Bogdan OROBCHUK[1], Ivan SYSAK[1], Serhii BABIUK[1],
Mikołaj KARPINSKI[2], Daniel JANCARCZYK[2]

ROZWÓJ I WDROŻENIE LOKALNEJ SIECI BEZPRZEWODOWEJ W PROCESIE EDUKACYJNYM NA BAZIE SYMULATORA KONTROLI WYSYŁKI

Streszczenie: W artykule omówiono badania, rozwój oraz zastosowanie lokalnych sieci bezprzewodowych w procesie edukacji. W szczególności, badano poziom sygnału transmisji danych dla lokalnych sieci bezprzewodowych wewnątrz budynków. Omówiono działanie sterujących jednostek telemechanicznych działających na sieciach przewodowych, gdzie operator komunikuje się z różnorodnomi czujnikami oraz siłownikami (urządzeniami uruchamiającymi). Stwarza to pewne trudności oraz zagrożenia działania dla operatora, który znajduje się obok jednostki telemechanicznej. Ponadto, w pracy rozważa się mozliwość zastosowania technologii bezprzewodowych w procesie uczenia. Zaproponowano jak zapewnić poprawne działanie operatorowi oraz zredukować czas dostępu do czujników i siłowników. Zwrócono uwagę na zastosowanie podsystemów bezprzewodowych typu ‘short-range’ (krótkiego zasiegu).

Słowa kluczowe: technologie telekomunikacyjne, Wi-Fi, sieć lokalna bezprzewodowa, process uczenia, telemechanika

DEVELOPMENT AND IMPLEMENTATION OF A LOCAL AREA WIRELESS NETWORK IN THE EDUCATIONAL PROCESS ON THE BASIS OF THE DISPATCH CONTROL SIMULATOR

Summary: The article is devoted to the issues of research, development and implementation of local area wireless networks in the educational process, especially, the study of the signal level for data transmission control of the local wireless network indoors. The controlled telemechanics unit uses wired systems for communication of the operator with various sensors and actuators, which creates certain difficulties and danger for the operation of the operator, which is located near the telemechanics unit. The article considers a potential use of wireless technologies in the learning process, which demonstrates how to ensure the operation of the operator and reduce the time to bypass all the sensors of the actuators. A short-range wireless subsystem was considered.

[1] Ternopil Ivan Puluj National Technical University, 56 Ruska St., 46001 Ternopil, Ukraine hramhome.1965@gmail.com
[2] University of Bielsko-Biala, 2 Willowa St., 43-309 Bielsko-Biala, Poland mkarpinski@ath.bielsko.pl, djancarczyk@ath.bielsko.pl

Keywords: telecommunication technologies, Wi-Fi, local area wireless network, learning process, telemechanics

1. Introduction

The education system in modern conditions is a subject of very high requirements: it must prepare specialists for life and work in a dynamic, changing world, where people are constantly faced with non-standard tasks, the solution of which involves the ability to build and analyze both their own actions and the course of various technological processes. The leading place in such system is occupied by innovative methods of preparing students at higher education system, who should become specialists with innovative thinking, though in the future they will be directly involved in the formation and implementation of innovation policy.

Currently, the spread and application of wireless information and telecommunications technologies is a real and accomplished fact, especially in the educational process. Our research focuses on the analysis and evaluation of those technologies that use the frequency ranges from 2400 to 2483.5 MHz and from 5725 to 5875 MHz and are dedicated to the use of high-frequency installations designed for industrial, scientific and medical purposes. These ranges belong to the ISM-range (Industrial, Scientific, Medical) [1].

At the moment, Ukraine is allowed to "build local radio networks in the frequency bands 2400-2483.5 MHz on the basis of devices with a maximum transmitter power not more than 100 MW and a maximum antenna gain - 3.5 dB only within buildings, structures, closed industrial and storage yards "[2].

Such decision allows to legally deploy such networks in scientific and educational institutions of Ukraine in order to increase the efficiency and quality of the educational process in universities and to conduct large-scale research on the application of new wireless technologies in practice. It should be noted that particular practical interest in building large heterogeneous wireless networks in universities and other educational institutions is the study of the interaction of wireless devices to build personal and local networks operating in the same frequency bands, but using different standards of digital information (for band 2, 4 GHz - 802.11 b/g/n - Wi-Fi standards, 802.15.4 - ZigBee, 6LoWPAN, 802.15.1 - Bluetooth, for band 5 GHz - 802.11 a/n - Wi-Fi standards) [3].

The use of personal and local wireless networks at educational institutions provides staff and students with mobile access to information and modern high-tech equipment needed for the educational process, thereby increasing the efficiency of the learning process.

The use of multiple devices operating in the same band creates the problem of noise immunity and the impact of radio interference on network performance. Many radio systems transmit narrowband signals. They are sensitive to radio interference. Therefore, to increase the noise immunity in communication channels, methods of signal spectrum expansion are used [4]. In our case, the task was to assess the magnitude of the negative impact of various wireless devices on the operation of devices in Wi-Fi access zones in the network infrastructure of the university.

To assess the mutual influence of network equipment on the equipment of Electrical Engineering Department of Ternopil Ivan Puluj National Technical University, three experimental researches were conducted and a wireless Wi-Fi network was built for the training simulator of the automated dispatch control system of electric power facilities [5].

2. Study of the impact of neighboring networks

Neighboring Wi-Fi networks operating in the same frequency range may interfere with the developed wireless network. These interferences (also called intra-channel) predominate in bands 802.11b and 802.11g networks. In the band 2.4 GHz there are only three channels that do not overlap (1, 6 and 11), and in some cases these channels have to be reused [6].

For the experimental study of the influence of intra-channel interference, two D-link access points were set up on the 1st channel. Then the data rate from the client equipment to one of the access points when the other access point is on and off and change the distance between them - 1 m, 10 m and 25 m was tested. Decreasing of transferred speed while switching on the other access point average at a distance of 1 m from the first one was 50%, at a distance of 10 m - about 40%, and at a distance of 25 m 25%.

However, due to interference, intra-channel interference can also occur between Wi-Fi devices that operate on adjacent frequency channels. For example, we investigated the 1st frequency channel with the band from 2.401 to 2.423 GHz and the 2nd channel with the band from 2.406 to 2.428 GHz. The results showed that the total area of two neighboring channels is approximately 78% of the channel width, which should also lead to a significant reduction in WLAN bandwidth.

Experiments have shown that the reduction in the transmission rate of the communication channel to one of the access points during the operation of the second one in the neighboring channel reaches about 40% compared to the switched off one. In the case where both access points operate on non-overlapping frequency channels, the speed decreases by an average of 10%. This indicates that the multipath transmission of radio waves in non-overlapping frequency channels also causes interference phenomena that generate interference in all channels.

3. Study of the impact of bluetooth devices on the operation of Wi-Fi networks

In this experiment, the degree of influence of the operation of Bluetooth modules in the 2.4 GHz band on the speed of information transfer between clients and the Wi-Fi access point was investigated. Standard 802.15.1 (Bluetooth) uses the method of Frequency Hopping Spread Spectrum (FHSS) to access the communication channel [7]. This means that devices are practically receiving / transmitting on 79 subchannels with a width of 1 MHz in the entire 2.4 GHz band when switching frequencies approximately 1600 times per second. The use of FHSS technology increases the stability, as it reduces the likelihood of using the same frequency subchannels by other devices at a particular time.

The following experiment was performed to evaluate the effect of Bluetooth devices on the rate of the 802.11g Wi-Fi access point operating in the 2.4 GHz range. The access point was installed at a distance of 3 m from the laptop with the developed transmission device, and working devices with Bluetooth modules are located between them. When testing the speed on each of the channels was found to reduce the speed of reception/transmission by an average of 20%.

4. Study of the impact of wireless radio devices

Wireless cordless phones are also potential sources of noise interference for local wireless Wi-Fi networks. Nokia analog cordless radio phone operating at 2.413 GHz, ie in the band of the 1st frequency channel of 802.11 b/g standard, was chosen for the experiment. Testing has shown that at the time of the telephone conversation there is a break in the wireless connection between the client and the access point on the 1st frequency channel, but the operation of the radio does not interfere with the devices of the developed Wi-Fi LAN on channels 6 and 11. Tests, when the phone was moved away from these devices at a distance of 10 m, 25 m and 40 m, respectively, were realized. When the phone was 10 m from the access point, the transmission speed on the 1st channel was reduced by 98% (from the maximum value in the absence of interference), when it was moved by 25 and 40 m, the transmission speed was reduced by 25 and 5%, respectively.

The next experiment examined the effect of Samsung digital radiotelephone operating in the same 2.4 GHz frequency band using FHSS technology. The experiment showed that placing a working phone next to the developed Wi-Fi network at a distance of up to 10 m can reduce the data transfer speed by a maximum of 15%.

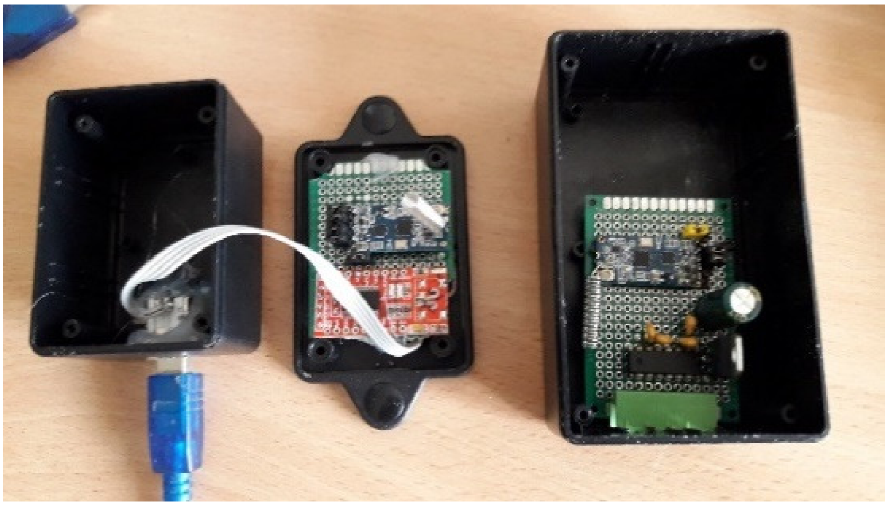
The results of the experiments showed that in the general case when building wireless networks to eliminate the impact of these interferences from other devices on the operation of Wi-Fi networks, it is more appropriate to use devices operating in a different frequency range, for example, 5 GHz band can be used for 802.11 b/g. However, they can have a negative impact on 802.11a and 802.11n network standard.

5. Algorithm for developing a local area wireless network for a training simulator

Modern controllers of telemechanics systems can receive information not only from sensors and transducers, but also from various microprocessor devices, such as meters, current protectors, microprocessor relay protection devices, and others. One of the local interfaces, for example, RS-485, is used for docking with such devices. Information exchange takes place using one of the compatible protocols, such as Modbus.

The control point (CP) of telemechanics in real operating systems is connected to the dispatch unit (DU) remotely, usually at a great distance. Therefore, for the operator who works directly on the object in the danger zone near the control cabinet, you need to use a separate device at workplace. There is a need to ensure the work of service personnel. The simplest way is to move the control and information collection units

of the telemechanics control system outside the danger zone. To solve this problem, you can use wireless technology, which makes it easy to use and no need to install cables.
The training simulator of the automated control system, for which the wireless local area network is developed, the substation contains models of power transformers, switching devices, models of loads on the outgoing lines, measuring devices for electrical measurements, sensors and telemechanics equipment. The simulator model of the substation allows to get acquainted with the methods of operative-dispatching control, with the methods of telecontrol and telemanagement of electric networks and parameters of power consumption.
At the moment, in the training simulator of the automated dispatch control system, the communication between CP and DU is carried out using a two-wire communication line (RS-485 interface) to the serial port of the computer via the RS-232 interface. The training simulator is built on the basis of the equipment of the constructing bureau of the company "Strila" [8].
A wireless local area network was developed to ensure the reliability of data transmission, redundancy and duplication of the communication channel, which is now a mandatory requirement for telemechanics systems in electricity, as an alternative communication channel for the training model-simulator. The developed project uses software and hardware implementation based on two devices: receiver and transmitter (Fig. 1)



a) transmitter *b) receiver*

Figure 1. Software and hardware implementation of a wireless network

As a hardware component in the transmitter, two devices are used combined into one: a microcontroller for data collection via an analog-to-digital converter and a wireless transmission device. The receiver uses only a wireless device to connect to the control cabinet.
A six-channel analog-to-digital converter of the microcontroller, activated by means of connected libraries, is used as a software component that performs primary processing.

A USB port is used to connect one wireless device to a personal computer (Fig. 2), and a direct connection is used to connect another device to the control cabinet microcontroller (Fig. 3). In both cases, the UART/TTL standard works.

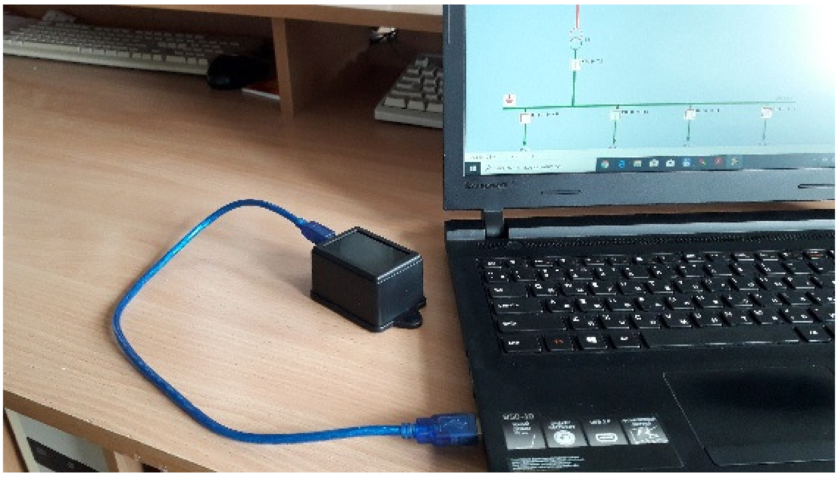


Figure 2. Connection of the transmitter to a PC via USB

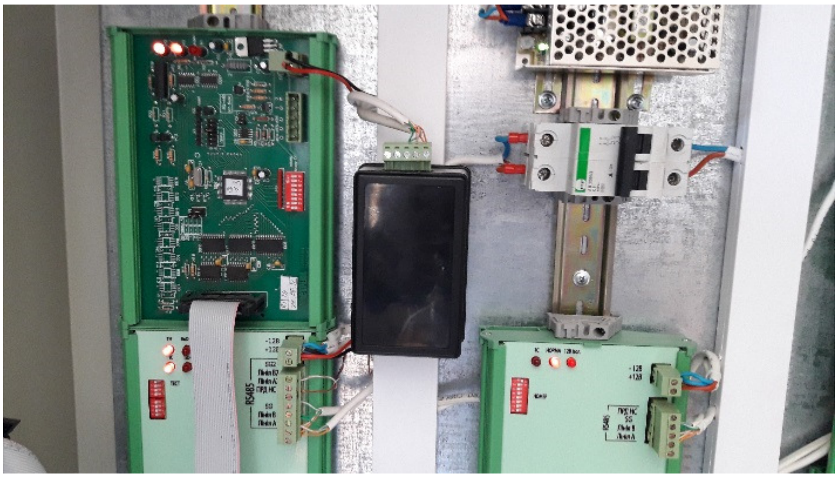


Figure 3. Connection of the receiver in the control cabinet via the RS-485 interface

The educational software and hardware complex, on which the local area wireless network is implemented, has a three-level structure, as shown in Fig. 4.

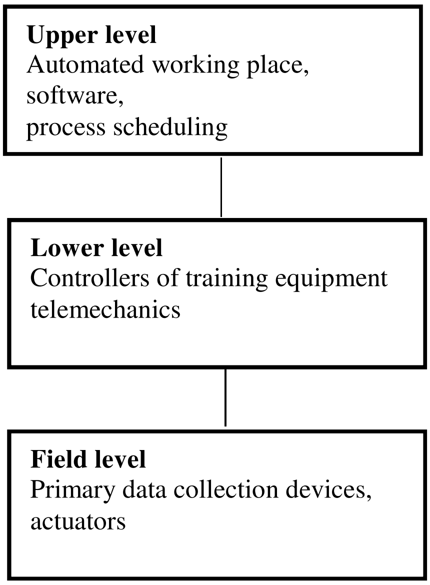


Figure 4. Three-level hierarchical structure of software and hardware complex

Thus, it is necessary to organize the use of wireless communication for modeling on a training simulator more comfortable and safer working conditions. The purpose of this project is to improve the quality of service of the telemechanics checkpoint by developing software and hardware for it, which solves the problem of automation and security.

A short-range wireless communication subsystem was developed for the controlled telemechanics point [9].

The developed software and hardware brings the information collection CP of the telemechanics outside the dangerous working area, which includes the service personnel at the facility.

The developed subsystem provides information transmission using wireless technology from the telemechanics control panel to the SCADA system of the dispatch control, which can be located at a distance of 100-1000 m from the CP.

The basis of the developed system is a programmable controller. Since the developed project requires the use of analog-to-digital conversion, a microcontroller is used, because almost all microcontrollers have analog-to-digital conversion.

The choice fell on the popular family of 8-bit microcontrollers from Atmel, in particular, ATmega328 was chosen. This microcontroller has a 10-bit analog-to-digital converter operating at a voltage of 0… 5 V. The crystal is easy to program, has low power consumption, low cost, small size and high resistance to failure.

ATMega328 contains 32 kB of built-in flash memory, which by the standards of the microcontroller is enough to solve many problems. Also, the micro-controller has a fairly large amount of RAM (2 kB). Performance is up to 20 million iterations per second (MIPS).

The APC220 device from APPCON Technologies was chosen for wireless data transmission for the project implementation. This transmitter has sufficient protection against external interference and communication range, while having low power consumption, low cost and a small size. The undoubted advantage is the presence of a transparent UART-interface, which allows you to connect easily to both, the microcontroller and the personal computer. The data transfer rate is sufficient to solve the problem of 19 kbit/s. The transmitter power is 13 dB and the receiver sensitivity is 113 dB.

With all the above features, devices can communicate with each other at a distance up to 1 km. It should be noted that the data for this distance is transmitted at an operating frequency of 418… 455 MHz. Compared to other devices operating at 2.4 GHz, the selected device with a lower frequency is more appropriate because it requires smaller dimensions and less power consumption.

Taking into account the above, a software platform was chosen, in particular, the Arduino IDE development environment was selected complete with a circuit board which meets the requirements of our project.

Thus, the use of all the considered devices allowed to achieve the set goal and to organize a short-range wireless communication subsystem for the training simulator of the automated control system.

6. Conclusion and future work

As a result of the performed research, the possibility of using and implementing a wireless short-range communication channel of the telemechanics control point for the training simulator of the automated control system was studied.

During the implementation of this project the following tasks were solved:

- the technical means on which the set task solved are chosen. The devices are compatible with each other and with the environment;
- the controller is selected, the ADC bit rate of which allows to carry out measurements from analog sensors, without going beyond the admissible error;
- implemented ADC on the controller;
- selected communication device that allows you to transmit the signal to the required and sufficient distance without loss;
- development a software tool that allows you to visually perform data reading by the operator;
- the requirements to energy consumption are considered, first of all because of economy of a charge of batteries: power supply on object is independent, a network of a direct current of 5 V;
- working capacity is provided in the range of working temperatures - 40 .. + 60 C.

It can be concluded that the use of the sub-system of wireless short-range communication for the organization of the communication channel in the training

simulator of the automated control system is justified. The selected equipment meets both requirements, functionality and reliability.
Thus, the organization of Wi-Fi in educational institutions requires a competent technical analysis and calculation that will optimize the requirements for the purchase of equipment, its location, providing the network with the necessary coverage area, and compliance with sanitary rules and regulations to prevent adverse effects of electromagnetic fields for the health of students and staff of the educational institution. The results of this project should be used for students to pass the curriculum in the areas of training specialists in modern power management systems, automated control systems and their use for education informatization, which will improve the quality of graduate training.

7. Acknowledgments

The authors are grateful for the important contribution to the development of the simulator model to Ternopil constructing bureau of radio engineering "Strila", in particular to the director Oleksandr Rafalyuk, chief engineer Oleksandr Piskun, programmer Serhii Dudin. Special thanks to the student-master of the Electrical Engineering Department of Ternopil Ivan Puluj National Technical University, Staryk Yurii for his help in developing modules of reception/transmission for wireless LAN. We also thank the dispatch service of Ternopiloblenergo, JSC for assistance in developing a control panel for the training simulator model.

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