GHz) band is seen as the pioneering mm-wave band.
3. The 700 MHz band, together with existing bands for mobile communications.

These three bands have radically different characteristics and will be used differently. The 700 MHz band can be used to provide wide area and indoor coverage. The 3.6 GHz band can be used to provide high capacity and coverage, using both existing macro cells and small cells. The 26 GHz band is likely to be deployed in areas with very high demand, to provide ultra-high capacity for innovative new services, enabling new business models to benefit from 5G for example transport hubs, entertainment venues, industrial sites and retail sites. Because of its propagation characteristics, the 26 GHz band will not be used to create wide area coverage. In due course, the mobile operators could perform transition of lower frequency mobile spectrum (800,

[3] UMTS was first developed for 1920-1980 MHz paired with 2110-2170 MHz.

900, 1800, 2100, 2600 MHz) to 5G, but some studies suggest that 4G LTE and its evolutions will continue to develop in parallel to 5G deployments [3].

The CEPT is studying the technical conditions and regulatory options for the use of the 3.6 and 26 GHz band in order to facilitate European harmonized introduction of 5G. The 3.4 – 3.8 GHz band is in Europe already harmonized for mobile and fixed communications networks (MFCN). The harmonized technical conditions are updated to incorporate the new 5G technology [7]. CEPT published harmonized technical conditions of the 26 GHz band (24.25 27.5 GHz) to enable its use in Europe and to promote the band for worldwide harmonization at the WRC-19 [8, 9].

Frequency bands for the future development of International Mobile Telecommunications (IMT) are on the agenda for the World Radio Conference of 2019. The agenda item is especially targeted to the identification of frequency bands in the mm-wave range between 24 and 86 GHz. There are already a number of initiatives started in various countries and regions of the world to use mm-wave bands ahead of any decision made by the WRC-19. The main focus of these initiatives is in the 24.25-27.5 GHz (the 26 GHz band) and 27.5-29.5 GHz (the 28 GHz band). Whereby the United States, as well as Japan and Korea focus on the 28 GHz band, and Europe as well as other regions focus on the 26 GHz band.

In the European preparation of the WRC-19, the focus is on the 40.5-43.5 GHz band and the 66-71 GHz band, next to the pioneering 26 GHz band. The 66-71 GHz band is foreseen as a band for license exempt frequency use. License exempt frequency use is regarded as important breeding ground for innovation and will contribute towards a dynamic market environment [3].

4 Authorization of 5G spectrum

Until now, mobile spectrum has been allocated usually on an exclusive, national basis. This approach has allowed mobile operators to avoid interference and deliver the expected Quality of Service experience for end users on a national level. However, it remains to be seen if the authorization of spectrum for 5G should be based totally on a national exclusive basis to realize the vision of 5G. As described above, the demand for business specific applications is to a large extend restricted to local areas without the need for wide area coverage. These applications may be provided by local networks. Realization of the vision of 5G may require local spectrum access by niche players and private networks to provide specific localized business applications and services next to national spectrum access for mobile operators.

4.1 Spectrum for mobile operators

Mobile operators will need additional spectrum to take advantage of the new possibilities 5G technology will offer. Their first applications will likely be enhanced mobile broadband services. Additional frequency bands for mobile operators is in Europe focused on the bands cited above in section 3.

The 700 MHz band should be assigned to mobile operators and made available for wireless broadband use by 30 June 2020 at the latest in all EU Member states [10]. Moreover, sufficiently large blocks of spectrum in the 3,4 – 3,8 GHz band and spectrum in the 24.25 to 27.5 GHz frequency band should be assigned before 31 December 2020 in order to facilitate roll-out of 5G.

Both the 700 MHz band and the 3.6 GHz band will be used to enhance wide area coverage and are therefore of vital importance for the mobile operators to facilitate 5G. European countries are now in a process of auctioning the 700 MHz band and the whole or a large part of the 3.6 GHz band. The 26 GHz will probably only be used in areas with a high demand and there is still some uncertainty around the technology as well as the market demand for this band. As a consequence, most countries in Europe are still in the process of defining the regulatory framework for the authorization of this band.

4.2 Spectrum for niche players and private networks

Business specific applications are already provided by PAMR operators and by solution providers to build a privately owned (PMR) network. The current offer is based on dedicated technology, such as TETRA, and is voice oriented, with restricted possibilities for data communications. There is a tendency to migrate to LTE and ultimately 5G to enable business specific broadband communications. However, this will require new and larger chunks of spectrum than available in the core bands for PMR and PAMR, mainly in the 400 MHz range.

Many of these networks will and can make use of existing unlicensed spectrum in the 5 GHz range. However, regulatory restrictions to allow unlicensed access, such as strict power limitations, will limit the possibilities to mainly indoor solutions. There might be a need for dedicated spectrum that can be used on an exclusive basis on the business premises (indoor and outdoor) to provide tailored solutions with the necessary quality of service.

Examples of private broadband networks can be found in e.g France, where AGURRE (Association des Grands Utilisateurs de Réseaux Radio d'Exploitation) groups eleven key organizations, in the sectors of transport and energy, who need a broadband professional mobile network to fulfil the evolution of their operating and safety tasks.[4] A dedicated LTE network is built in the 2.6 GHz TDD band for airport operations. Other examples can be found in the Netherlands, where more than 100 licenses are issued in the 3.6 GHz band for local networks of which many are based on LTE. These licenses are used for a variety of (business) specific applications ranging from an automated container terminal in the Rotterdam harbor, to security and surveillance in cities and provisioning of wireless broadband services in underserved rural areas.

Since there is a need for mobile operators to introduce 5G in the 3.6 GHz band, the 3.6 GHz band will offer limited possibilities for local networks for niche players and

[4] Those organizations are the Aéroports de Paris Group, Air France, EDF, RATP, RTE, the Sanef Group, SNCF Mobilités, SNCF Réseau, Société du Grand Paris, SYTRAL and TIGF.

privately owned solutions. The most likely opportunities are in the upper part of the band (especially 3700 to 3800 MHz) where licenses on a local basis could be made available in order to protect satellite earth stations that are active in the 3800 – 4200 MHz band. This possibility is chosen in e.g. Germany. Some larger countries with limited satellite earth stations, such as the UK are studying possibilities in the 3800 – 4200 MHz itself [11]. However, countries should be very careful, as this band is of prime importance for satellite operations.

Niche spectrum for niche players

A more feasible possibility is to find "niche spectrum" for niche players to provide tailored local solutions. "Niche spectrum" in the sense that the spectrum is outside the scope of the European harmonized bands for wide area coverage such as the existing bands for mobile operators. However, these niche bands should be part of the 3GPP standardization effort in order to take advantage of the economies-of-scale of the LTE and 5G ecosystem.

Various countries in Europe have already made spectrum available that is used to provide indoor solutions, based on spectrum in the 1800 MHz band (e.g. the Netherlands), 2.6 GHz TDD spectrum (e.g. in Belgium) or in the 3.6 GHz band (e.g. in Portugal and Ireland)

A "niche" band that could be used is the 2.3 – 2.4 GHz band. This band is harmonized for mobile communications, but in many countries not available for nationwide coverage due to incumbent use (mainly wireless cameras). Possibilities to make this band available will be explored in more detail in the next section.

Another possibility is the 1880 – 1900/1920 MHz band. The lower part of the band (1880-1900 MHz) is now harmonized in Europe for indoor cordless telecommunications (DECT). Possibilities to make the band available for other mobile technology (LTE and 5G) should be explored. The upper part of the band (1900 – 1920 MHz) could be made part of this study as a possible extension. This band is in most European countries not used. It used to be part of the 3G (UMTS) licenses, but the TDD component of UMTS was never used in Europe. The whole band of 1880 – 1920 is within the remit of 3GPP standardization, and the band is used in China. Therefore, the handsets are already available.

A third possibility is the use of (parts of) the 26 GHz band. The band will only be used to provide ultra-high capacity in restricted areas. This will give possibilities to share the band between mobile operators and local networks.

4.3 Spectrum for specific verticals

5G is able to deliver a versatile and flexible mix of services that is tailored to the needs of a specific user group or a specific kind of usage. This includes the possibility to deliver public and societal services and applications that currently are provided through the use of dedicated spectrum allocations, such as public safety services (Public Protection and Disaster Relief) and services related to transport and traffic management (Intelligent Transport Systems). This may reduce the need for exclusive

assignment of spectrum for those specific applications. Examples are the next generation of PPDR projects such as the Emergency Services Network (ESN) in the UK and FirstNet in the US.

However, there might still be instances where the vertical has very specific requirement and these will have to be assured to serve the public objectives. In that case, there still might be a need for dedicated spectrum. A good example can be found in the safety related aspects of ITS. Dedicated spectrum is set aside to assure the related safety service at all cost.

Governments should be very reluctant to set spectrum aside. Many verticals might state that the requirements are so unique that they need dedicated spectrum, while their needs could be served by a more generic network, as shown for PPDR above. Another example of today is the utility sector that claimed dedicated spectrum for smart meters. However, there are possibilities to provide smart meter readings as a service on an existing mobile or IoT network. This reduces the need for dedicated spectrum. However, there may be a need for the vertical sector to be involved in the standardization to assure that the needs of the vertical sector will be supported by the next generation of mobile technology as has been done by the PPDR and railway community. Both user groups provided their user requirements to the standardization activities of 3GPP.

5 The need for sharing

5G will provide new opportunities for spectrum sharing in both licensed and unlicensed spectrum. Spectrum sharing solutions can be used to make spectrum available on a local level for niche players. Sharing is thereby used to protect incumbent users and to allow different local 5G networks to coexist. Spectrum sharing will go beyond the traditional static sharing whereby spectrum is shared on a geographical basis. Spectrum sharing in 5G will be more dynamic. It will expand and enhance the spectrum sharing technologies already introduced in LTE.

A promising area of investigation is sharing between mobile operators and private local networks. These private networks are in most cases used in isolated spots (such as an industry plant or a warehouse) where there will be limited demand for wide area connectivity as provided by mobile operators. This gives possibilities to re-use part of the spectrum from the mobile operators for local networks. Coordination and time synchronization may be needed to prevent interference between the networks. Studies are needed to investigate the support of guaranteed QoS when sharing spectrum as well as QoS support when roaming from the local network to the wide area network.

Listen before talk mechanisms are used to share unlicensed spectrum, as e.g. introduced for MulteFire in the 5 GHz range. However the use of directional antennas and beamforming will pose a challenge. These narrow beams will be more difficult to detect. Although the chances of a collision are also reduced, the level of interference will be more excessive. Various mechanisms have been proposed to overcome this problem, ranging from beam coordination to centrally organized spectrum pooling arrangements [12, 13].

More dynamic forms of shared access that are already present in regulations are Licensed Shared Access (LSA) in Europe and Citizens Broadband Radio Service (CBRS) in the United States. CBRS is a three-tier sharing model for the 3550-3700 MHz band. This model allows secondary licensed access and tertiary unlicensed access to accommodate a variety of commercial uses on a shared basis with the primary incumbent federal and non-federal users of the band [14].

LSA is a sharing concept that is introduced in Europe to share spectrum between incumbents and (licensed) LSA-users. Licensed access would result in guarantees for spectrum access for both the incumbent and the licensed secondary user. It was introduced to provide spectrum access for mobile broadband in the 2.3-2.4 GHz range. New LSA work has started to address spectrum access for new entrants to provide locally deployed high-quality 5G networks [15].

The scope of LSA could be broadened to improve efficient shared use not only for the mobile operator, but also for incumbent users. To give an example, in a number of European countries, the incumbent users of the 2.3 – 2.4 GHz band are wireless cameras. These cameras are used on a temporarily basis in a limited geographical area to capture media events. In the Netherlands, a so-called booking system is used to reserve and acquire a license for this temporarily and local use. The booking system is used to optimize shared use of the band between the wireless cameras. Investigations are now ongoing if this optimized use will provide possibilities to introduce mobile communications in the band. There seem to be possibilities especially for local mobile networks targeted at specific business segments. Sharing between wireless cameras and local networks is more promising than sharing between wireless cameras and mobile operators to provide enhanced mobile broadband. The reason being that the wireless cameras will normally not be used at company premises and industrial areas whereas wireless cameras are used to capture media events which are often also a hot spot area for mobile operators.

LSA based concepts can also be used to optimize the shared use of a band based on actual propagation conditions. Currently shared use is based on a worst case scenario for the propagation conditions. Hence there is ample room for improvement in shared use if the sharing can be based on more realistic and actual propagation conditions.

Recent measurements in the 3.6 GHz range have shown that the propagation conditions in this band are highly depending on the weather conditions. Worst case propagation conditions occur only for a very limited period of time per year and mainly in the evening till early morning hours [16]. Shared use of the 3.6 GHz band by mobile communications whilst protecting satellite earth stations could be greatly improved if the weather conditions are monitored and the geographical exclusion zone surrounding the satellite earth station is made smaller as long as the weather conditions allow to do so.

6 Conclusion

Realization of the vision of 5G to deliver reliable wireless connectivity tailored to the versatile needs of different business segments will require changes in the regulatory

environment for mobile communications. It will require a departure from authorization purely based on auctioning nationwide licenses. Realization of the vision of 5G requires local spectrum access by niche players and private networks to provide specific localized business applications and services next to national spectrum access for mobile operators. Access to spectrum for 5G should be based on a combination of nationwide available exclusive licensed spectrum, exclusive local licensed spectrum and unlicensed spectrum access. This will put more emphasis on spectrum sharing. Technology can be used to make sharing more dynamic based on the actual demand and realistic propagation conditions to improve efficient use of shared spectrum.

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