



A METHOD FOR ASSESSING THE CONDITION OF BASE STATIONS TO DETERMINE THE NEED

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Abstract: *The issues of determining the need to modernize base stations of a cellular network are considered based on the mathematical apparatus of the theory of fuzzy sets.*

Keywords: *Base stations, modernization, method.*

A condition for successful management of a complex system is making the right decisions on its further functioning and development [1]. The operation of complex systems currently involves handling large amounts of data [2]. The collected information must be stored in a certain way, visual results can be obtained based on it, and various information about the state of the systems must be processed. In the future, when processing such results, you can draw up an action plan and carry out corrective work. There are systems, the successful operation and performance of which depend on a significant number of factors, such as scientific and technical achievements, the social needs of users, the economic and political situation in the country. Such systems are the cellular networks of a telecom operator, in which the difficulty is in collecting information about the state of the equipment in use, including base stations. Nevertheless, mobile communication networks currently occupy a dominant position in the data transmission market [3]. Difficulties in collecting information about the state of base stations are determined by a large number of factors influencing their state, and the imperfection of the processes for obtaining and processing the information received. As a result, the operator has insufficient information not only about the physical, but also about the obsolescence of base station equipment. All this leads to a decrease in the efficiency of equipment management and to making incorrect decisions regarding the development of the entire network as a whole.

Конкуренентоспособность оператора связи на телекоммуникационном рынке определяется надёжной системой предоставления качественных услуг и четкой работой всего оборудования. Именно поэтому оператор вынужден повышать эффективность существующей инфраструктуры сети, т. е. обеспечивать качество связи при минимальных затратах. Сотовая сеть оператора строится на основе базовых станций, которые позволяют абонентам оставаться на связи. На базовые станции приходится значительная доля операционных и капитальных затрат telecom operator, which is why it is so important to monitor and improve their



work as necessary during operation. To improve the quality of the provided communication services, the telecom operator needs to allocate significant funds to modernize the equipment of base stations [4]. Upgrade costs are determined by the type of equipment installed and the location of the base station. To ensure the quality of functioning of the cellular network, communication enterprises are creating maintenance and repair systems that manage the technical condition of the facilities in the service area. The efficiency of network equipment depends on the maintenance and repair system [5]. When addressing issues of modernization of both the entire network and individual equipment, the operator is forced to take into account not only its experience in operating certain equipment, but also the supplier's capabilities in the design, construction, supply, installation and maintenance of equipment [6].

When upgrading base stations, the following difficulties arise:

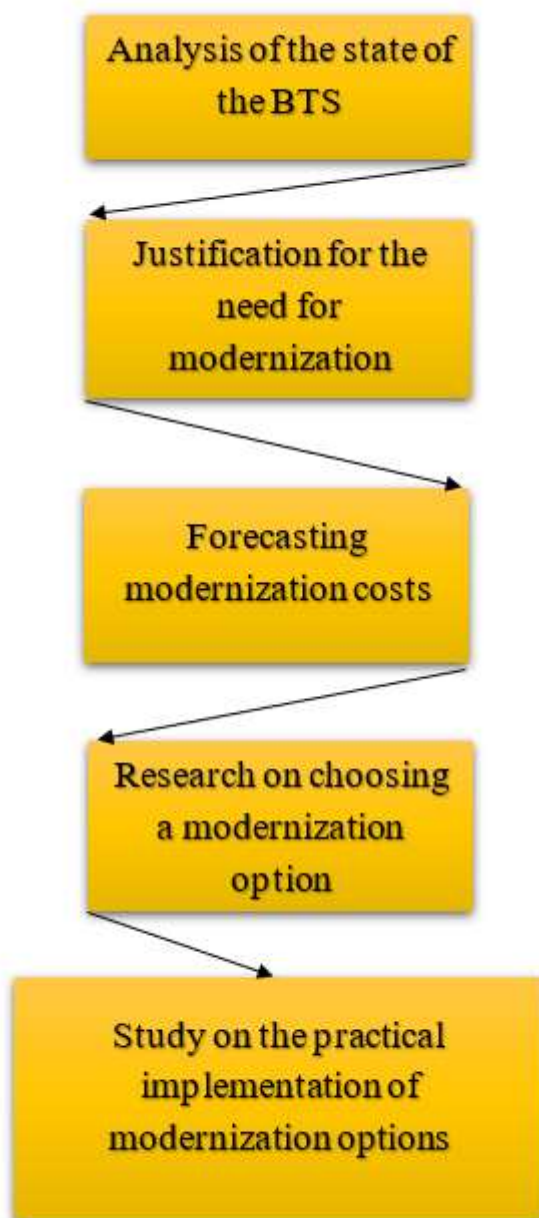
- take into account the complexity of the object being modernized (base stations are a system consisting of various components, the functioning of which is influenced by many factors);
- determine the need for modernization and its effectiveness (modernization should ensure maintaining the level of communication quality while reducing costs and maintaining maximum profits);
- highlight the main indicators of the need for modernization (to make an adequate decision, the analysis of the state of base stations should be carried out taking into account various indicators);
- take into account uncertainties (the effectiveness of modernization is influenced by taking into account many factors, but they cannot be taken into account completely).

The operation of base stations is influenced not only by technical indicators, but also by socio-economic factors, therefore, taking into account the need to modernize base stations using a one-dimensional indicator will lead to incomplete information about their performance and functioning. For a comprehensive assessment of the need for modernization, it is necessary to take into account a number of indicators.

Solving the problem of determining the need to modernize base stations

Base station equipment is subject to not only physical, but also moral wear and tear due to the lag of equipment elements from modern requirements and changes in requirements for the quality and composition of target functions. Modernization of base stations allows you to improve their functional properties and reduce operating costs; in addition, modernization allows you to delay the end of the life cycle of the base station. Due to the complexity of the task of upgrading base stations, it is decomposed into a number of separate tasks, such as analyzing the state of the base stations of the operator's cellular network; justification for the need for modernization; highlighting modernization options; formation of indicators of the need for modernization; forecasting the functioning of the base station after modernization; cost forecasting for modernization and subsequent operation; study of

the possibility of modernization; choice of modernization option; research on the practical implementation of modernization (Fig. 1).



Rice. 1. Stages of solving the problem of upgrading a base station (BS)

The total effect of destructive factors leads to moral and physical wear and tear of base station equipment. The increase in the number of target tasks is due to the expansion of the package of services and improvement of technologies. The growth in the volume of transmitted data, the introduction of 3G, 4G and even 5G mobile communication technologies, and the growth in Internet access speeds, in turn, increase the load on the mobile network and require the use of modern elements [8]. Target objectives are determined by scientific and technical progress in the field of providing cellular services. The appearance of obsolescence is associated with a lag in technical characteristics and indicators from the requirements. This is also due to scientific and technical progress and the development of research and development



work (R&D) in the development of new generations of communications with high technical capabilities. The technical parameters of base stations determine the key performance indicators of the network (Key Performance Indicator - KPI). They allow you to analyze the efficiency of the network and the level of achievement of goals for the provision of communication services. Technical quality indicators include the percentage of successful and unsuccessful calls, calls with premature connection disconnection, calls with unsatisfactory voice quality at the time of call control during testing, etc. Operating costs are largely dependent on energy costs, which are driven by rising energy costs. There are various technologies that can reduce the operating costs of a base station system, but they require modernization, and the results of implementing such technologies are not always obvious. When introducing energy-saving technologies, energy consumption may depend on external factors. For example, in dynamic systems, unused blocks of the base station can be turned off, and then the energy consumption will depend on the traffic (load). If an air cooling system is used, the energy consumption depends on the air temperature outside the container. Costs during operation can also be caused by the maintenance of base stations, the volume of which directly depends on failures, accidents and equipment malfunctions [8]. Maintenance labor is necessary for regulated maintenance of equipment. Often different types of work are separated (for example, servicing equipment in containers, stepladder work on towers).

An increase in the number of target tasks, stricter requirements for technical indicators and characteristics, frequent failures and accidents, as well as increased operating costs together lead to the exhaustion of the residual resource of the base station in terms of moral and physical wear and tear. The development of a method for determining the need to modernize base stations is based on the method of fuzzy set theory for creating decision-making systems under conditions of uncertainty. To determine the need for modernization, we will apply the mathematical apparatus of fuzzy set theory, which will allow us to generalize and formulate the opinions and knowledge of experts, since decision-making on modernization should be based not only on the numerical indicators of the network and equipment, but also on verbal information and linguistic judgments.

Conclusion

The proposed method and the implementation of research results open up the possibility of increasing the efficiency of managing the structure and development of the operator's network in the process of providing services through a more complete and accurate accounting of information about the state of individual elements of base station equipment and making decisions on their modernization. By involving experts in solving this issue and using the theory of fuzzy sets, it is possible to take into account both the results of precise measurements and fuzzy judgments.



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