Principles of the transition from 4G LTE to 5G

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Abstract: Information has become one of the key concepts of the modern world. Hundreds of methods are being developed every day to store, process, and use it. But, one way or another, timely and high-quality data transmission always comes to the fore. If 10 years ago a stationary computer connected to the Internet was able to meet the needs of a person, now we often need to transmit some information in the situation here and now. And then mobile technologies come to the rescue.

1. Introduction
Today, there are four generations of cellular communication in the world. But now there is an announcement of the fifth generation. The 5G network is expected to be available to mobile users by 2020. At the same time, the state of the modern market indicates that, despite the rapid development of technologies, the second, third and fourth generations exist in parallel, and do not replace each other. Moreover, there are no questions about the second generation and the GSM standard: the number of subscribers connected to it around the world is growing daily. The third generation and the Wi-Fi standard have also taken their niche. But what belongs to the fourth generation is still a controversial issue. So does the 5G standard (s) make sense and what would it be from the user's point of view? A schematic comparison of the capabilities of 3G, 4G and 5G networks is shown in Figure 1.

![Figure 1. Comparison of 3G, 4G, and 5G network capabilities](image-url)
2. Materials and Methods

4G technology

To begin with, let's analyze what the latest generation currently exists.

The 4G network standard involves the provision of services via the IP protocol and implies primarily two technologies: WiMAX (Worldwide Interoperability for Microwave Access) and LTE (Long-Term Evolution). Of course, these are not the only 4G standards, but they are well-known.

For the successful operation of the WiMAX technology, a base station and a receiver are required. The receiver and the antenna of the base station are connected in the low-frequency range of 2-11 GHz. Standard bandwidth up to 1 Gbit/s, range up to 10 km. The diagram of the 4G network is shown in the figure.

However, forecasts mostly say that LTE technology will eventually completely replace WiMAX technology. And at the moment, some authors, speaking about the 4G network, already mean only LTE.

According to research, by the end of 2015, there were approximately 400 commercially used LTE networks in more than 138 countries worldwide.

LTE is based on the principle of data transfer between the base and mobile stations. The network is divided into a radio access nodes and the nodes of the reference station. To provide bidirectional data transmission between the base and mobile stations, the standard uses frequency and time duplex [1]. To provide multiple access, the network uses OFDMA in the downlink and CS-FDMA in the uplink. OFDMA is based on a set of modular orthogonal carriers up to 2048, as opposed to 256 OFDM technology used in the Wi-Fi standard. OFDM dictates the device to transmit data using the entire set of subcarriers, whereas OFDMA supports data transmission on subcarriers of a dedicated channel to the user, which increases the power of the transmitter.

The main advantages of OFDMA technology include the reduction of mutual interference in devices with omni-directional antennas and greater flexibility of devices with different types of antennas [2].

The MIMO (Multiple Input-Multiple Output) technology, which, unlike previous standards, was incorporated into LTE from the very beginning, is also aimed at increasing the data transfer speed. The speed increase is achieved by using different antennas that can transmit different data streams. Also, different antennas can increase reliability by transmitting the same data [1].

If we talk about the data transfer speed, then LTE assumes 150 Mbit/s, which allows you to watch movies online, play games, listen to music, as well as to provide voice and video over IP communications [6].

Finally, we must not forget that when we talk about LTE, we are dealing with mobile technologies, and therefore with the speed of movement. In principle, the system is able to maintain the
characteristics at a speed of up to 350 km/h, and at a speed of up to 500 km/h to maintain high performance. Both of these figures are many times higher than the possible speed of movement of a pedestrian or even a motorist.

**LTE-Advanced a step forward**

The LTE standard has taken its niche with the reduced cost of services and more flexible use of new and existing frequencies, and has been developed in LTE-A (LTE-Advanced) technology. First of all, the new standard declared an increase in speed to 1 Gbit/s. Naturally, this can most easily be achieved by expanding the bandwidth, which in LTE-A is provided by combining carriers. This method is called Carrier Aggregation. The carrier pooling can, in this case, reach 5, increasing the total channel width to 100 MHz. Moreover, the combined carriers can be located both in a continuous frequency range, and in different frequency ranges; but the total number of combined carriers in the descending range must be greater than the number of combined carriers in the ascending range [3].

As a result, different speed options are offered for LTE-A in different sources, but the maximum declared value is 1 Gbit/s for stationary subscribers and 300 Mbit/s for mobile subscribers.

What do we get in reality? Here, alas, everything is not so rosy. The maximum performance is achievable only with the load of a single subscriber on the base station, which, given the number of subscribers of each operator, is simply impossible. And with each new person, the load only grows. As a result, even those tariffs that involve unlimited traffic actually impose restrictions.

**The need for 5G**

Figure 3 shows the growth of Internet users over the past five years. According to various sources, by 2020, their number will increase to 5 billion people. This means that the number of data downloads of varying severity, the number of subscribers listening to music and watching videos online, as well as using other services, will also increase proportionally. It should also be taken into account that the needs of people are constantly growing: if only recently primitive flash games on a mobile phone were considered the height of the development of the gaming industry, now most subscribers want to have good graphics, 3D effects, high-quality soundtracks, and gadget manufacturers are happy to meet customers. All this will inevitably lead to the fact that the existing networks will simply not cope with the increased load. If we talk about industry, then the Internet of Things concept, which assumes uninterrupted communication with high speed, is primarily important here. But today it is not always possible to guarantee it.

![Figure. 3. Growth in the number of network users](image-url)

Thus, all this together led to the need for a new concept of the network. How it will be implemented, it is difficult to say now. At the forefront, of course, is the increase in speed through
high broadband, according to forecasts, from 10 to 100 Gbit/s. In this case, the network delay will not exceed 10 ms. This will allow you to connect devices of various complexity.

It is also assumed that thanks to the adaptation of the network, which will automatically distribute the bandwidth size depending on the load (the type of device or depending on the application that is running from this device), the concept of network drop, speed reduction during operation and other inconveniences associated with an increase in the number of subscribers will become a thing of the past.

As already mentioned, MIMO technology involves the use of different antennas (Fig. 4). This is, without a doubt, an advantage. However, it should be understood that it is impossible to increase the number of antennas indefinitely: the size of the phones will also grow, turning them from mobile to stationary. In addition, do not forget that in addition to data (voice, graphic, and other user information), it is also necessary to transmit service signals.

It is assumed that 5G will be able to solve this problem. In any case, devices that are close enough to each other (the measure of proximity is characterized by the technical characteristics of specific devices, but is approximately no more than a dozen meters) will be able to transmit personal data directly from device to device, bypassing the network, while only service signals will go through the network.

Of course, this is not new, but this is the basic concept: not a new technology, but the integration of all existing ones. A number of publications even indicate that 5G will eliminate the hardware component, using existing equipment. But it is programmatically possible to switch between networks. For example, when leaving the 4G coverage area, 3G will automatically start functioning, and if it is not available, 2G will be used. In fairness, it should be said that operators are already selling their modems with this service, but in reality the transition does not occur not only in automatic, but also in manual mode. And it turns out that if a subscriber falls into the gaps outside the 4G coverage area, which we have not so little, then he simply loses the Internet.

3. Results and Discussion
It is already known that the first tests were conducted in Japan, which were successful. Other countries working in the market of information and communication technologies are not far behind. So, at the University of Surrey (UK), with the help of an innovative set of equipment, a record data transfer rate of more than 1 Tbit/s was achieved at the moment. The university expects to hold a public demonstration in 2018.

In Russia, the first launch of 5G is also planned for 2018, namely for the World Cup. Several companies are already testing the new technology [4].
Today, there is an LTE-U (LTE Unlicensed) technology, the meaning of which follows from its name: the use of the LTE standard on the unlicensed frequency spectrum. Of course, this is only allowed on low-power base stations and is designed to work in a confined space. Using a set of small ranges of unused frequencies leads to an increase in bandwidth.

The new standard and widespread Wi-Fi technology have not been ignored. However, its application here is somewhat unusual, namely for the design of local networks. For simultaneous use of LTE and Wi-Fi, a channel aggregation technology has been developed that allows both standards to be used in devices that support one of the technologies [5, 7, 8]. But there are still too many nuances of using LTE-U. And it is not known whether they will be overcome, or the technology will not be widely used.

4. Conclusion
Summarizing all of the above, we can conclude that it is clear that the new technology will be. It is justified by the prerequisites, and work on it has already moved to the testing stage, including in the open space. However, whether to be implemented announced indicators and performed the tasks, or standard will be just a staging area for the next technology will be available only when there will be the commercial launch of 5G networks.

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