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The radio access network of the cellular communication system

ABSTRACT

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INTRODUTION

Since the advent of cellular mobile communication in the 80s of the 20th century and up to the present day there has been a continuous growth in the number of users and the expansion of the range of services provided. Almost every person has a mobile phone, which allows to always stay in touch. New technological possibilities have led to the fact that the phones have practically turned into a full–fledged computer from which it is possible to access the Internet, send mail and many other things. Needs of mobile subscribers grow so promptly that to the existing networks of generation 3G which have successfully fixed in leaders of granting of communication services, not to catch up with them while new technologies of broadband access are capable to satisfy them.

LTE (Long Term Evolution) is a logical continuation and improvement of third generation networks. LTE was approved by the Third Generation Partnership Project (3GPP) in January 2008. In the Republic of Belarus, the LTE radio access network was put into commercial operation on 17 December 2015. Construction of the network is carried out by the first infrastructure operator becloud for its further provision to all interested operators. By the end of 2016, 4G services were already available to residents of oblast centers, and today there is an active deployment of LTE network in large district centers, such as Bobruisk, Baranovichi, Lida, Orsha, Mozyr and others. LTE technology copes with the task perfectly, providing high data transmission speeds, thereby expanding the range of services in mobile networks and reducing the cost of their provision.

The purpose of the thesis is to develop a radio access network of cellular communication standard LTE of Polotsk, Vitebsk region. In order to achieve this goal, it is necessary to solve the following tasks:

– to carry out a comparative analysis of cellular communication systems on the basis of the studied literature and patent sources;

– substantiate the technical requirements to the projected radio access network;

– choose and justify the structural scheme of the projected network;

– calculate the main technical parameters and model the coverage area of the projected radio access network;

– perform a feasibility study of the projected radio access network;

Calculation of the coverage area of base stations will be carried out with the help of Atoll software, which is designed for complex frequency–territorial planning and technical and economic optimization of mobile radio networks at the stages of their design and deployment, as well as in the process of their operation and modernization.

OFDMA technology in the downstream E–UTRAN network

E–UTRAN's downstream network uses OFDMA technology for high distribution flexibility and scalability of radio resources for data channels with different bandwidths. In the line "down" the following types of modulation are used: QPSK, 16QAM, 64QAM. It is also provided the use of technology MIMO (Multiple Input–Multiple Output), which allows you to significantly increase the noise immunity of communication channels, i.e. reduce the relative number of bits received with error, without reducing the speed of data transmission in the conditions of multi–beam signal propagation. MIMO technology provides data transfer of many users (MU–MIMO) and a single user (SU–MIMO) [25].

OFDM orthogonal frequency multiplexing technology is based on the formation of a multi–frequency signal consisting of many carrying frequencies differing by the value of $\Delta f = |\omega n - \omega n{-}1|/2{-}\pi$, selected from the condition of orthogonality of signals on the neighboring carrying frequencies (ωn – n–th radial carrying frequency).

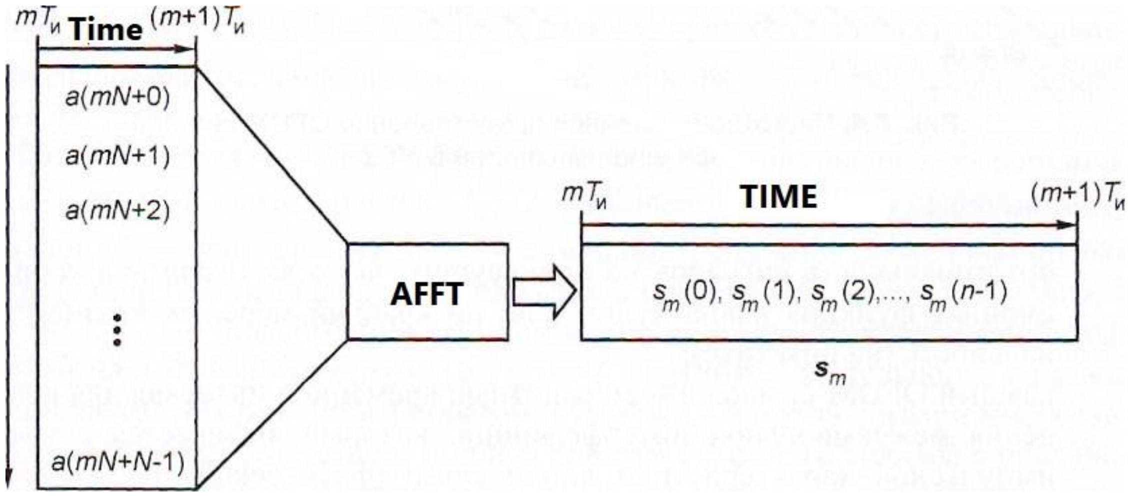

Figure 1– OFDM/QAM signal formation scheme when using OPF

Using MIMO technology in LTE networks

MIMO is a method of spatial coding of the signal, which allows to increase the bandwidth at which the data transfer is carried out with the help of N antennas and their reception by M antennas. Transmitting and receiving antennas are separated so as to achieve a weak correlation between adjacent antennas. Application of MIMO technology makes it possible to increase the noise immunity of communication channels, reduce the relative number of bits received with error. In networks of the fourth generation various modes of work with several transmitting and receiving antennas are provided. Work of such systems can be organized on two principles: on a principle of spatial consolidation and on a principle of space–time coding [26].

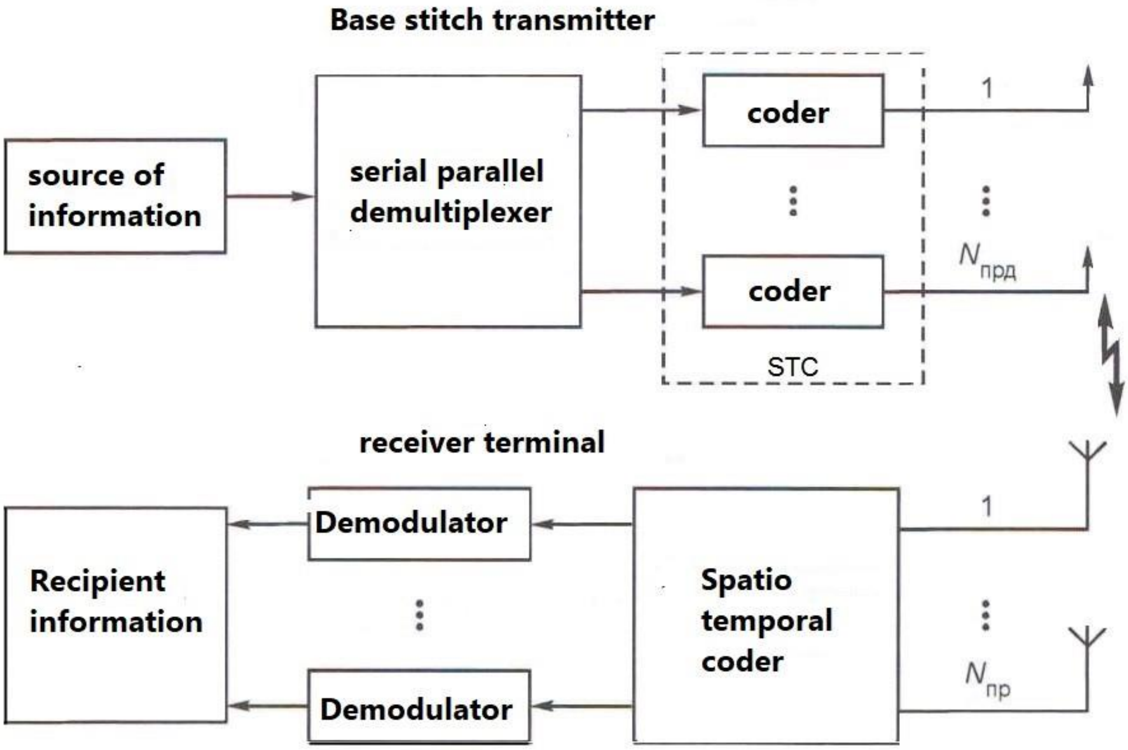

Figure 2 – Generalized structural scheme of communication system based on MIMO technology with STC

Handover procedure in LTE network

In cellular communications, the handover procedure refers to the process of transferring service to a subscriber during a call or cellular transfer session. This is one of the key procedures that allows you to consider a subscriber truly mobile. In cellular communication there may be several reasons for the relay transmission procedure.

The subscriber can leave the coverage area of one base station and enter the coverage area of another. The main task in the transmission of the connection between cells is to prevent a significant deterioration in the quality of communication and to prevent its termination.

Another prerequisite for a handover may be that the load on one cell is too high (e.g. in crowded areas), so measures are being taken to switch the mobile station to another cell with a lower load.

Unlike GSM networks, where the environmental analysis and selection of the handover cell is done by the base station controller, in LTE networks such actions are entrusted to the base stations themselves. Figure 3 shows an example of an active UE user terminal handover moving from eNB1 to eNB2 coverage.

As you move in this direction, UE sends a measurement report to the eNB1 service base station, which shows that the quality of the signal received from the neighboring eNB2 base station is better than from eNB1. When preparing the handover, the eNB1 sends a request to the eNB2 via the X2 interface: "HO REQUEST". The final decision on the handover can be influenced by the current priority of the user, the information about which is transmitted via the EPS–channel.

The eNB2 target computer configures the required resources in accordance with the QoS information received over the EPS–channel and reserves the Cell Radio Network Temporary Identifier (C–RNTI) for the subscriber, as well as the preamble of the Random Access RACH channel. Identifier C–RNTI is unique for each subscriber terminal within a cell.

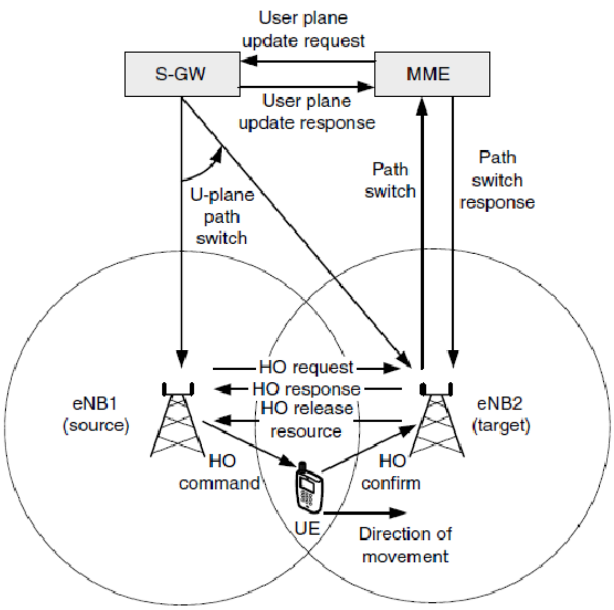

Figure 3 – Handover on an LTE network

Calculating network bandwidth

The network bandwidth is estimated based on the average spectral efficiency of the cell under certain conditions. The spectral efficiency of a cellular communication system is an indicator calculated as the ratio of the speed (in bits/sec) of transmitted data to the 1 Hz bandwidth used. This value characterizes the speed of data transmission in a given frequency band. Spectral efficiency has a huge impact on the efficiency of the use of the frequency resource, the allocated network, and the quality of services.

The average planned bandwidth of the RN of the projected network is determined by multiplying the number of BS by the average bandwidth of eNB. The expression will look like:

$$R_N = \left(R_{eNB(UL)} + R_{eNB(DL)}\right) \cdot N_{eNB}. \tag{4.14}$$

$$R_N = (44.1 + 101.4) \cdot 39 = 5674.5\ Mbps..$$

In the following, we will check the capacity of the planned network and compare it with the calculated capacity. Let's determine the average traffic of one subscriber in the hours of low load (PSTN).

$$R_{NM} = \frac{T_M}{N_{NM} \cdot N_D}. \tag{4.15}$$

where

T_M – Average monthly traffic of one subscriber, Gbit/month;

N_{NM} – date NM in day, N_{NM} = 10;

N_D – day number per month, N_D = 30.

$$R_{NM} = \frac{30}{10 \cdot 30} = 0.1Mbps.$$

Then the total traffic of the projected network in the hours of the highest load will be equal:

$$R_{totel(NM)} = R_{NM} \cdot N_{akm.ab}. \qquad (4.16)$$

when $N_{akm.ab}$. – number of active subscribers in the network equal to 80% of the total number of potential subscribers.

$$R_{totel(NM)} = 0.1 \cdot 53600 = 5360Mbps.$$

The results of the calculations show that $R_N > R_{totel(NM)}$. This condition indicates that the network under design will not be overloaded in NM.

Design of the cellular radio access network of the LTE standard in Polotsk using the Atoll software package

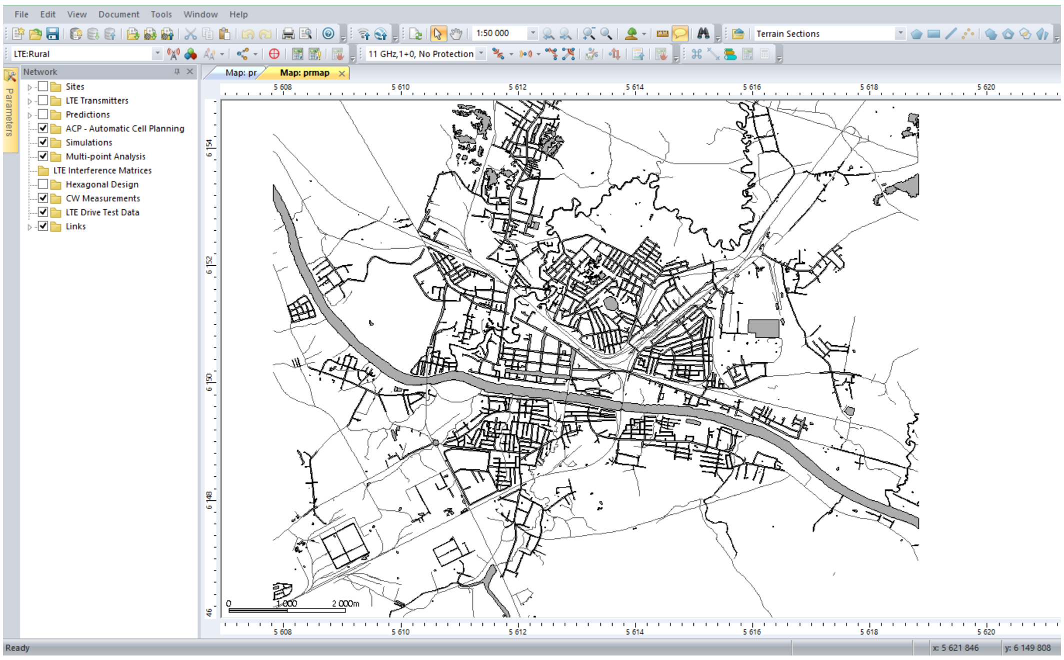

Figure 4 – Atoll Workspace Panel

The stage of calculations for the selected number of base stations and equipment parameters. With the help of the program, it is possible to calculate the transmission ability, the city coverage with transmitters. The signal level in the covered area and other characteristics. After the end of the modeling process on the map near the base stations, an image of the coverage areas of the transmitters of the three sectors appears. As a result, we obtain a coverage map of the city of Polotsk with the calculated signal level, shown in Figure 5.

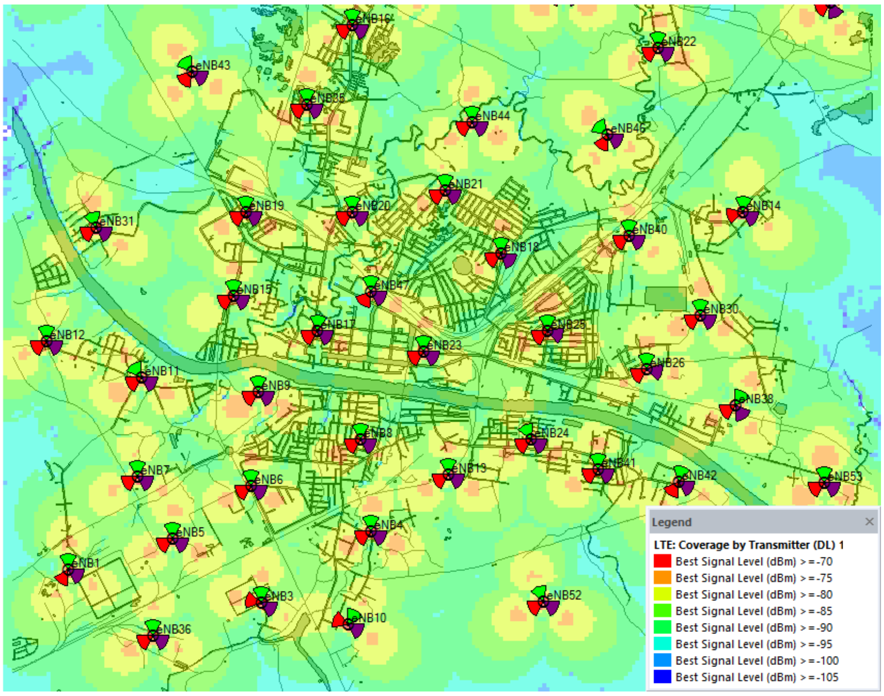

Figure 5 – Map of the city of Polotsk with a calculated signal level

As a result, more than 75% of the covered area has a signal level ranging from –75 to –90 dBm, the most acceptable for modern subscriber equipment. Figure 6 shows the result of calculating the rate of transmission of subscriber data in the direction from BS to MS

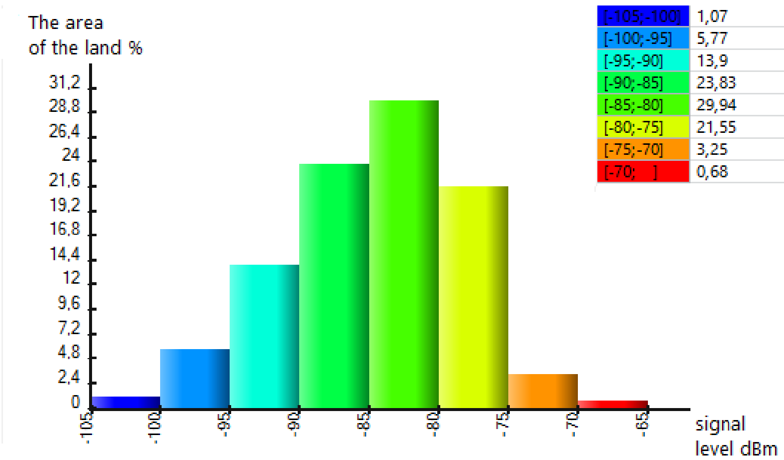

Figure 6 – The histogram of the signal level in the city of Polotsk

Thus, the incoming speed for subscribers of the 4G network on average will reach 60–80 Mbps.

CONCLUSION

The subject of the thesis was the LTE cellular network of Polotsk. The main objectives of the work are the calculation of the main energy parameters and planning of the coverage area of the deployable radio access network, the choice of the structural scheme of the projected network, as well as technical and economic justification of the costs of its implementation.

In the course of the work the main stages of cellular communication development were given, the peculiarities of LTE network architecture, LTE radio interface functioning, as well as E–UTRAN radio interface structure were revealed when using OFDMA and SC–FDMA multiple access technologies. The analysis of MIMO technology capabilities is performed and the interaction of LTE networks with mobile communication networks of other 3GPP standards is studied. In oneways calculations of energy parameters the model of COST231–Hata radio waves propagation is put in place, which is the most optimal one for determination of transmission losses during network design in medium and large cities. Modeling of the radio coverage zone was carried out with the help of Atoll software complex. As a result, the radio access network of LTE standard is obtained taking into account the specified parameters.