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GENERALIZED ARCHITECTURE OF AUTOMATED CONTROL SYSTEMS IN LOW-BANDWIDTH COMMUNICATION NETWORKS

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Abstract: there is no typical architecture for the construction of governmental automated control systems of the low echelon management level with the constant movements of users in low-bandwidth communication networks based on UHF/VHF radio stations. Proposed a generalized architecture of automated control system of the lower management level in low-bandwidth communication networks based on UHF/VHF radio stations, which consists of three main levels: access level, interaction level and control level. The analysis of the concept of using the JDSS and NFFI protocols, the three-level hierarchical model of the Cisco company, and the generalized organizational structure of the communication system of the lower-level management unit was carried out.

Key words: automated control systems, low-bandwidth communication networks, network architecture, three-level hierarchical model, JDSS, NFFI, model, probability of service, probability of failure.

Introduction

Planning and designing the communication system of automated control systems (ACS) of the tactical control link with the active movement of users is one of

the main problems in Ukraine since 2014 [1-5]. Modernization of communication means [6-7] by the governmental services of Ukraine has led to the use of modern means of radio communication, which provide means for transmitting/receiving not only voice messages, but also data transmission in accordance with the TCP/IP protocol stack. Thus, the management and monitoring of state units and the Armed Forces of Ukraine got the opportunity to move from the classical concept of managing voice messages to the creation of digital ACS. Such systems mainly work in communication networks based on UHF/VHF radio stations. The implementation of digital ACS based on UHF/VHF radio stations is not a new problem for the countries of the North Atlantic Treaty Organization. That is why a number of protocols were created for the tactical control link, which implement basic data exchange services in low-bandwidth communication networks. Among such protocols, it is necessary to single out the Joint Dismounted Soldier System (JDSS) protocol of the STANAG 4677 standard [8]. These standards are mainly used for interoperability between different NATO countries, but they describe their use as a basic standard and protocol for the creation of new digital ACS.

Information transmission technologies in the governmental ACS of the low echelon management level with the constant movements of users in low-bandwidth communication networks based on UHF/VHF radio stations must meet a number of requirements [1]: increased reliability requirements, scalability of the system during operation, the ability to work in low-speed communication networks, security and survivability.

The purpose of the work is to develop a generalized architecture of ACS in low-bandwidth communication networks based on UHF/VHF radio stations with active user movement to improve the performance indicators of the communication system.

ACS architecture in low-bandwidth communication networks

The concept of the STANAG 4677 standard provides for the use of the JDSS protocol as a digital gateway between the existing ACS of NATO troops. The work [1] considered the concept in which the JDSS and NFFI protocols are the basis of

governmental ACS of the low echelon management level with the active user movement as basic algorithms and protocols. According to the concept, the JDSS and NFFI protocols are not used at gateways between different ACS, but are used as a system-forming mechanism for transmitting information in ACS with high requirements for responsiveness, reliability, survivability and scalability in low-bandwidth communication networks based on UHF/VHF radio stations (fig.1 [1]).

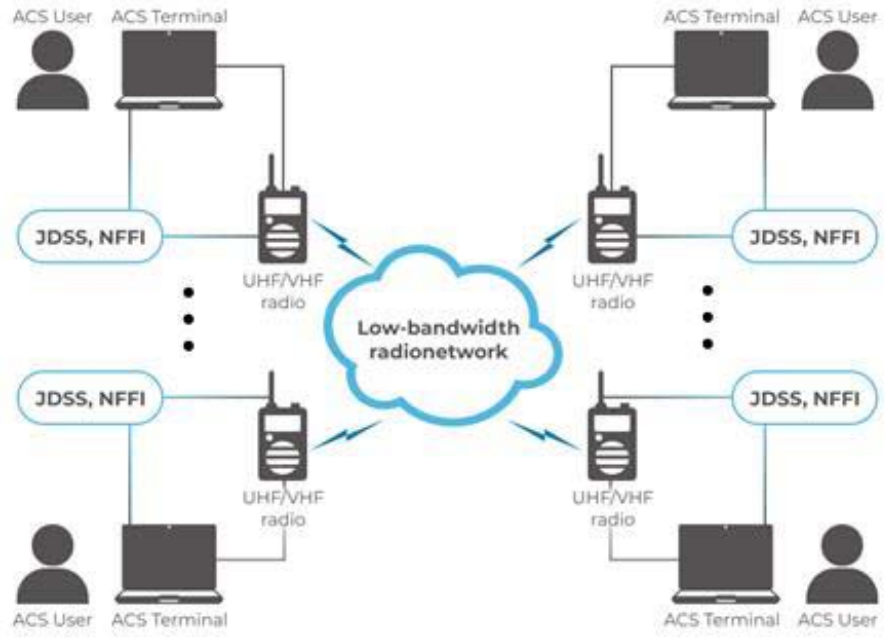

Fig. 1. The concept of using the JDSS and NFFI protocols of the governmental ACS of the low echelon management level

This concept describes only the basic model of ACS construction in low-bandwidth communication networks with a limited number of users and does not take into account the simultaneous use of several radio communication channels.

There is currently no typical architecture for the construction of governmental ACS of the low echelon management level with the constant movements of users in low-bandwidth communication networks based on UHF/VHF radio stations, but it is possible to present a generalized model of the architecture of such systems. Based on the research conducted in [1-4] and the features of ACS in low-bandwidth communication networks, we will consider the three-level hierarchical model of the Cisco company as a basic model. Three levels are defined in this model: core layer,

distribution layer, access layer. The three-level hierarchical model of the Cisco company is shown in Fig. 2.

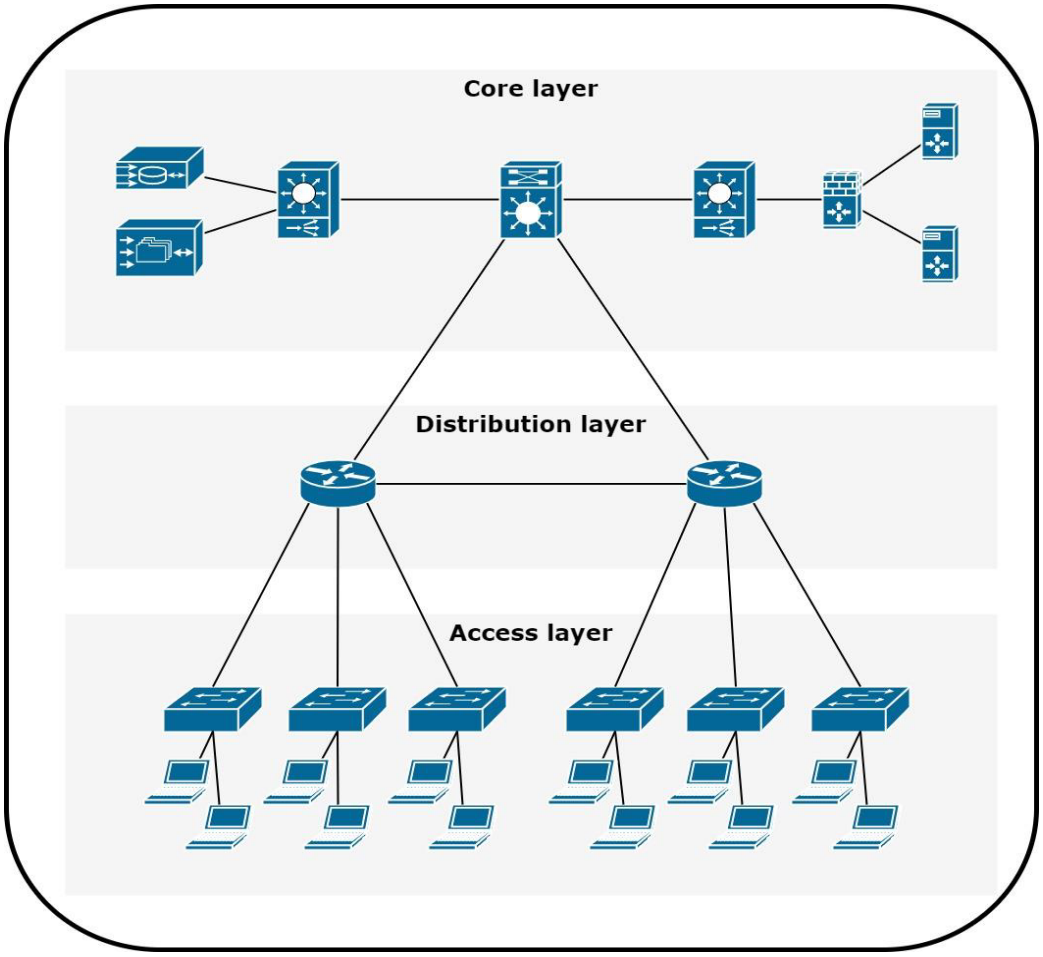

Fig. 2. The three-level hierarchical model of the Cisco company

A hierarchical three-level model describes the network architecture of one entity (enterprise, production, organizations, etc.) and represents the processes of interaction of users with each other and with other elements of the communication system. In order to adapt this model to the architecture of governmental ACS of the low echelon management level with the constant movements of users in low-bandwidth communication networks based on UHF/VHF radio stations, it is necessary to consider the organizational structure of a typical digital ACS. If we consider that one of the most common areas of use such ACS is the military sector, then today the main autonomous element of the tactical control link is a battalion or battalion tactical groups [6, 7]. The generalized organizational structure of the communication system of the lower management unit is shown in Fig. 3 [7, 9].

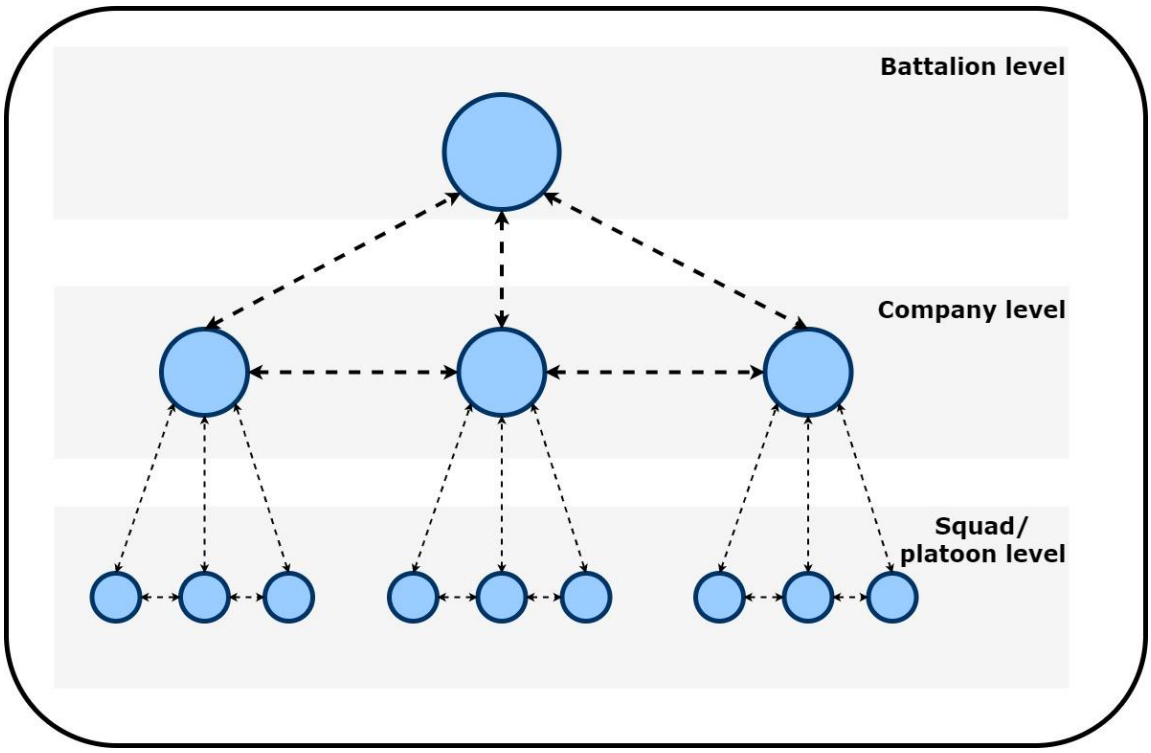

Fig. 3. Generalized organizational structure of the communication system of the lower management unit

The following levels can be attributed to the generalized organizational structure of the communication system of the lower management unit: the level of divisions/platoons, the level of a company, and the level of a battalion.

It is not difficult to see that the hierarchical model of the Cisco company's communication network and the generalized organizational structure of the communication system of the lower management unit have similar algorithms of construction and interaction. If we use the concept of the JDSS and NFFI protocols of the govermental ACS, the three-level hierarchical model of the Cisco company, the generalized organizational structure of the communication system and the results of work [1-4, 9], then it is possible to propose a generalized architecture of the construction of the ACS in low-bandwidth communication networks based on UHF/VHF radio stations. This architecture consists of three levels: management, interaction and access. Each level has ACS users and uses the JDSS and NFFI protocols of the STANAG 4677 standard as the basic data exchange mechanisms, which allows each level in this architecture to work autonomously. The message synchronization algorithms of the STANAG 4677 standard allow ACS users to work

at each level separately and, when communication channels between them appear, to automatically transfer data between levels. The generalized architecture of the ACS of the low echelon management level in low-bandwidth communication networks based on UHF/VHF radio stations is shown in Fig. 4.

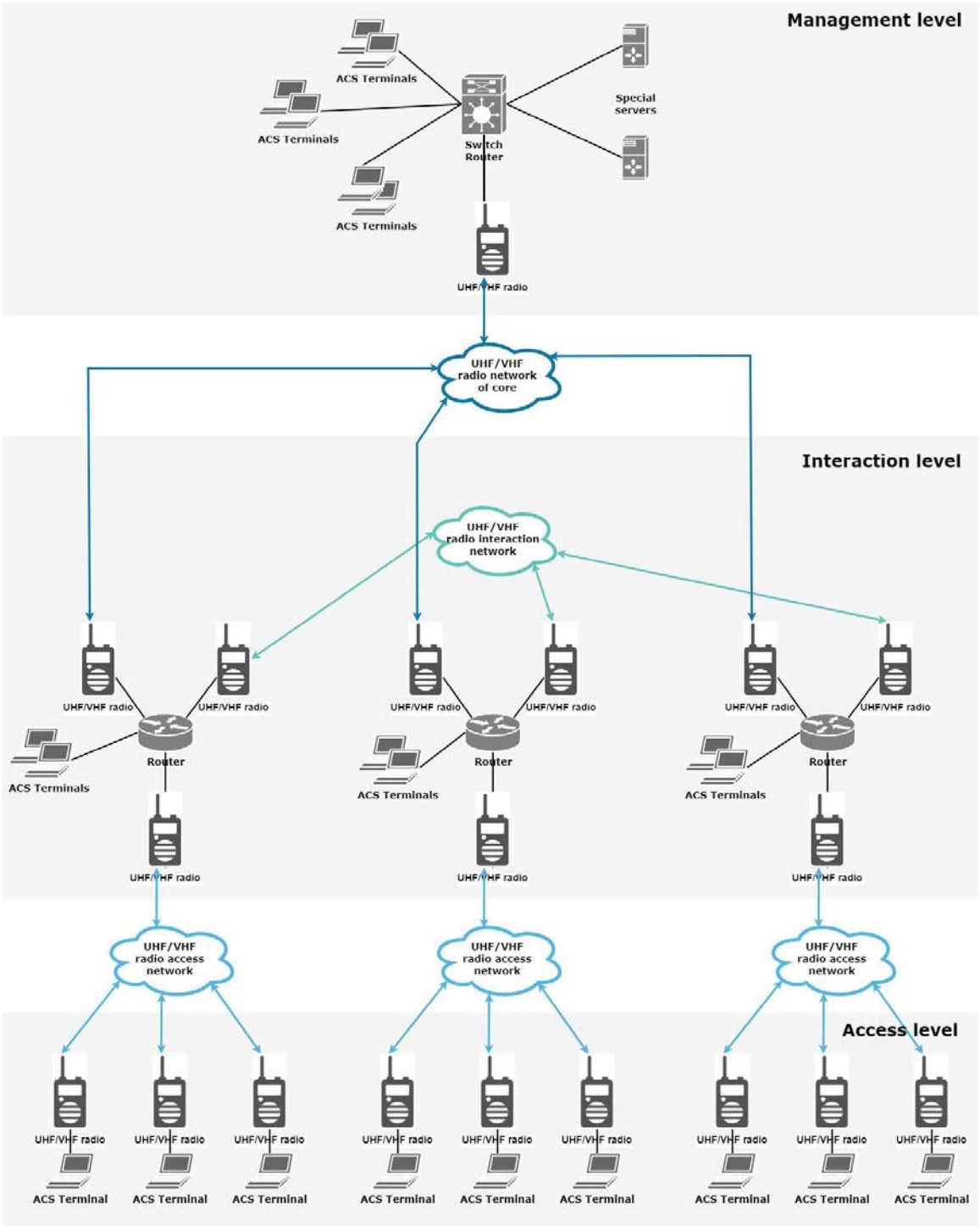

Fig. 4. The generalized architecture of the ACS of the low echelon management level in low-bandwidth communication networks

The proposed generalized architecture of the ACS of the low echelon management level shows the main elements of the communication system and their interaction. The research of the communication networks indicators built on the UHF/VHF radio stations [4, 5] shows that limited data transmission bandwidth, long data packet delivery time, high jitter and a high probability of losses in the channel can lead to an increase in the probability of service denial to ACS users. Therefore, when building ACS in low-bandwidth communication networks based on UHF/VHF radio stations, it is necessary to evaluate the load on communication channels and calculate the probability of service failures even at the stage of designing the automatic ACS communication system.

Conclusions

1. The analysis of using the JDSS protocol concept for the construction of governmental ACS of the low echelon management level was carried out. It was determined that this concept describes only the basic model of the ACS construction in low-bandwidth communication networks with a limited number of users and does not take into account the simultaneous use of several radio communication channels.

2. The generalized architecture of the governmental ACS of the low echelon management level in low-bandwidth communication networks is proposed for improving the indicators of the functioning of the communication system and determining the availability of services even at the stage of design and planning.

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