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The Way to 5G Networks and Spectrum Policies to Cope with High Data Communication Consumption - The Albanian Case

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Abstract - Future generation networks and 5G as a new generation for mobile technologies are part of many studies and research work in the world today. 5G is expected to offer much more than simple higher speed in data communication. Massive Machine type of Communication (mMTC) as part of IoT, vertical data usage with very demanding KPI-s and very low latency requests are related with 5G networks developments. There are a number of challenges related with 5G standardization and developments under discussion. This article will be focused on spectrum policies for data communication in 5G networks. This article gives the results of research work on spectrum management and spectrum usage in some European countries for 5G networks. Also it identifies the main challenges related to spectrum policies in Europe countries and in Albania. In the conclusion are given some recommendations related to spectrum policies in order to cope the future demand for data communication in 5G networks.

Keywords - *5G, IMT-2020, IoT, mMTC, M2M, spectrum policy*

1. Introduction

The 5G mobile network, known as the fifth mobile generation is expected to meet the future demands for data and many different use cases. The 5G development is seen also as a revolution in architecture which provides a flexibility and cost efficient network. Based on different studies and reports, in 5G it is expected to have up to 1 million devices connected in a square km.

The high demand for data traffic, the development of mobile applications and smart devices are the key drivers for this evolution from 3G to 4G and now to 5G. The 5G deployment is a complex process and is associated with a number of challenges.

Currently the process of 5G standardization is still ongoing. There are a number of projects and research teams in the world working on that issue. The different use cases of 5G networks are grouped from ITU [1], in a triangle of categories as given below.

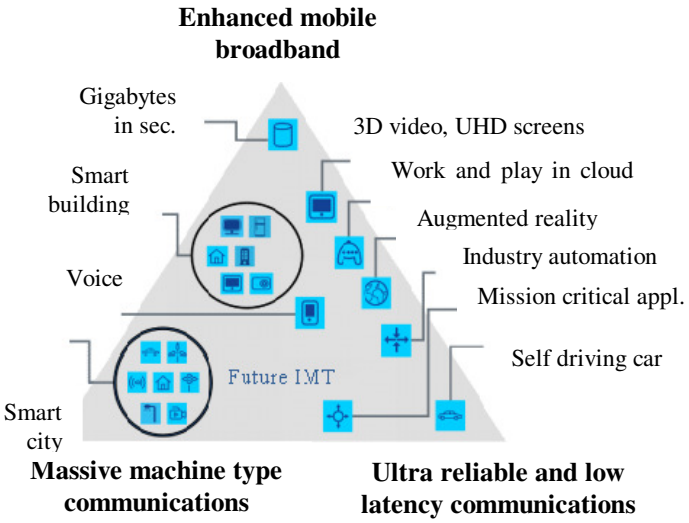

Fig. 1 Usage scenarios of IMT for 2020 and beyond;
Source: ITU-R recommandation M.2083-0

This classification is based on the requirements and specifications of each group: massive type of communication (mMTC), ultra reliable and low latency

communications and enhanced mobile broadband. In general three groups of ITU triangle have similar basic requirements and also some differences regarding the technical requirements, mobility, latency, its usability etc. 5G networks should support emerging new use cases, new applications which require very high data rate communications and low and ultra-low latency.

The massive machine type of communication, (mMTC) is related with the enormous number of connected devices, in other words it is a massive IoT. The main use of this kind of communication is expected in smart cities by deploying a great number of sensors for data communication and exchange. According to [2], not all devices have the same requirement, so 5G networks will have to be adaptable even to different types of IoT devices. ITU studies notices that future IMT will require more flexible network nodes which are configurable based on the Software-Defined Networking (SDN) architecture and network function virtualization (NFV) for optimal processing the node functions and improving the operational efficiency of network.

In addition, when speaking of the mobile data traffic the type of applications and the trend of their usage it is needed to be considered. Referring to Cisco VNI 2017 [3], "*globally, M2M connections will grow from 780 million in 2016 to 3.3 billion by 2021, a 34% CAGR a fourfold growth*". The faster growth in mobile data traffic will be as follows: mobile video 66.5%, mobile web/data 24.9%, M2M 5.1% and mobile file sharing 3.5%. More mobile video means more traffic capacities to cope with market demand and keep Quality of Services as a strong arm in a competition market.

Besides the differences in technical requirements between each group of use cases of 5G, the main requirement is related with spectrum. The high demand for spectrum bandwidth is a challenge for regulatory bodies. It requires a clear vision and spectrum policies for the future of data communications in 5G.

2. Spectrum and technical requirements for 5G networks

5G network deployment asks for a significant spectrum bandwidth in order to achieve the technical requirements. Referring to Nokia [4], the spectrum bandwidth, estimated per operator could be ~500MHz below 20GHz, ~1GHz between 20-40GHz and ~2 GHz above 40GHz. The discussions today are related with possibilities of use the different bands below 1GHz and over 6GHz for 5G networks. The main bands below 1GHz include 700 MHz and 800 MHz. Considering the 5G requirements, massive machine type of communication and high density coverage in limited areas, such as in business centers the millimeter wave coverage, are also important.

The bands below 1GHz are normally used for mobile communication in first generation and second generation. The mobile companies use the licensed frequencies for their networks. The frequencies are a key asset for mobile networks. Based on a survey made by TIA [5], the licensed frequencies owned or operated from one operator in average are from 40-80MHz, to over 180 MHz, while the bands used for mobile networks are usually from 700 MHz to 2.6GHz. The frequencies need for 5G network in order to cope with high data traffic [4], is much higher than in current situation.

The spectrum requirements is closely related with high technical requirements for 5G. ITU recommendation notices that "the peak data rate of IMT-2020 for enhanced Mobile Broadband is expected to reach 10 Gbit/s" and under certain conditions and scenarios IMT-2020 would support up to 20 Gbit/s peak data rate". These requirements asks for three times higher spectrum efficiency of IMT-2020 compared with IMT advanced. These technical requirements raise the future radio access requirements and of course need new spectrum policies.
IMT-2020 is expected to support 10 Mbit/s/m2 area traffic capacity, and also to support 10 times to 100 times higher number of connected devices. These technical requirements ask for network densification, which raises a number of challenges such as the availability of spectrum for the small coverage with high and very high data rate, interference free, the problems of site acquisitions, the environment protection, protection from radiation etc. The high density of the connected devices and small and ultra small cells on the other hand is related with some environment and regulatory issues such as radiations, right of way etc. which need to be considered in further studies. WiFi offload is also a potential to be used and combined in solutions for coverage and provision of services under certain conditions and areas such as in mMTC and IoT.

3. Global Spectrum policies for 5G networks and challenges

Extension of spectrum for 5G or IMT-2020, is a global discussion. From technical point of view it is related with

industry developments and standardization. On regulatory side, some key decisions are needed, especially for the harmonization of spectrum use and allocation new spectrum for 5G etc.

The International Radio-communication Conference of ITU, WRC-2015 decided about the frequency bands under 6GHz and for IMT, 5G networks. So, 700MHz and 800MHz as well as 3.4-3.6 GHz are allocated for IMT networks. The 700 MHz band and 800 MHz band are important in order to realize the wide coverage with 5G network.

Furthermore, it was required to see additional bands for future IMT, such as the millimeter wave frequencies on a certain number of bands situated between 24 GHz - 86 GHz. The studies for such frequencies are ongoing and it is expected to be addressed in the WRC-19.

There are 33.25 GHz in total identified as possible for development of 5G networks. From the technical point of view a number of challenges are raised: 5G networks will be based on different carrier aggregation and also it is required to provide the specific performance for different users and services.

According to ITU publication [6], *"the scope of 5G is much broader than the previous generations of mobile broadband communication systems*". This is related of course to technical challenges such as standardization process, increased number of applications, devices, actors, spectrum efficiency and harmonization, new business models for data communications etc.

Spectrum efficiency is one of the key requirements in spectrum policies and spectrum management. The 5G networks is expected to be deployed in different frequency bands under 1GHz, 3GHz and above 6GHz. For each frequency band there are different technical requirements such as: regarding carrier bandwidth from n*20MHz for frequencies under 1GHz, to n*100MHz for frequencies in the 10 GHz bands and 1-2GHz band required for frequencies over 30 GHz.

The spectrum efficiency is asking for cooperation and co-existence of different access technologies and also for studies on interference, discussion and solutions for radio access network in different bands.

Another difference is related to the coverage and cell size. The frequencies under 1GHz are necessary to have a good coverage through macro cells, but in frequencies over 6GHz we will build small and ultra small cells with higher capacity and throughput.

The harmonization of spectrum policies for 5G is a challenge. Currently there is lack of global spectrum harmonization on LTE deployment. Referring to the GSMA Intelligence Report [7], the situation of LTE deployments by region for 4G networks is as below.

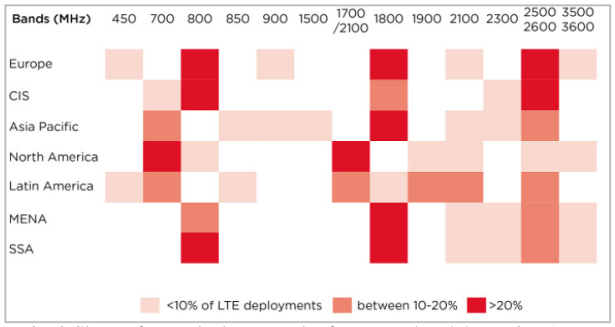

Fig. 2 Share of LTE deployments by frequency band, by region (January 2015); *Source:* GSMA Intelligence Report

The definition of a global standard for 5G which will be compatible with an enormous number of different devices in different countries of the world will be the best option for all.

4. LTE networks in Europe and EU spectrum policy for 5G

The spectrum requirement for 5G networks is seen today in two directions: the frequencies under 1GHz and the frequencies above 6GHz. Referring to data published to [9], the situation in Europe related with allocation of frequencies under 1GHz for mobile networks is as below:

All European countries, where the number of operators is between two to four operators, have allocated 900 MHz, 1800 MHz and 2100 MHz for mobile networks. The majority of them, has allocated and issued the frequencies in 800 MHz band.

Currently the band 700 MHz, is allocated and issued for 5G networks in few countries such as France, Germany, and Finland. In some other countries the 700 MHz band is already allocated for 5G networks but not yet licensed such as Iceland, Denmark and Netherland. In Netherland the auction for 700 MHz is planned for 2019.

Based on the research done on the different national frequency plans of European countries, the frequencies over 6GHz, for the time being in majority of them, are

allocated for fix services, satellite, inter-satellite etc. Only in few cases a part of these frequencies are allocated for LTE and mobile services e.g. the sub-bands (40-40.5 GHz and 42.5-43.5 GHz) in Serbia and Montenegro.

According to [8], "5G for Europe: An Action Plan" document, there is a strong support for early decision in EU countries related the spectrum needed for 5G especially for early decisions on 5G pioneer bands in advance of WRC-2019. The most preferred bands identified in EU as pioneer bands for 5G are the bands under 1GHz: 700 MHz, 3.4-3.8 GHz and the 24-27 GHz. There is a decision in EU level to free the 700 MHz band for 5G within 2020. Currently 700 MHz is licensed in three EU countries and is allocated for 5G in three other countries. Meantime the EU countries need to adopt their national plans and spectrum policies within 2018 in order to address the issues related with 700 MHz such as: unsolved cross border coordination issues in order to avoid interferences, technical migration of broadcasting services from 700 MHz etc.

If we consider the licensing regime for the time being, the mobile networks operate mainly in dedicated license frequencies. The process of licensing is based in auctions and the license fee is normally high. The spectrum has a great impact in total costs of mobile networks. Referring to spectrum licensed already in 800 MHz in some Europe countries the price of frequencies is high. The table below gives the results of 800 MHz auctions in some European countries based on data published in spectrum monitoring [9].

Table 1: Results of 800 MHz auctions in Europe countries

Country	Date	Rounds	Proceeds billions	Bench	
Italy	1.09.2011	325	€2.96	0.0509	296%
Germany	0.05.2010	224	€3.58	0.0485	282%
France	2.12.2011		€2.64	0.0334	194%
Portugal	0.11.2011	9	€0.27	0.0284	165%
Spain	9.07.2011	166	€1.31	0.0243	141%
Sweden	4.03.2011	31	€0.23	0.0172	100%
Switzerland	2.02.2012		€0.	0.0	%

Source: Adopted by author based on data published in: www.spectrummonitoring.org

Looking on benchmark values (price per 1Hz/population), there is a big difference if we compare Italy and Germany with Sweden, Spain or Switzerland. Also there are differences in number of rounds of auctions from 9 in Portugal to 325 rounds in Italy.

According to European Leadership in 5G, the key question is *„whether 5G enables services that consumers – business and individuals – are willing to pay for"*. Considering the spectrum needed for 5G from 100 MHz to 1-2 GHz, it means also higher costs for spectrum. In order to fulfil the requirements it is necessary to adopt new policies and regulations for reduction of such costs.

Regarding to the spectrum policies, EU recently has undertaken a reform in electronic communication regulation [10]. Part of this reform is regulation of frequencies especially to prolong the licenses period for 5G frequencies in order to increase the spectrum efficiency and asking for more converged spectrum policies within EU.

The new spectrum policies should promote greater use of general authorizations and spectrum shared use with a view to enable the development of new innovative applications and services. Sharing use of the spectrum and also prolongation of license period may reduce the costs of spectrum and lead to a better benefit to end user.

5. The Albanian case

There are four mobile network operators in the market. The mobile market is well developed with good coverage with 3G/4G which is offered from all mobile market players. Mobile broadband provided based on HSPA/HSPA+ was introduced late in Albania on 2010, while 4G/LTE was presented on September 2015.

The data communication in recent years is increased fast. The graph below gives the data traffic and voice traffic in mobile market in Albania during 2011-2016 based on date published from AKEP [11].

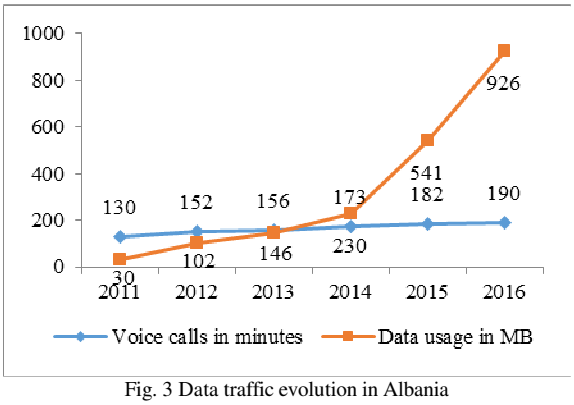

Fig. 3 Data traffic evolution in Albania
Source: Author based on data of AKEP

As far as spectrum policy is regarded the main regulation in place follow the EU approach. The licensing regime is based on general authorizations in cases where no scarce resources are required. The individual authorizations are issued for frequencies for mobile networks. The licensing procedure for these frequencies is based on open international bid similar to auctions.

Referring to data published in spectrum monitoring, the four mobile operators are operating in 900MHz, 1800 MHz, 2.1 GHz and 2.6GHz distributed between them as below.

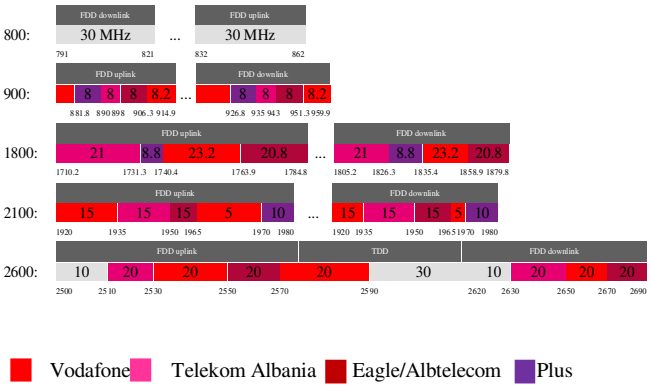

Fig. 4 Spectrum usage in Albania
Source:http://www.spectrummonitoring.com/frequencies/#Albania

The band 800 MHz is not allocated yet for mobile networks. Currently the 800MHz band is still occupied from broadcasters, while the 700MHz band is not allocated yet for LTE. The new national frequency plan was recently approved [12]. The 800MHz band is allocated for LTE and a deadline to free this band from broadcasters is defined within 30th of June 2017.
Furthermore a new spectrum policy is needed to give the future usage of spectrum for 5G under 1GHz and also over 1GHz in line with global developments and EU recent decisions.

6. Main challenges and recommendations

Main challenges of spectrum policies globally, and regionally are:

- to allocate additional spectrum for future networks;
- to solve with consensus a global standard issue for 5G or IMT-2020;
- to address the interference problem in operation in different frequency bands under and over 1GHz;
- to adopt a regulation regime for new scheme of operation for 5G networks in different bands over 6GHz;

A global standardization for 5G will maximize the benefits for all stakeholders through economy of scale and will help the compatibility with different type of devices and users. Spectrum policy for 5G needs to promote and put in place spectrum sharing which will lead to cost reductions.

7. Conclusions and future work

The way to 5G is a complex process, there are a lot of challenges still ahead for policymakers, regulators, the industry and network operators too. The spectrum policy is one of the key issues in this process. This article is focused on spectrum policy for 5G networks. Based on a research in different ongoing studies and current situation in Europe countries the article gives the main challenges related to 5G especially with spectrum. The current use of spectrum for LTE networks in Europe countries and in different regions in the world suffers lack of harmonization. The spectrum policies under development in EU countries support the 5G deployment and especially allocation of additional spectrum for 5G network. In case of Albania 800 MHz is not licensed yet for LTE, while the 700MHz band is not allocated for LTE. WRC-2019 is expected to decide for additional spectrum over 6GHz. The implications of spectrum policy in pricing models for data communication in different usage cases as well as the relation of pricing models with key performance indicators need to be studied.

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