

Promising wireless applications in the construction industry

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Abstract. Wireless technology such as Wi-Fi, Bluetooth and other are used in many areas of the economy [1-3]. Experts know the advantages and disadvantages of wireless technology. The advantages include the fact that, firstly, the mobile work of employees is ensured, and secondly, wireless control of technical and household appliances and technological processes is possible. The disadvantages of technology include the fact that the proper level of information security is not always ensured. In addition, when using this technology should be done difficult work associated with determining the possible impact of other wireless networks, as well as different types of electromagnetic fields. In the field of construction, wireless solutions are associated with the projects "Smart Home" and "Smart City". Meanwhile, with the help of wireless technologies, other solutions are possible to improve the efficiency of work in the construction industry. The purpose of this work is to consider such solutions, to study the possibility of their application in the construction industry and to develop practical conclusions and recommendations based on this research.

1 Introduction

Wireless technologies are widely used in many areas of the economy, including the construction industry. The use of these technologies mainly concerns the solutions "Smart Home" and "Smart City". However, there are a number of other areas in construction, where the use of wireless technologies, primarily Wi-Fi, can have a serious economic effect. The following is the material associated with the study of these technologies and the development of appropriate practical recommendations.

2 Materials and methods

The first of the possible applications of wireless technologies in construction concerns the technical solution "structured cabling systems SCS". SCS allows to bring into a single system a variety of network services: local area networks, telephone networks, security systems. SCS is a hierarchical cable system mounted in a building (or in a group of buildings). Structured cable systems consist of structural subsystems: vertical, horizontal and other (figure 1).

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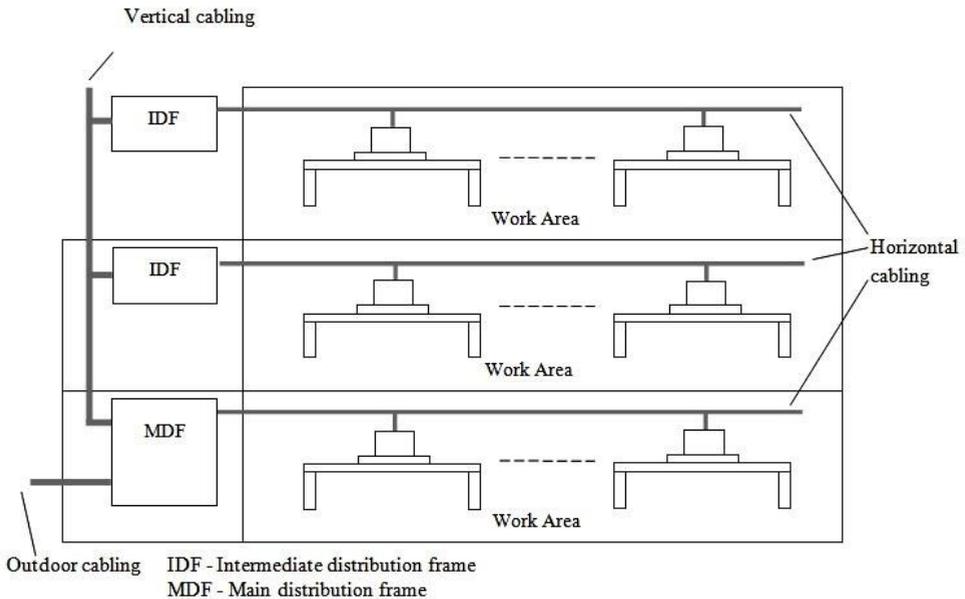


Fig. 1. Vertical and horizontal subsystems of SCS.

In some subsystems (in particular, vertical) the use of wireless communication is almost impossible: in such subsystems, extremely high bandwidth is required, which can be provided, for example, by fiber-optic lines. In most cases, horizontal subsystems use twisted pair copper conductors. A solution based on the use of four twisted pairs covered with a common plastic sheath is usually applied. Modifications to this solution are possible: shielding, increasing the number of twisted pairs. It should be emphasized that all technical solutions in the SCS should strictly comply with regulatory documents.

Prerequisites for use in the horizontal subsystem of wireless solutions are explained by several factors. In some types of buildings (for example, of historical value) cabling is extremely undesirable or unacceptable. In addition, developers are attracted by the useful properties of wireless communications: the mobile work of employees is ensured; there are no restrictions on the number of employees simultaneously using the Internet. However, the use of Wi-Fi wireless has until recently encountered the following problems:

- the first Wi-Fi standards 802.11a, 802.11b, 802.11g had a low transmission speed (the maximum speed for the 802.11a and 802.11g standards was 54 Mbit/s, the real speed was 20 Mbit/s; for the 802.11.b standard the speed was even lower). Such speeds for many applications are insufficient.

- The above Wi-Fi standards had poor cryptographic protection (WEP encryption standard), respectively, had low information security (could be easily cracked), which did not suit potential users.

The emergence of new Wi-Fi standards: 802.11n, 802.11ac, 802.11ax significantly changed the situation.

First, significantly increased the transmission speed (the maximum speed for 802.11ax comes to 11G Gbit/s).

Secondly, improve information security due to a "strong" cryptography (the data encryption standards WPA and WPA2).

These factors have significantly changed the view on the use of Wi-Fi in horizontal subsystems of SCS: many developers consider it expedient to install this equipment

(although the technology based on using twisted copper pairs still dominates in this segment).

The second direction in the use of wireless networks in the construction industry is the automation of warehousing. Here, Wi-Fi technology allows significantly improve work efficiency. Indeed, almost all modern devices involved in warehouse automation use a wireless Wi-Fi connection. These are handheld scanners of RFID tags, mobile printers, surveillance cameras, data collection terminals, climate control sensors, security sensors, etc.

In construction, the following situation is typical: warehouses have a sufficiently large area and are located at a considerable distance from the construction object. Then the wireless network is the best solution in terms of financial costs. An additional argument in favor of a wireless solution is that cables, that are several hundred meters long, can interfere with construction work. Calculating the cost of creating a network, it should be noted that a significant part of the equipment can be used many times at other construction sites.

The specific solution depends largely on the conditions in which the construction takes place — the landscape of the area, the surrounding buildings, and the characteristics of the warehouse itself. Combined solutions are possible - the connection between access points is carried out using a cable (for example, fiber optic), while scanners, surveillance cameras and other objects are connected using a wireless connection.

When performing work related to the installation of a Wi-Fi network in warehouses designed for construction, you should consider a number of factors listed below:

1) Type of warehouse. Here are the following options.

- Street warehouses. In this case, the equipment should have a wide range of operating temperatures, as well as an increased class of shell protection. The protection class is determined by the appropriate marking using an international protection mark (IP) and two digits. The maximum degree of protection for this classification is IP68: that is, a dustproof device that can withstand prolonged immersion in water under pressure. Given the conditions of a particular warehouse, you should select the desired protection class (for example, IP67).

Another feature of this type of warehouse is the need to install street access points - on the roofs of adjacent buildings or towers.

- Indoor warehouses. The conditions of storage in such warehouses can be very different. So, for example, may be a warehouse, operating over a wide temperature range when wide fluctuations of humidity. Here you also need to select the type of network equipment (from the point of view of sealing). In addition, such warehouses may be "impervious" to external signals, therefore, we should provide special measures to ensure the reliability of Wi-Fi equipment.

- Mixed storage option. Here, when choosing a sealing class, one should proceed from the specifics of each zone.

2) The need for preliminary radio engineering research. While doing this work, one should take into account as much as possible factors that may affect the operation of Wi-Fi equipment: potential sources of interference, interference from other wireless networks. The attenuation and reflection coefficients of walls, racks, the possible effect of stored building materials and products are taken into account.

With the help of Wi-Fi-network, you can create an integrated warehouse management system, which can be an important part of a common ERP system.

Of course, all work associated with the installation of Wi-Fi-network in warehouses must be performed by professional experts in the field of telecommunications. However, the management of the construction company must control the work, taking into account the above factors.

Next, we consider the direction of wireless communications, which, in our opinion, is undervalued in the construction industry - professional mobile radio PMR. Currently, the term "professional mobile radio" is commonly understood as two-way mobile radio systems using a range of ultrashort waves.

PMR are intended for limited groups of users united by professional principle. They are used by law enforcement agencies, emergency services, in energy, transport and some manufacturing enterprises.

Let present the arguments for the use of PMR in construction. The use of professional radio communications is primarily due to the need for operational control and quick response to the situation during construction work. Here the key role is played by the most important advantage of the PMR - high speed of connection establishment.

The time to establish one connection in public cellular networks, depending on the base station load, can be tens of seconds. During peak hours or in an emergency, there is no guarantee that the connection will take place at all. It is clear that in the conditions of operational construction work such an effect can lead to extremely undesirable consequences. The use of professional mobile communication allows you to correct the situation.

An important prerequisite for using PMR is independence from public cellular networks of various standards (including GSM). Public networks are essentially networks of equal users. The concept of public networks does not allow to assign subscribers a multi-level priorities, provide them with the right of an extraordinary connection, effectively implement group interaction. The function of emergency emergency call is absent altogether. All this allows to carry out PMR.

A certain brake on the implementation of this extremely promising type of communication is the false notion that a radiotelephone is a bulky and inconvenient device similar to a cheap type of walkie-talkie that is often used by fishermen or hunters. A modern professional device is compact, lightweight and convenient to use.

The above material proves that when carrying out construction works in many cases it is advisable, and sometimes necessary to use a professional mobile communication system.

Finishing consideration of professional radio communication systems, let us indicate the most popular solution of such systems in construction - dispatch radio communication systems. Modern dispatching systems guarantee fast and reliable communication with workers in various construction sites, staff serving the construction equipment and transport. Systems monitor the situation, respond quickly, coordinate actions throughout the construction area.

Then we look at another important aspect of wireless communication - satellite technology. There are two main directions of the use of artificial satellites:

- based of satellites in geostationary orbit (~ 35 800 km above sea level)
- based of low-flying satellites (for simplicity, we include in this category all satellites in orbits below geostationary)

In the field of construction, both types of communication can be used. Let's start with geostationary satellites. A feature of the geostationary orbit is that the receiver in the service area constantly "sees" the satellite at the same point. The zone of "visibility" of such a satellite is almost half of the territory of the earth, which in the conditions of Russia is very important. The main advantage of the technology is that it is possible to establish communication and connect the Internet within a few hours at remote sites - where the use of other types of communication is impossible or impractical.

In this direction of satellite communications, it should be noted technology VSAT (Very Small Aperture Terminal). This technology is characterized by a small antenna size (type size 1.2 m). Satellite technology VSAT has been successfully used in Russia since the 90s

of the XX century. A simplified communication scheme using VSAT technology is shown in figure.2

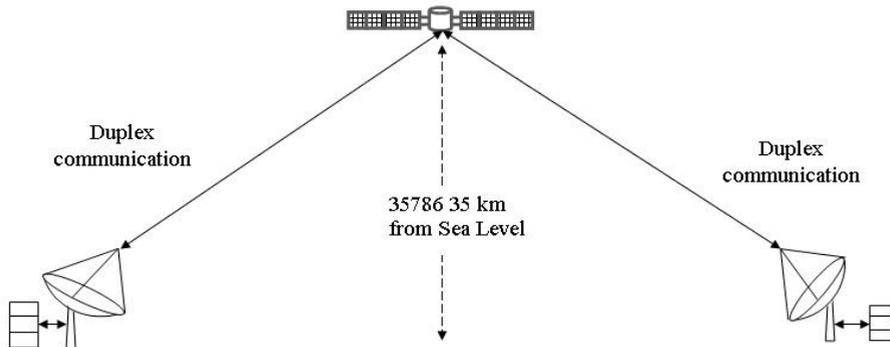


Fig. 2. A simplified communication scheme using VSAT technology.

The signal from the VSAT subscriber terminal located in the building of the remote region, is sent to the satellite where it is amplified and is forwarded to the network control center (NCC) of a satellite operator. Information from NCC via the Internet is received in the Central office of a construction company, which can be at very great distance both from GCC and from the construction site. A VPN channel is used for communication between the NOC and the Central Office. Virtual Private Network - VPN is used to create a secure channel on top of another network (in this case, the Internet). Information security is based on the use of cryptographic protocols. Using cryptography (along with other methods) allows you to: protect data transmitted over the network from an unauthorized access, ensure data integrity, authenticate, etc.

The main disadvantage of the technology is a large signal delay. Since the satellite is located at a considerable distance from the earth, then there is no need to talk about high transmission rates.

In the field of construction can be situation, when the use of this technology is justified:

- in the construction of remote objects, in the absence of cable and cellular communications, when the establishment of this communications is not economically justified;
- for large-scale construction that require data from additional weather stations. Such data automatically can be transferred via VSAT technology. These data, along with others, can be used for intelligent data processing (for example, may be used the technology Big Data [4-7]).

The advantages of geostationary satellite communications can be illustrated by a specific example. There is a construction site located thousands of kilometers from the main office in an area with poorly developed communication infrastructure. On the construction site there are several video cameras, information from which is fed to the satellite terminal, consisting of a transceiver and antenna (see figure. 1). Thanks to satellite communications in the central office, managers can monitor the construction progress online or in recording.

After analyzing the advantages and disadvantages of the satellite technology VSAT, as well as assessing the results of the implementation, we can conclude that this technology will not receive a "revolutionary" development (like Big Data technology). Nevertheless, VSAT will constantly occupy its segment in the field of IT technologies, providing construction companies with additional options for the implementation of their decisions.

The second direction of satellite communications is based on the use of satellites located in a closer orbit to the earth. The advantage of such systems is that, since they are much closer to the earth than geostationary satellites, they do not require high power transmitter. Consequently, devices can be used, in size and power approaching cellular communication devices. In addition, and this is especially important, the time it takes for the signal to reach the satellite is shortened many times, so it is possible communication with moving objects.

The disadvantage is that, unlike geostationary, low-flying satellites are not constantly above a certain area of the earth, but are continuously rotating. To ensure continuous communication, several satellites are needed (most often several dozen) and various relay systems, which greatly complicates the structure of the systems. Therefore, the creation of the first system of this type of Iridium was discontinued at the final stage for financial reasons (now these works have been resumed). Currently, there are several systems of this type, including systems made in Russia.

Systems with low-flying satellites can be used for communication with fixed objects, communication and monitoring of mobile objects. In the construction industry, various vehicles, construction equipment, etc. can serve as mobile objects. Since these tasks are in demand in practice, this direction of satellite communications should certainly be considered promising.

3 Conclusions

The paper explores the possibility of using wireless solutions in the construction industry. At the beginning, the possibility of using wireless networks Wi – Fi was considered. Two directions are indicated where successful implementation of these networks is possible.

First, Wi – Fi technology can be effectively used in horizontal highways of structured cabling systems (SCS). Arguments in favor of using this technology are indicated. In some types of buildings (for example, of historical value), cabling is extremely undesirable or unacceptable, here you should use Wi-Fi. Wireless connectivity provides employee mobility; There are no hard limits on the number of employees simultaneously using the Internet. Modern Wi-Fi standards provide high speed transmission and reliable information protection.

Secondly, Wi – Fi technology can be successfully used for warehouse automation. Indeed, almost all modern devices involved in warehouse automation use a wireless Wi-Fi connection. These are handheld scanners, mobile printers, security cameras, security sensors and other equipment. The factors contributing to the effective use of Wi – Fi in the warehouses of a construction organization were investigated, practical recommendations were given.

The work investigated the professional mobile radio PMR and the possibility of its use to improve the efficiency of work in construction. The main advantage of the PMR is noted - the ability to instantly connect with the necessary employee or service, while cellular communication takes many seconds, during peak hours there is no guarantee that the connection will take place at all. It is noted that during the work at the construction site, this advantage may be key. Other benefits of PMR are considered: the ability to assign users to multi-level priorities, the right to a priority connection for the implementation of group interaction and others. The most popular solution for these systems in construction is indicated - dispatch radio communication systems. These systems guarantee fast and reliable communication with workers at various construction sites, monitor the situation, respond quickly, coordinate actions throughout the construction zone.

The paper explores another important aspect of the use of wireless communications in construction - it is a question of using satellite technology. It is shown that two types of

satellite communications can be effectively used in construction: on the basis of geostationary satellites and on the basis of low-flying satellites. In the first case, the use of VSAT technology is recommended. This technology allows you to establish communication and connect the Internet in a short time at remote construction sites - where the use of other types of communication is impossible or impractical. The second type of communication can be used for communication and monitoring of mobile objects involved in construction: vehicles, mobile construction equipment, etc. Concrete examples are given, practical recommendations are given.

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