ANALYSIS OF USAGE OF RADIO FREQUENCY SPECTRUM IN 5G NETWORKS

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Abstract: *This article is devoted to the search and research of frequency resources for the development of 5G networks, including the specific features of the NG-RAN radio network architecture, options for connecting gNB base stations to the 5G Core network, as well as frequencies for the development of 5G networks. The analysis of search resources is explained.*

Keywords: *5G generation, NG-RAN, gNB, Core .*

One of the main obstacles to the development of 5G networks is the lack of frequency resources necessary to ensure the necessary quality of services in the conditions of exponential growth of user traffic. In particular, the problem of shortage of frequencies in the lower parts of the radio frequency spectrum up to 6 GHz is caused by the high loading of this part of the spectrum.

Radio frequencies for use in 5G networks can be conventionally divided into the following two main bands:

- lower - up to 6 GHz;
- high - from 6 GHz to 100 GHz.

These frequency bands have specific characteristics that affect how they can be used in 5G networks. Lower frequency bands of 5G networks (up to 6 GHz):

- enables creation of wide coverage zones, ensuring cost-effective provision of mobile communication services;

requires wider frequency channel bandwidths (hundreds of MHz) than 4G/LTE networks to achieve high throughput ;

- Requiring the identification of new frequency bands up to 6 GHz for 5G networks.

High frequency bands of 5G networks (from 6 GHz to 100 GHz):

- required for applications that require very high data rates;
- requires wider 5G frequency channel bands (for example, 1 GHz per operator) in a small coverage area (hundreds of meters) outside buildings;

- allows multiple use of frequency channels, as well as their use in combination with existing communication networks.

The following criteria were used in the METIS-I project in the phase before the 15th World Radiocommunication Conference (2012-2015) to search for new frequency bands for 5G networks (Figure 1).

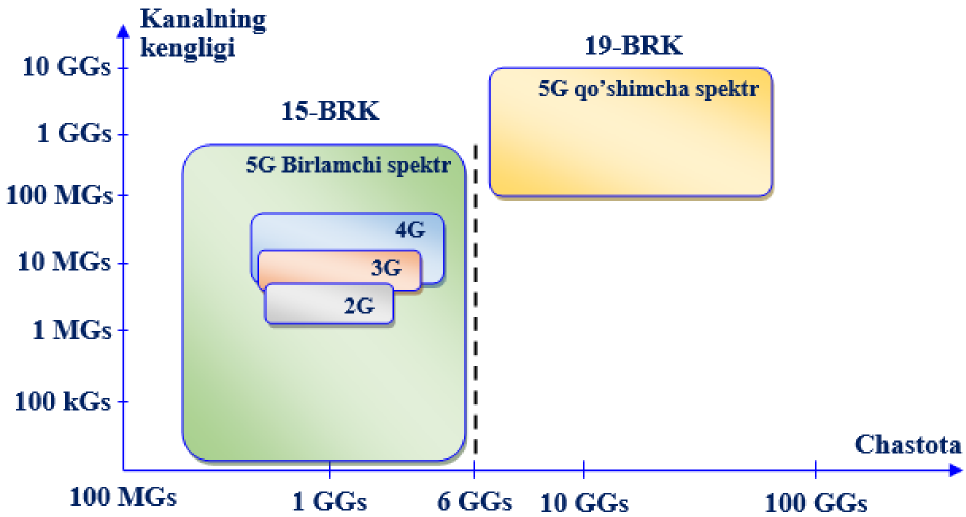

Figure 1. 5G spectrum allocation strategy in 15-BRK and 19-BRK

Additional conditions for the search for new frequency bands for 5G networks were:

- In the first stage, the possibility of aggregation of carriers was evaluated, that is, the frequency band should be continuous. However, if the search for such a band does not lead to positive results, then simple aggregation representations combining a small number of non-adjacent spectra will be evaluated in the second phase of the METIS-II project.

- bands where only one 5G network can be built should not be excluded from consideration at the initial stage of research, that is, there is no need to place several parallel working networks in one frequency band.

Based on the selected criteria, priority frequency bands in the ranges from 9.9 GHz to 95 GHz were determined in the METIS-I and-II projects, which are presented in Figure 2.2 (dashed). Analysis of these bands shows that most of the priority bands are located in the 100 GHz frequency band.

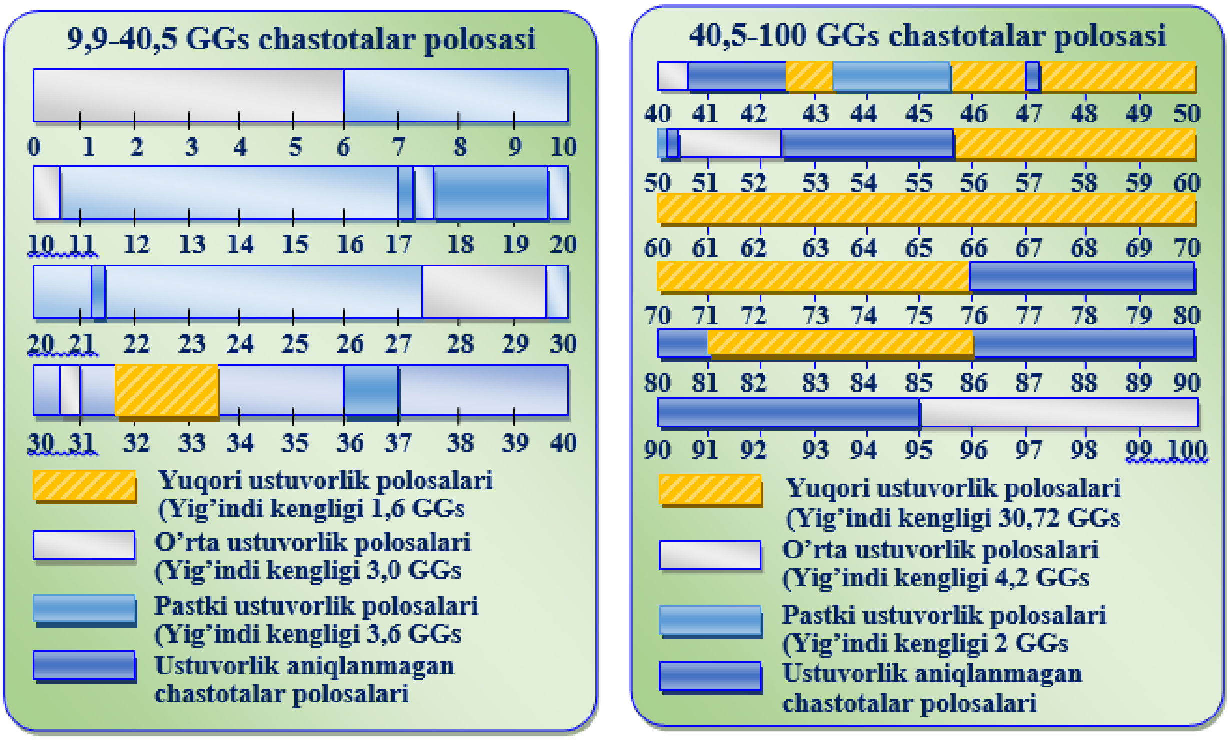

Figure 2. Priority frequency bands for the development of 5G networks

In addition to the research on the search for frequency bands for 5G networks conducted in the METIS-I project, the XEAI-R Research Commission of the Radiocommunication Sector will carry out an assessment of the need for radio frequency spectrum for 5G networks. They are based on the positions of major regional associations of Communications Administrations, such as SERT, RSS, ASMG, CITEL , etc., and assessments of spectrum needs for 5G, as well as assessments of national Communications Administrations.

In 2013, XEAI-R M.2290 [3] was issued as a result of the work carried out in the Radiocommunication sector, which presented the results of the study of global spectrum needs for terrestrial IMT networks in 2020. Estimated spectrum requirements include previously defined requirements for IMT networks and additional requirements for 5G network spectrum. The calculation of spectrum needs in these studies was carried out according to the method described in the Recommendation XEAI-R M. 1768-1 [4] and based on forecasting the growth of subscriber traffic. In this case, the total need for spectrum for networks built on the basis of different radio communication technologies - RAT G1 (for pre-IMT, IMT-2000 and its evolutions) and RAT G2 (IMT-Advanced) until 2020 for high/low densities of users (Table 1) was evaluated. Analysis of the research results presented in Table 2.1 shows that the need for radio frequency spectrum will be 1340 - 1960 MHz by 2020 only for the development of IMT networks.

Estimated spectrum needs for different countries (Table 2) include previously determined spectrum needs for IMT networks and additional spectrum requirements that take into account the characteristics of the national mobile communication market.

Table 1

Estimated values of spectrum needs for RAT G1 and RAT G2 technology networks

User density	*Spectrum needs for RATG1 networks*	*Spectrum needs for RATG2 networks*	*Aggregate spectrum requirement for RATG1 and RATG2 networks*
Low	***440 MHz***	***990 MHz***	***1340 MHz***
High	***540 MHz***	***1420 MHz***	***1960 MHz***

Table 2

Spectrum needs for IMT networks in different countries

Country, organization	*Year of assessment*	*The need for spectrum*
Australia	until 2020	***1081 MGs (additional 300 MGs required by 2020)***
Russia	2020	***1081 MGs (additional 385 MGs required by 2020)***
China	2015, 2020	***579 - 690 MHz by 2015; 1490 - 1810 MHz by 2020***
India	2017, 2020	***300 Mhz additional need by 2017; An additional 200 Mhz is needed by 2020***
Great Britain	2020	***775 - 1080 MHz for low demand; 2230 - 2770 MHz for high demand***
GSMA	2020	***1600 - 1800 MHz for different countries***

It should also be noted that there are differences in the characteristics of markets and the pace of network construction, as well as the timing of data traffic growth in mobile networks in different countries.

In order to ensure the continuous growth of traffic in the future IMT-2020 networks until 2020 and beyond, it is desirable to use a larger bandwidth of channels (compared to those currently in use). If additional spectrum bands are possible for IMT networks, then the potential difficulties for users operating in these spectrum bands should also be taken into account.

In February 2017, in preparation for the XEAI-R 19th BRC, working group 5D conducted a series of studies to determine the spectrum needs for 5G networks, the results of which were 5-1/36E for the 5/1 target group given in the communication document [5]. In these studies;

- Various methods of determining spectrum needs were used, taking into account the technical characteristics of 5G networks.

The research also included data on the assessment of spectrum needs for 5G networks in several countries around the world. The results of the aforementioned XEAI-R studies on the assessment of spectrum needs for 5G networks are presented in Table 3.

As can be seen from Table 3, the calculated values of the required spectrum for 5G networks differ greatly depending on the methods adopted and the initial data selected for calculation. The obtained results range from 0.8 GHz to 8 GHz in the frequency bands below 43.5 GHz, and up to 12 GHz in the bands above 43.5 GHz, with a total spectrum requirement of up to 20 GHz.

Table 3

Assessment of spectrum needs for 5G networks

Calculation method for 5G networks	*Number of examples*	*Initial data for calculation*	*Total need for spectrum, GHz*	*Spectrum needs, GHz, depending on the frequency range of the carrier*
By application	***1***	***High density areas, high density areas, urban areas***	*18.7*	***3.3 (24.25 - 33.4 GHz) 6.1 (37-52.6 GHz) 9.3 (66 - 86 GHz)***
		High density areas, urban areas	*11.4*	***2.0 (24.25-33.4 GHz) 3.7 (37 - 52.6 GHz) 5.7 (66 - 86 GHz)***
	2	***Very dense areas***	*3.7*	***0.67 (24.25 - 33.4 GHz) 1.2 (37-52.6 GHz) 1.9 (66 - 86 GHz)***

		Places where people are dense	*1.8*	*0.33 (24.25 - 33.4 GHz) 0.61 (37 - 52.6 GHz) 0.93 0.93 (66 - 86 GHz)*
According to technical characteristics (option 1)	*1*	*1 Gbit/s data transfer rate through the user interface when serving N simultaneous users or devices at the edge of the network, for example in a building*	*3.33 (N=1), 6.67 (N=2),* 13.33 (*N=4)*	
		N users at the same time or 100 Mbit/s data transfer speed through the user interface on edge devices in a wide coverage area	*0.67 (N=1), 1.32 (N=2), 2.64 (N=4)*	
	2	*YeMVV "Dense City" view*	*0.83-4.17*	
		YeMVV "Building" view	*3-15*	
	3	*10 Mbit/s file transfer at 1 ms by a single user at the edge of the market*	*33.33 (one way)*	
		1 Mbit/s file transfer at 1 ms by a single user at the edge of the market	*3.33 (one way)*	

		0.1 Mbit/s file transfer at 1 ms by a single user at the edge of the market	*333 (one way)*	
According to technical characteristics (option 2)	-	*The macro level of the network in a dense city*	*0.808-1.078*	*<6 GHz*
	-	*The micro level of the network in a dense city*	*14.8-19.7*	*5.8-7.7 (24.25 - 43.5 GHz)*
		in the building		*9-12 (24.25 - 43.5 GHz and 45.5-86 GHz)*
Data taken from individual countries and taking into account their national characteristics	-	-	*7-16*	*2-6 (24.25 - 43.5 GHz) 5-10 (43.5-86 GHz)*

The peak spectrum needs were obtained at a data rate of 1000 Mbit/s calculated for a large number of serviced subscribers. When computing data rates up to 100 Mbit/s, spectrum requirements are reduced to a few GHz.

It should be noted that today this issue remains open. More accurate values of the spectrum of radio frequencies required for the construction of 5G networks can be obtained based on the data of experimental and commercial use of 5G networks.

CONCLUSION

5G technology is a new generation of mobile communication technologies. It is currently being developed and implemented by leading international and national standardization bodies, after the current development phase of 4G/LTE/IMT-Advanced, it is a new stage in the evolution of mobile telecommunication standards, and combines functional capabilities, data transfer rates and other technical characteristics. increases how many times.

The 5G generation of mobile communication is an intelligent platform for the development of not only technologies, but also artificial intelligence technologies that provide ultra-fast radio communication, low latency and more reliable connection, and meet the ever-growing requirements for data transmission for the needs of the digital economy. remains.

The transition to 5G mobile networks involves the introduction of new principles of radio frequency spectrum use and the use of new frequencies in millimeter wave frequency bands, the creation of a virtualized 5G network infrastructure based on technological and infrastructural heterogeneity, and a business oriented towards the mass use of M2M and IoT (uRLLC and mIoT) services. requires the introduction of models.

The SERT countries will include the following frequency bands in the future bands for the development of 5G networks, three of which will give priority to the frequency bands -24.25 - 27.5 GHz, 31.8 - 33.4 GHz and 40.5 - 43.5 GHz. 45.5 - 48.9 GHz, 71 - 76 GHz and 81 - 86 GHz frequency bands require research. CERT YESS (18)06 confirms the priority for the frequency bands 24.25 - 27.5 GHz by adopting Decision [11], which introduces appropriate conditions for the protection of this and other services in adjacent frequency bands. This decision provides for the procedure for licensing the use of frequency bands for 5G networks.

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