



# THE ROLE OF NETWORK COMPONENTS IN IMPROVING THE RELIABILITY AND SURVIVABILITY OF MOBILE COMMUNICATION NETWORKS

D.A.DAVRONBEKOV and U.K.MATYOKUBOV\*

Tashkent University of Information Technologies named after Muhammad al-Khwarizmi

\*Email: [otkir\\_matyokubov89@mail.ru](mailto:otkir_matyokubov89@mail.ru)

**Abstract**—This article compares the different architectures of mobile communication networks (MCN) and examines the survivability of the network. Typical survival strategies for improving MCN survivability, failure mitigation strategies for network elements, wireless network survival rates, failure scenarios at MCN levels, and survival indicators are presented. The importance of fiber-optic communication in the construction of communication lines between MCN components has been studied. The issue of designing MCNs in a cost-effective and highly viable way is considered, and the necessary expressions of the design process are given.

**Keywords**— Mobile communication networks, BSC, MSC, BTS, HLR, VLR, communication lines, mobile communication technologies, reliability, survivability, optical communication networks, radio communication.

## I INTRODUCTION

The study of wireless networks focuses on increasing users' uninterrupted and high-quality access to mobile services, reducing call blocking, improving mobility management techniques, and optimizing wireless connections. Reliability and survivability issues have been extensively studied in wired networks and have achieved some effective results, but we cannot say the same about wireless networks [1]. For wireless and wired networks, we can distinguish two main differences between reliability and survivability:

1. Relatively low tolerance in conventional wireless networks.
2. The probability that the scope of the adverse effects of the disturbance will increase over time is high. This can be explained by the fact that the performance of MCN elements is more interdependent and user mobility.

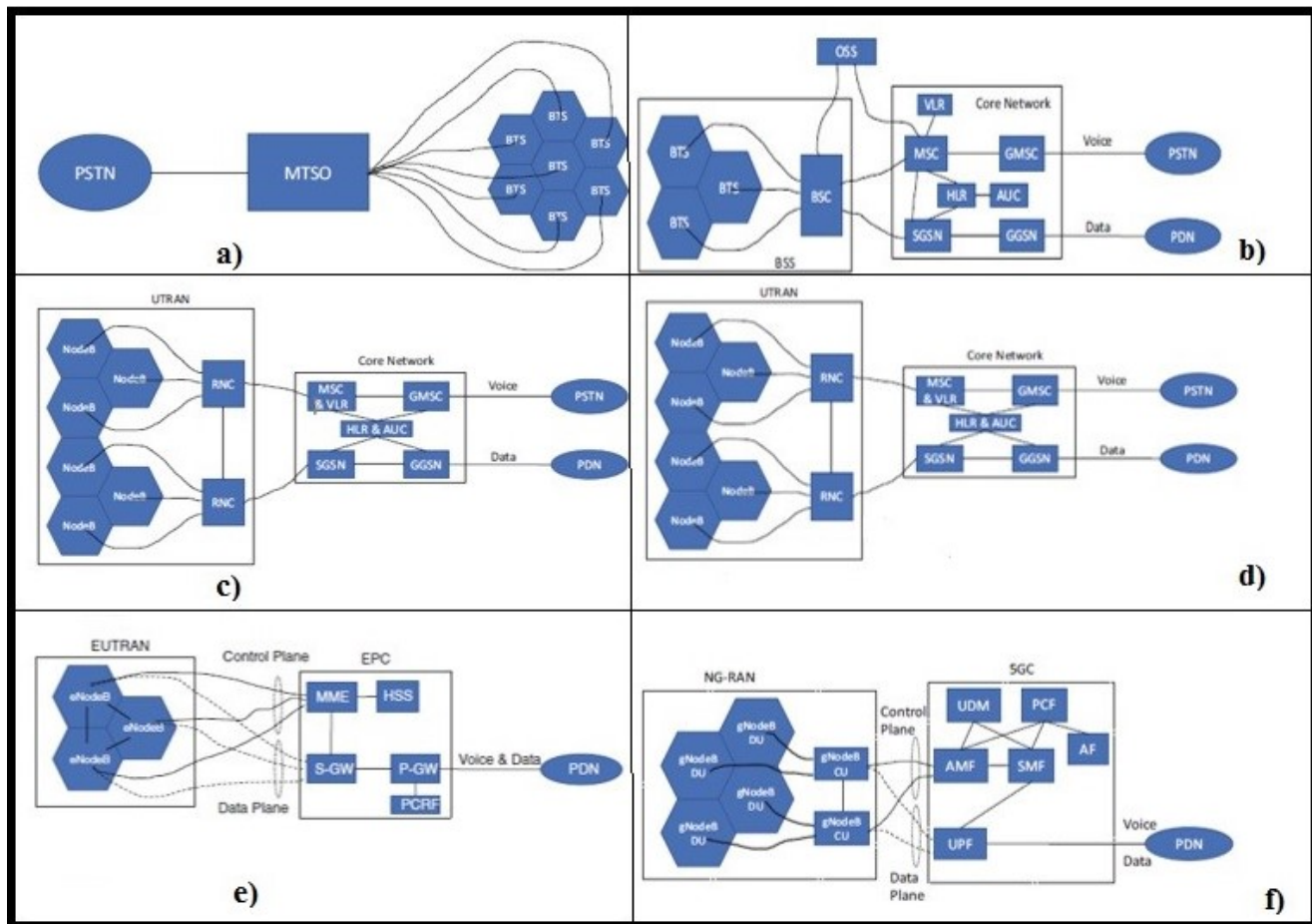
## II THE MAIN PART

If we pay attention to the architecture of wireless networks, the main elements are BSC (base station controller), MSC (mobile service switching center), BTS (base transceiver station), HLR (Home location register), VLR (Visitor location register), mobile user and communication lines. Of course, with the development of mobile networks, the elements of the network, the principles of their operation, the architecture have also changed. The comparisons are shown in Figure 1.

The consequences of failures in the elements of the network architecture and the impact on users vary. There are strategies to partially mitigate the effects of failures caused by wireless network elements (see Table 1).

In this work, we assess the reliability and survivability of the MCN, in particular, the breadth of the fault area and the causes of the failure by analyzing the architecture structure, communication line structure, and mobile communication technologies. Survivability levels of the wireless network (Table 2), fault scenarios and survival indicators at the MAT levels (Table 3), typical survivability strategies, based on the existing MAT architecture, survivability features and conclusions from scientific research in this area (Table 4).

If we look at the work to increase the survivability of the network in the field of telecommunications, most of the work and the results obtained belong to the type of wired networks [2]. Unfortunately, it is not advisable to apply the findings of these studies to wireless networks. But the advanced technologies and effective methods used in any direction should be used for the development of mobile networks.



**Fig. 1:** Changes in the architecture of mobile networks in the evolution of development. a) 1G network architecture block diagram b) 2G GSM network architecture block diagram c) 3G WCDMA network architecture block diagram d) HSDPA network architecture block diagram e) 4G LTE network architecture block diagram f) 5G network architecture block diagram

#### A The importance of fiber optic communication in the development of mobile networks.

In MCN, optical fiber connections are used between BTS and BSC, switching and monitoring centers. Optical fibers provide high throughput, low loss, small size and weight, immunity against electromagnetic interference, and a high level of signal security. In addition, using advanced technology, the data transmission speed between two nodes of the optical network can be increased from 10 G bit / s to 100 T bit / s [3].

An optical backbone network is typically used to provide high-speed (10/40/100 G bit / s) data exchange over various long-distance regional networks. The coverage of the optical trunk network can be terrestrial or trans cosmic.

Today's telecommunications network needs to implement the services it needs to protect and support user data. These needs require that networks be optimized and dynamically increased. Research in recent years has shown that changes

in both networks (MCN and optical communication network) are looking for a common platform for easy transition from one domain to another[4].

Today, backbone and regional networks are mainly optical, and in the input segments, mostly wireless technology is used. The successful development of MCN is directly related to the evolution of optical fiber communication. With this in mind, the following research areas will become more relevant in the future:

Currently, the issue of connecting 5G wireless technologies directly to optical

- Ensuring the convergence of advanced technologies in the field of wireless and optical communications;
- Taking into account the diversity of wireless network services when building an optical network;
- Take into account the interdependence of wireless and

Faulty component	User effects	Effects on frequency channels	Typical risks	Recovery methods
MSC	High	Low	Operator errors SW random HW update updates.	Return to replacing the old SW HW
HLR/VLR	High	Low	Operator errors SW random HW update updates.	Return to replacing the old SW HW
BSC	Average	Average	SW randomly updates HW deficiency.	Return to replacing the old SW HW
BS	Low	Average	Accidental HW failure is damage to the antenna or tower	Power switch repair
Communication line connections	Average	From low to Average	Random HW deficiency of fiber	Power replacement
microwave links (MSC-BSC) (BSC-BS)	Average	From low to Average	Atmospheric anomalies Accidental HW failure Antenna or tower damage	Wait or reset
Radio communications	Low	High	Noise and low SNR	Power management

TABLE 1: FAULTS REDUCTION STRATEGIES FOR WIRELESS NETWORK ELEMENTS

Level	Components	Communication Lines	Function
Introduction to radio level	Mobile blocks, base stations	Digital radio channels with TDMA, FDMA or CDMA	Defining a physical interface for radio communication
Input link rate	BS, BSC	Wired or radio communication.	BS cluster management, radio channel management
Transport	BS, BSC, MSC, alarm network.	Wired or radio communication, SS7 wired connection	Call and connection management, mobility management
Intelligent	MSC, HLR, VLR, EIR, AUC, alarm network.	Wired or radio communication, SS7 wired connection	Service management, mobility management

TABLE 2: SURVIVABILITY LEVELS OF THE WIRELESS NETWORK.

optical network technologies.

network components is being promoted. The structural architecture of such a network is shown in Figure 3.

*B Use of energy saving methods in fiber optic networks.*

It is well known that the use of fiber-optic networks has some advantages, but requires a lot of money. In addition, as the network expands, energy consumption will increase. There is a growing need for green wireless networks to address these issues [5]. Given that information and communication technology consumes about 1,100-1,800 terawatt-

hours of electricity annually, we see that this requires large sums of money from mobile operators [6].

In determining the energy consumption limit in transport systems, the energy of the optical transmitters and receivers used in the terminals and intermediate repeaters must be taken into account. Key energy reduction strategies include ways to increase switching energy efficiency, reduce the amount of switching infrastructure in the network, develop low-energy transportation technologies, and reduce the energy consumption of the access network.

Level	Unsuccessful scenario	Potential impact	Possible measurements
Introduction	BS loss	Partial or complete loss of service in a cell, increase in traffic in adjacent cells that do not work	Possibility of blocking calls, possibility of forced cancellation of the call
Transport	Loss of BSC-MSC link	Partial or complete loss of service in a cell cluster, increase in traffic in cells associated with failure	Possibility of blocking calls, possibility of forced cancellation of calls, call setting delay, call delay, registration delays
Intelligent	VLR loss	Loss of roaming service in the MSC coverage area	Lost user load, delay in database access, probability of data accuracy

TABLE 3: LEVEL FAULT SCENARIOS AND SURVIVABILITY RATES.

Level	Tolerance and caution	Restore traffic
Introduction to radio level	Spare frequency components, complementary cells.	Loading protocols, dynamic channel distribution, flexible channel quality protocols
Input link rate	Backup BS-BSC link, multiple access from BS to BSC, loop topology for BS-BSC interconnect.	Automatic protection switching, dynamic routing protocol.
Transport	BSC-MSC backup connection, ring topology for BSC-MSC connection, multi-band connection from BSC to MSC	Automatic protection switch, dynamic routing, call settings
Intelligent	Physical diversity in signal network connections, diversity of physical databases	Dynamic routing, checkpoint protocols

TABLE 4: TYPICAL SURVIVABILITY STRATEGIES.

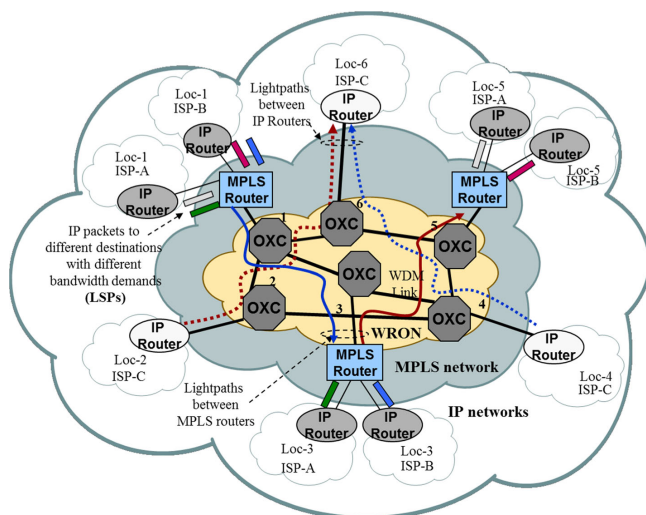
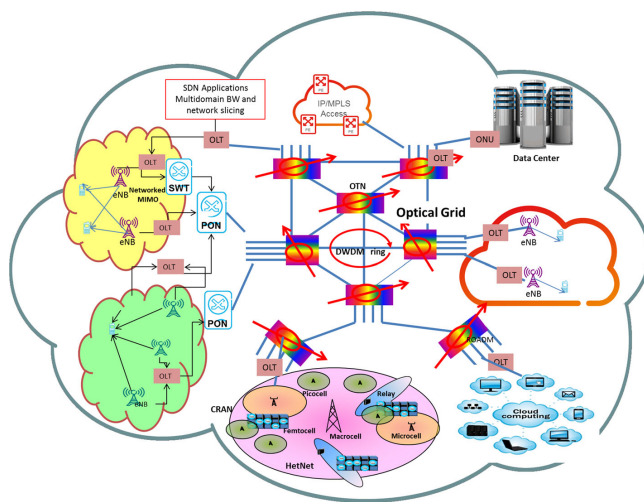


Fig. 2: The simple structure of an optical network

### C Introduction of general use of optical fiber communication lines.

As the introduction of 4G and 5G technologies requires large capital expenditures from mobile operators, they need to look for new ways to save on the cost of developing their networks [7, 8]. Currently, the most effective means of reducing capital expenditures is the business model of network sharing [9, 10]. This model is widely used in many countries, with the transition of mobile communication systems to 4G, a sharp increase in demand for broadband communication lines connecting various elements of the network, including base stations, is expected. It is known that one of the main features of LTE and WiMAX networks is the organization of communication channels directly between base stations [11, 12]. Currently, base stations are connected to switching centers and controllers via wired (optical fiber cables or twisted pair cables) and wireless radio-relay lines (RRL) [13, 14].

The maximum data transfer rate in LTE Advanced net-

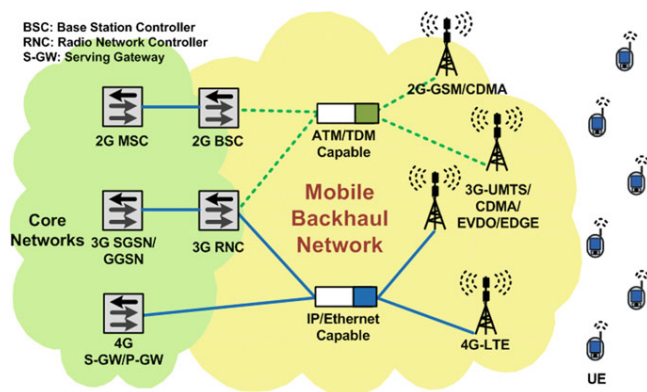


**Fig. 3:** Use of fiber-optic communication lines in wireless networks

works is 1 Gbit / s. The organization of data transmission channels by RRL of high-speed technologies may not be justified (due to the relatively low data rate, low noise, calculation of frequency bands, etc.). The use of copper cables is not advisable at all. Therefore, fiber optic networking is the only solution for fourth-generation high-speed mobile communication technologies. The bandwidth of modern fiber-optic communication networks is much higher than the requirements for 4G networks. However, the creation of networks based on fiber-optic cables by each mobile operator requires large capital expenditures. Using common optical cables for multiple operators can drastically reduce them. This applies to both the transport network and the lines connecting the base stations to the planned 4G networks.

An operator that owns a communication line simply provides services to its customer and other operators while maintaining full control over the network. It will have the right to lease communication channels, lease optical fibers and sell optical fibers. These processes are beneficial to both parties. Studies show that savings can range from 37-40% to 50-54%. It should be noted that even if mobile operators provide services in different technologies, there will be no problems with the general use of the network. A system for sharing information between different technologies is shown in Figure 4.

However, it should also be noted a number of additional challenges that mobile operators face with this model. Here, the division of responsibilities for technical support and cable operation should be considered in advance. Any work on a common cable may be carried out only by agreement of the parties. Optical fibers can break at any time due to mechanical impact, latent manufacturing defects, or wear. It is therefore important to provide mechanisms to quickly repair



**Fig. 4:** Use of fiber-optic communication lines in wireless networks

damage to the cable.

*D Designing a MCN at minimal cost, taking into account the level of survivability and reliability.*

The following should be considered when designing mobile networks resistant to natural and man-made disasters.

- Analysis of radio wave propagation topology of base stations (BTS, BSC) located at the facility;
- Selection of the most optimal area with a high level of security as a center for traffic collection and replacement;
- Ensuring that each cell is assigned to an MSC, taking into account certain constraints that may be observed as a result of adverse effects, including capacity constraints, routing diversity, transmission frequency to ensure reliability, etc .;

- Selection of the optimal option of connections between nodes or network elements (BTS, BSC, MSC) depending on the location conditions of the area.

Many aspects of the design problem have been addressed in a number of studies, such as graph separation [15, 16], cell placement problem [17]. It should be noted that specific algorithms may not be suitable for medium and large cellular networks [18]. Each optimization problem must be solved taking into account the impact on other issues. Improving the reliability and survivability of each network requires additional costs. Here are a few things to keep in mind when designing high-reliability and viable mobile networks and minimizing costs.

- The correct choice of the location and types of BTS;
- Ensuring that each BTS is connected to one BSC;
- Ensuring that each BSC is connected to one MSC;
- Ensuring that each MSC is connected to the public network;
- The number of BTS-BSC connections connected to the BSC should not exceed the maximum number of BTS interfaces that can be installed on this BSC;
- The sum of power of BTS connected to BSC should not exceed its carrying capacity;
- The sum of power of BTS connected to BSC should not exceed its carrying capacity;
- The number of BSC-MSC connections connected to the BSC should not exceed the maximum number of MSC interfaces that can be installed on that BSC;
- The number of BSC-MSC connections connected to the MSC should not exceed the maximum number of BSC interfaces that can be installed on that MSC;
- The sum of the interface rates set for each MSC should not exceed its bandwidth.

The price function, which represents the total value of the network, consists of the cost of connections and interfaces and the cost of BSC and MSC.

We express the cost of connections and interfaces using the following formula:

$$C_{L/I}(v, x) = \sum_{r \in K} \sum_{i \in I_r} a_{ij}^r v_{ij} + \sum_{j \in J} \sum_{k \in K} \sum_{l \in L} b_{jk}^l x_{jk}^l \quad (1)$$

We express the prices of BSC and MSC by the following formula:

$$C_{B/M}(y, z) = \sum_{j \in J} \sum_{s \in S} c_j^s y_j^s + \sum_{k \in K} \sum_{t \in T} d_k^t z_k^t \quad (2)$$

The following expressions can be used in the design of mobile networks with high reliability and survivability, cost minimization, taking into account various constraints and in the design of network elements based on the established model (expressed in Formula 3).

$$\min C_{L/I}(v, x) + C_{B/M}(y, z) \quad (3)$$

Restrictions on the appointment of BTS:

$$\sum_{j \in J} v_{ij} = 1 \quad (i \in I) \quad (4)$$

Restrictions on the appointment of BSC:

$$\sum_{k \in K} \omega_{jk} = \sum_{s \in S} y_j^s \quad (j \in J) \quad (5)$$

Specificity limitations in BSC:

$$\sum_{s \in S} y_j^s \leq 1 \quad (j \in J) \quad (6)$$

Specificity limitations in MSC:

$$\sum_{t \in T} z_k^t \leq 1 \quad (k \in K) \quad (7)$$

BSC capacity limitation (BTS interface level):

$$\sum_{r \in R} n^r \sum_{i \in I_r} v_{ij} \leq \sum_{s \in S} m_{BTS}^s y_j^s \quad (j \in J) \quad (8)$$

Limitation of BSC capabilities (MSC interface level):

$$\sum_{l \in L} \sum_{k \in K} x_{jk}^l \leq \sum_{s \in S} m_{MSC}^s y_j^s \quad (j \in J) \quad (9)$$

BSC capacity limitation:

$$\sum_{r \in R} a^r \sum_{i \in I_r} v_{ij} \leq \sum_{s \in S} n^s y_j^s \quad (j \in J) \quad (10)$$

Limited MSC capabilities (BSC interface level):

$$\sum_{l \in L} \sum_{j \in J} x_{jk}^l \leq \sum_{t \in T} m_{BSC}^t z_k^t \quad (k \in K) \quad (11)$$

Limited MSC capacity (switching capacity):

$$\sum_{l \in L} \beta^l \sum_{j \in J} x_{jk}^l \leq \sum_{t \in T} \eta^t z_k^t \quad (k \in K) \quad (12)$$

Limited BTS-BSC connectivity:

$$f_i \leq \alpha^r \quad (i \in I_r, r \in R) \quad (13)$$

Limited BSC-MSC connectivity:

$$f_j \leq \sum_{k \in R} \sum_{l \in L} \beta^l x_{jk}^l \quad (j \in J) \quad (14)$$

Restrictions on traffic flow maintenance:

$$f_i = \sum_{o \in I} (g^{io} + g^{oi}) + g^{ip} + g^{pi} \quad (i \in I) \quad (15)$$

$$f_j = \sum_{i \in I} v_{ij} \left( \sum_{o \in I} (g^{io} + g^{oi}) \right) + \sum_{i \in I} v_{ij} (g^{ip} + g^{pi}) \quad (j \in J) \quad (16)$$

Additional restrictions:

$$\sum_{i \in I} x_{jk}^i \leq \omega_{jk} \max_{s \in S} \{m_{MSC}^s\} \quad (j \in J), (k \in K) \quad (17)$$

$$\omega_{jk} \leq \sum_{i \in I} x_{jk}^i \quad (j \in J), (k \in K) \quad (18)$$

### III CONCLUSION

The impact of faults in the MCN depends on various factors such as the location and shape of the affected area, user mobility, and user behavior. In addition, it depends on the correct design of the network components and the selection of appropriate components and communication lines. This work presents measurements to determine the survivability of the MCN, survival strategies for each level, and recovery methods. The importance of fiber-optic communication in the development of MCN, energy-saving methods in fiber-optic networks, the introduction of general use of fiber-optic communication lines were discussed. Mathematical expressions for the design of the location of MCN components and their types, the design of the network topology and the choice of communication types are given.

### REFERENCES

- [1] Abdulaziz M Nazarov Prof et al. Controlling and forecasting the reliability of integrated circuits of radio systems transmitting information. *Chemical Technology, Control and Management*, 2020(1):32–39, 2020.
- [2] DA Davronbekov, UT Aliev, JD Isroilov, and XF Alimdjanov. Power providing methods for wireless sensors. In *2019 International Conference on Information Science and Communications Technologies (ICISCT)*, pages 1–3. IEEE, 2019.
- [3] ZT Hakimov and DA Davronbekov. Equalization of spectral characterist of optical signanls by acousto-optic filters. In *2007 3rd IEEE/IFIP International Conference in Central Asia on Internet*, pages 1–3. IEEE, 2007.
- [4] Dilmurod Abdujalilovich Davronbekov et al. The role of wireless networking technology today. In : , , , pages 77–79, 2020.
- [5] Jaafar MH Elmirghani, Thierry Klein, K Hinton, TEH El-Gorashi, Ahmed Q Lawey, and Xiaowen Dong. Greentouch greenmeter core network power consumption models and results. In *2014 IEEE Online Conference on Green Communications (OnlineGreenComm)*, pages 1–8. IEEE, 2014.
- [6] UK Matyokubov. Davronbekov da the impact of mobile communication power supply systems on communication reliability and viability and their solutions. *International Journal of Advanced Science and Technology*, 29(5):3374–3385, 2020.
- [7] D Davronbekov. Sredstva peredachi i priyema informatsii v mobilnix sistemax svyazi. *konspekt leksiy*, 2011.
- [8] U Matyakubov and D Davronbekov. Increasing energy efficiency of base stations in mobile communication system. *Acta of Turin Polytechnic University in Tashkent*, 10(1):19, 2020.
- [9] IA Bogoroditskaya. Chrz network sharing k 4g. pages 56–56. IEEE, 2011.
- [10] TO Rakhimov, UK Matyokubov, and MR Yangiboyeva. Immediate modeling of matlab-simevents transmitting communication work process. *Acta of Turin Polytechnic University in Tashkent*, 9(1):76–79, 2019.
- [11] L Shusterman S Portnoy. Perspektivnie arxitekturi opornix setey dlya sistem mobilnoy svyazi 4g, 2011.
- [12] U Matyakubov and D Davronbekov. Approaches to the organization of disasterresistant mobile network architecture in uzbekistan. *Acta of Turin Polytechnic University in Tashkent*, 10(2):10, 2020.
- [13] Davronbekov D.A. Bsprovodn sistm svyazi konspekt leksiy ii-chast programmirovaniye. 2015.
- [14] Davronbekov D. Odin iz podxodov k ponyatiyu slojnoj radiotexnicheskoy sistemi. *Vestnik TUIT*, 4:53–57, 2008.
- [15] Arif Merchant and Bhaskar Sengupta. Multiway graph partitioning with applications to pcs networks. pages 593–600, 1994.
- [16] Arif Merchant and Bhaskar Sengupta. Assignment of cells to switches in pcs networks. *IEEE/ACM Transactions on networking*, 3(5):521–526, 1995.
- [17] Darko Skorin-Kapov and Jadranka Skorin-Kapov. On tabu search for the location of interacting hub facilities. *European Journal of Operational Research*, 73(3):502–509, 1994.

- [18] Louis Anthony Cox and Jennifer Ryan Sanchez. Designing least-cost survivable wireless backhaul networks. *Journal of Heuristics*, 6(4):525–540, 2000.