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ANALYSIS OF THE FREQUENCY ALLOCATION EXPERIENCE IN THE WORLD AND UZBEKISTAN FOR 5G-BASED SYSTEMS

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This paper provides analytical data on the development trends of 5G-based services, the world experience of frequency allocation for 5G, as well as the allocation of frequencies for 5G and IoT services in Uzbekistan.

Development trends of 5G-based services

5G is both a new communication standard and the technological evolution of mobile networks, as well as a new paradigm of telecommunications and information technology services. The 5G network includes a densely distributed matrix of computing, storage and networking functions.

The development of mobile networks during the transition to 5G technologies is characterized by the following features [1, 11]:

1) Holographic and multimedia services with full availability effect, including fundamentally new services, including 360° comprehensive interactive video content; full range of virtual and augmented reality services; ultra low latency services (rescue robot remote control and autonomous vehicle control); Internet of Things services based on the mass connection of devices; large-scale data-based intelligent services and tactile Internet services will be introduced [12].

2) Multiple growth of mobile traffic is observed. This is due to [13]:

– increased consumption of video services and increased video size;
– increase in the number of devices connected to the network;
– increasing the speed of application use;
– widespread use of cloud technologies;
– use and update modern online games.

3) The share of smartphones in mobile data traffic will reach 95%.

4) Mobile video – becoming the main form of mobile data traffic [14].

5) At the first stage of development of 5G communication networks, the most popular functions and services will be related to the final applications with high requirements for content quality: gigabit speed, “live” sports broadcasts, elements of virtual reality movies, the use of augmented reality elements to drive cars in real time. Subscribers are also interested in new services such as simultaneous translation from a foreign language, “Smart City”, “Smart Home”, drone control [15, 16].

6) The following features are less important for potential subscribers of 5G network: longer battery life, enhanced security of personal data, the highest quality video stream, the ability to connect to almost any device network in the home [17].

World experience of frequency allocation for 5G

Each type of 5G service requires specific technical requirements that are optimally implemented in different frequency bands. 5G-based services are provided using LTE-Advanced and NR technology solutions. The evolutionary data of the standards based on these solutions are given in Table 1 [2, 18].

Table 1. Analytical data on LTE-Advanced and NR standards

Characteristic	Bandwidth	Ranges	Delay	Maximum speed	Areas of application
LTE-Advanced standards					
NB-IoT	180/200 kHz	450-3800 MGHz separate bands	A few seconds	130 kbps	Simple IoT devices
LTE-eMTC	1.06 MHz	450-3800 MHz separate bands	Tens of ms	Up to 1 Mbps	Low power devices
LTE-Advanced	1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz.	450-3800 MHz separate bands	5-10 ms	Up to 2 Gbps	Mobile broadband access, professional communication, IoT systems
LTE-eLAA/ MultiFire	20 MHz	5150-5350 MHz, 5470-5850 MHz	5-10 ms	Hundreds of Mbps	Mobile broadband access, private network, IIoT
LTE-V2X/ C-V2X	10 MHz or 20 MHz	5855-5925 MHz	Up to 4 ms	Up to 44 Mbps	Autonomous control systems
NR standards					
NR (6GHz gacha)	5 MHz, 10 MHz, 15 MHz, 20 MHz, 25 MHz, 30 MHz, 40 MHz, 50 MHz, 60 MHz, 80 MHz and 100 MHz	450-3800 MHz separate bands, also, 3800-4200 MHz and 4400-5000 MHz	1 ms	2 Gbps or more	Mobile broadband access, critical IoT systems
NR 2-faza (6GHz dan)	50 MHz, 100 MHz, 200 MHz and 400 MHz	26,5-29,5 GHz, 24,25-27,5 GHz and 37-40 GHz	1 ms	Up to 20 Gbps	Mobile broadband access, high traffic capacity and critical IoT systems

According to the Technical Specifications of the 3GPP Partnership Project, the frequency bands for 5G are divided into the following 3 groups [3, 19, 20]:

– Frequency range below 1 GHz;
– 1-6 GHz frequency range;
– Frequency range above 6 GHz.

Frequency range below 1 GHz have the best transmission characteristics in urban, suburban and rural areas, provide effective radio coverage for large areas, as well as indoor coverage, and are relevant for the use of IoT devices [21].

The 1-6 GHz frequency range has good propagation characteristics in urban, suburban and rural areas, and is wide enough to form high-speed channels with spectral bands up to 100 MHz [22, 23].

Frequencies above 6 GHz are designed to establish ultra-high-speed communication channels at short distances from the base station using channels with a spectrum width of up to 400 MHz that provide ultra-low latency in the NR (New Radio) radio interface. Frequencies above 6 GHz have poor propagation characteristics [24].

Current results of compatibility studies in the small range of 37-42.5 GHz suggest that there are no significant difficulties in coordinating existing radio services with IMT systems [25]. However, different radio electronic services are available in this small range in different countries. Given this division of the spectrum, it is recommended to use an approach that allows the subscriber terminal to select the appropriate subnet depending on the region in which it is currently used [26-29].

The introduction of the small band 40.5-43.5 GHz is important for research on the effectiveness of the introduction of 5G/IMT-2020 networks and, if possible, for use in 5G networks in the future, to prevent other services from migrating from this band to this band need [30, 31].

Frequency distribution for mobile base stations in Uzbekistan

Today, the demand for services provided by mobile operators in Uzbekistan is growing. Extensive work is being carried out in the Republic of Uzbekistan to ensure the full coverage, development, improvement of the quality of services provided, increase the volume and capacity of data transmission [32].

In order to facilitate the introduction of modern digital technologies in the country by the Republican Council on Radio Frequencies and to simplify the procedure for processing (modernization), production and import of radio electronic means in the Republic of Uzbekistan, the basic technical the requirements for the parameters and the frequency bands allocated for them have been approved [4, 33]. Table 2 describes the requirements for 4G mobile systems [34-36].

Table 2. Basic technical requirements for long-term mobile development system (4G – LTE/IMT-Advanced)

The number of operating frequencies of the radio network equipment	Operating frequency range (BTS receives, UE transmits), MHz	Operating frequency range (BTS receives, UE transmits), MHz	Duplex distribution method
1	1920-1980	2110-2170	FDD
2	1850-1910	1930-1990	FDD
3	1710-1785	1805-1880	FDD
4	1710-1755	2110-2155	FDD
5	824-849	869-894	FDD
6	830-840	875-885	FDD
7	2500-2570	2620-2690	FDD
8	880-915	925-960	FDD
9	1749.9-1784.9	1844.9-1879.9	FDD
10	1710-1770	2110-2170	FDD
11	1427.9-1447.9	1475.9-1495.9	FDD
12	698-716	728-746	FDD
13	777-787	746-756	FDD

14	788-798	758-768	FDD
17	704-716	734-746	FDD
18	815-830	860-875	FDD
19	830-845	875-890	FDD
20	832-862	791-821	FDD
21	1447.9-1462.9	1495.9-1510.9	FDD
33	1900-1920	1900-1920	TDD
34	2010-2025	2010-2025	TDD
35	1850-1910	1850-1910	TDD
36	1930-1990	1930-1990	TDD
37	1910-1930	1910-1930	TDD
38	2570-2620	2570-2620	TDD
39	1880-1920	1880-1920	TDD
40	2300-2400	2300-2400	TDD

4G mobile communication systems use QPSK (squared spatial modulation), 16QAM (squared amplitude modulation with 16 levels), and 64QAM (squared amplitude modulation with 64 levels) [4, 37].

In addition, the basic technical characteristics of radio-electronic devices operating on LTE-Advanced must meet the requirements of the standards Oz DSt 3044: 2016 and Oz DSt 3447: 2020 [4, 38-40].

The following are the basic technical requirements for the 5th generation mobile communication system (5G/IMT-2020), as well as information on the allocated frequency bands (see Table 3).

Table 3. Operating frequency ranges of 5G/IMT-2020 equipment networks

No.	**Operating frequency range, MHz**	**Step of possible values of the carrier, MHz**	**Duplex distribution method**
1	3400-3600	40, 60, 80, 100	TDD
2	3600-3800	40, 60, 80, 100	TDD

The loading power of 5G systems is 200 W, the allowable value of the Radio Interference voltage is -99.2 dBm at the operating frequency (3400-3600 MHz) and at the side frequencies (3600-3800 MHz) [4, 41-42]. The modulation type is 256QAM, 64QAM, 16QAM, QPSK modulations based on Gaussian modulation.

Frequency distribution for narrowband wireless technologies in Uzbekistan

Management of production processes, accounting of resources (electricity, gas, water, etc.) for the widespread use of information and communication technologies in various sectors of the economy, such as manufacturing, housing and communal services, health, agriculture, etc., radio communication technologies of data transmission networks have been developed and introduced in the framework of the application of IoT technologies in monitoring the condition of the patient, monitoring the growth status of plants, etc. One such radio technology is LPWAN (Low Power Wide Area Networks), a narrowband wireless network technology for IoT communication [43-44]. It transmits data over long distances from various sensors and counters. Currently, there are several standards for LPWAN technologies, such as LoRaWAN, SigFox, and others [5, 45].

For the purpose of application of narrowband wireless technologies of the Internet of Things with low radiation power and coverage of several kilometers and more for data collection and processing on the basis of LPWAN technologies in the territory of the Republic of Uzbekistan by legal entities and individuals 863-870 MHz and 922-928 MHz radio frequency bands have been allocated on a secondary basis for use [6, 46-47].

In addition, the following requirements apply to the use of LPWAN technology devices in these radio frequency bands [6, 48-50]:

– the maximum capacity of the final device and base station of the network based on LPWAN technology should not exceed 25 mWt;

– the use of radio equipment within airports and airfields is determined by the electromagnetic situation;

– the radio equipment used shall not cause harmful radio interference to other radio electronic devices and other radio services shall not be required to be protected from interference by radio electronic means;

– the technical characteristics of the radio equipment used must comply with the standards and norms established in the Republic in terms of radiation parameters.

Frequency distribution for radio electronic means of data transmission network in Uzbekistan

In order to accelerate the development of broadband networks in the Republic of Uzbekistan, to eliminate the factors that negatively affect the rapid development, to improve the quality and variety of services and to simplify the procedure for using the data transmission network imported into the territory of the Republic It is stipulated that radio electronic devices may be used on a secondary basis in the 2400-2483.5 MHz, 5150-5190 MHz, 5210-5350 MHz, 5520-5550 MHz and 5570-5650 MHz radio frequency bands, as well as in the 60 GHz radio frequency band [7, 51]. In this case, the technical characteristics of radio-electronic devices are required to comply with the standards and norms established for radio parameters in the country [8, 52].

Status of use of low-power base stations with a capacity of not more than 500 MW indoors by mobile operators in the territory of the Republic of Uzbekistan

Extensive work is being carried out in the Republic of Uzbekistan to ensure full coverage of the networks of mobile operators, improve the quality of services provided, including increasing the volume and capacity of high-speed data transmission [9, 53-54].

In order to accelerate the development of telecommunications networks, create the necessary infrastructure for the development of the digital economy in the regions, as well as to simplify the use of low-power base stations by radio operators in the regions of the Republic of Uzbekistan 450, 700, 800, 900. 1800 , 1900. 2100. 2G (GSM), 3G (CDMA, UMTS/IMT-2000), 4G (LTE/IMT-Advanced), 5G (IMT-2020) and their subsequent modifications in the frequencies of radio frequencies of 2300, 2600 and 3500 MHz. Permission to use low-power mobile base stations with effective radiation power not exceeding 27 dBm (500 mW) for indoor communication (except for mobile base stations installed near classified facilities), which do not require perfect construction of telecommunication infrastructure. naming is specified [10, 55]. At the same time, the technical characteristics of radio-electronic devices are required to comply with the standards and norms established for radio parameters in the country.

Conclusion

This paper analyzes the development trends of 5G-based services and the world experience of frequency allocation for 5G communication. Based on this, analytical data on LTE-Advanced and NR standards are provided. Frequency allocation for mobile base stations, narrowband wireless technologies, data transmission network radio-electronic devices in Uzbekistan has also been studied. The main technical requirements for long-term development of mobile communications (4G - LTE / IMT-Advanced) and the operating frequency ranges of 5G / IMT-2020 equipment networks are given. In addition, the use of low-power base stations with a capacity of not more than 500 mW in indoor buildings by mobile operators was analyzed.

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