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DEVELOPMENT OF A CYBERPHYSICAL SYSTEM FOR MONITORING FIRE SAFETY

Abstract. The Megamart company's cyber physical fire safety system was developed with the possibility of flexible changing types and sets of functions performed by reprogramming. system uses RFID technology with the development of a computer network. The computer system allows for the system's technical and software modernization, as well as ensures the fulfillment of all functions of the technical assignment. The system was validated using a model of the corporate network scheme using the program Cisco Packet Tracer program.
Keywords: cyber physical system, RFID technology, IoT.

Introduction. Cyber-physical monitoring systems are used in many areas of life. From simple indoor temperature control systems to complex and multi-component systems. As these systems become more complex and the number of functions they perform increases, the management process becomes more and more complex. Also, the costs of maintenance of service personnel, repairs and maintenance are increasing rapidly. However, there are many automation tools that control some types of systems, such as heating, ventilation, microclimate support, lighting, fire alarm, smoke filtration, entry/exit control, but the management and maintenance of all these systems requires the presence of appropriate personnel.

Using a cyber-physical system for monitoring office premises is a new type of service. The principle of the cyber-physical system for monitoring provides a completely new approach to the organization of workplaces and the security of office premises, stores and hypermarkets, in which the efficiency of operation and reliability of management of all subsystems increases due to the combination of software and hardware.

A cyber-physical system (CFS) is a mechanism controlled or monitored by computer algorithms and closely related to the Internet and its users [2]. The components of the CFS interact at different temporal and spatial levels and may have different, different from each other, behavior models. They interact with each other in

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different ways that can vary depending on the context. CFCs are somewhat similar in architecture to the Internet of Things (IoT), but they have a higher level of interconnection between physical and computer components.

Task definition. The aim of this article is the process of developing a cyber-physical system of fire safety the company Megamart based on RFID technology with the construction of a computer network.

Main part. The fire protection system is a complex set of technical and organizational measures aimed at preventing dangerous fire situations and limiting material damage. It includes various components such as automatic fire extinguishing systems, warning and evacuation systems, water supply systems, etc. The Internet of Things (IoT) refers to a system of interconnected objects that could collect and transmit data over a wireless network without the need for human intervention.

The firefighting equipment industry is being revolutionized by Internet of Things technology. By connecting to a wide-coverage LPWA network or even a cellular network, IoT for fire safety provides the opportunity to improve preventative measures and speed up fire response.

Networks that combine various IoT technologies can be installed anywhere on the scene of a fire to share and transmit data to protect the firefighting team. Often, IoT integrates with existing alarm systems, personal safety equipment, and firefighting equipment with minimal changes to simplify the fire department's modernization process.

Lightweight RFID trackers capable of determining the location of team members at any time. They can be easily integrated into any combination for permanent communication with a centralized network. By monitoring the location of each team member in real-time and combining them with thermal imaging, commanders can begin to create a detailed location map and provide precise guidance on operations. RFID, or radio frequency identification, is a technology that uses a wireless method to read the unique identification numbers of objects or people using radio waves.

The basic principle of operation is that the reader sends out a radio wave that is received by one tag. The tag receives energy and responds with a signal of the same frequency, modulating it according to the information stored in its memory. The reader receives this signal, recovers the information and identifies the tag. A higher-level identity system then verifies this data and guides further actions. This system is attractive because it allows contactless interaction between the reader and RFID tags without limiting the position of the object with the tag. The operating range of the RFID system is divided into several types: short-range identification (reading at a distance of up to 20 cm), medium-range identification (from 20 cm to 5 m) and long-range identification (from 5 m to 100 m).

The use of RFID systems is especially relevant for companies engaged in the production, supply and sale of various goods. [11].

The main hardware components of this system are:

1. RFID reader (scanner) - a device for receiving data from the corresponding tags or cards;

2. RFID-tag (card) - an information carrier with a unique identifier of the employee;

3. Wi-Fi router - required to transfer data from the scanner to the database server;

4. Database server - used to store and process employee authorization data.

In accordance with the technical requirements, the address space 10.22.185.0/21 was used to implement the fire safety system of the Megamart company. Address block 10.0.9.0/24 was used to address channels between routers. The IoT device network is configured in the address space 209.165.200.0/24.

The cyber-physical system fire safety of the company Megamart uses the EIGRP dynamic routing protocol according to technical requirements. This protocol is distance-vectored and uses an autonomous system numbered 9.

During the configuration of routing on the routers of this cyber-physical system, the bandwidth of 128 Kb/s, the cost metric of 7500 and the channel speed of 128000 are set on the serial interfaces, in accordance with the technical requirements.

To ensure network functionality, secure remote access to active network devices, interaction between nodes from different VLANs, and automatic IP address assignment using the DHCP protocol are also tested.

Internet of Things objects facilitate interaction between systems, people, and services to develop computationally intensive autonomous applications. The computer network of the fire protection system for the Megamart office uses IoT cloud computing technologies.

A fire sensor detects a flame by checking the property and detecting if the value of the IR property is within the range in which the sensor looks at the fire and emits a digital signal.

The first step is to select a network gateway for the system - the DLC100 (Home Gateway) router, which supports the IoT server.

The second step is to select and connect IoT devices. "Smart" fire safety items for the Megamart office are connected to the WiFi network supported by the

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DLC100. To connect to the network on things, the following are configured: SSID, authentication method, authentication key, obtaining an IP address by DHCP, then the specified IoT server.

The second step is to select and connect IoT devices. "Smart" fire safety items for the Megamart office are connected to the WiFi network supported by the DLC100. To connect to the network, the following are configured: SSID, authentication method, authentication key, obtaining an IP address by DHCP, then the specified IoT server (Fig. 1).

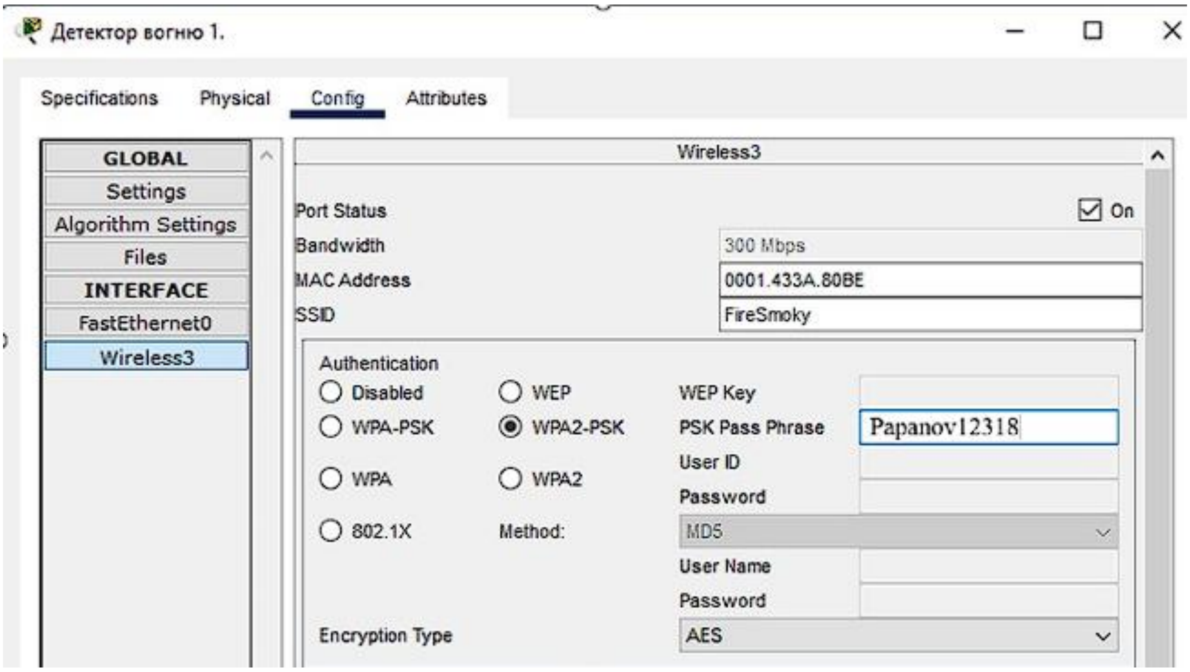

Figure 1 – Configuring the interface of the wireless device

After completing the settings, the "smart" things of the fire safety system will be displayed on the IoT server.

The configuration of connecting "smart" things to the IoT server is shown (Fig. 2 and Fig. 3).

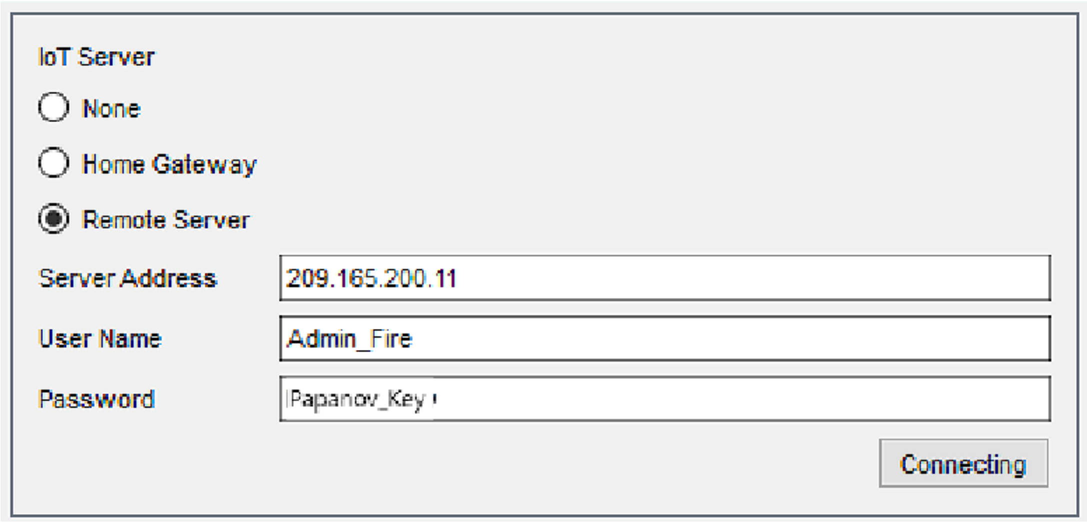

Figure 2 - Configuring the connection of "smart" things to the IoT server

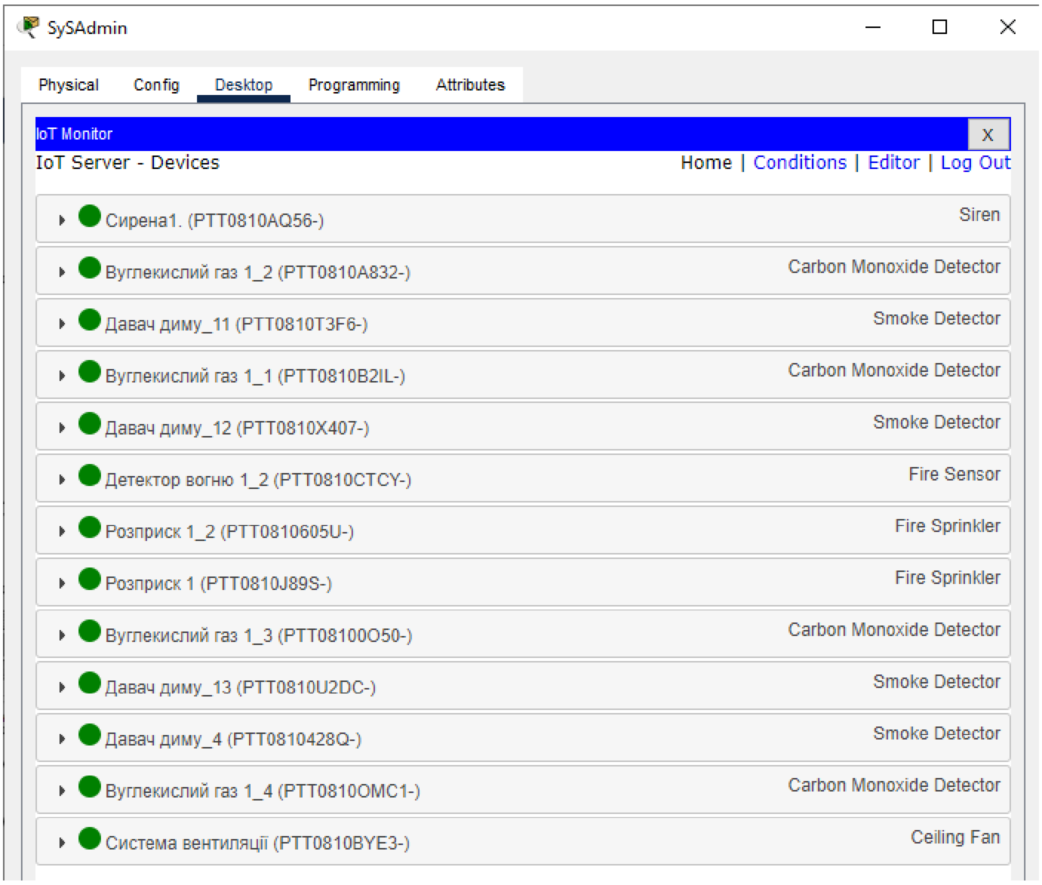

Figure 3 - "Smart" things on the IoT server

In the third step, the algorithms of the fire protection system are executed. Algorithms are written on the IoT server using its web interface as a script.

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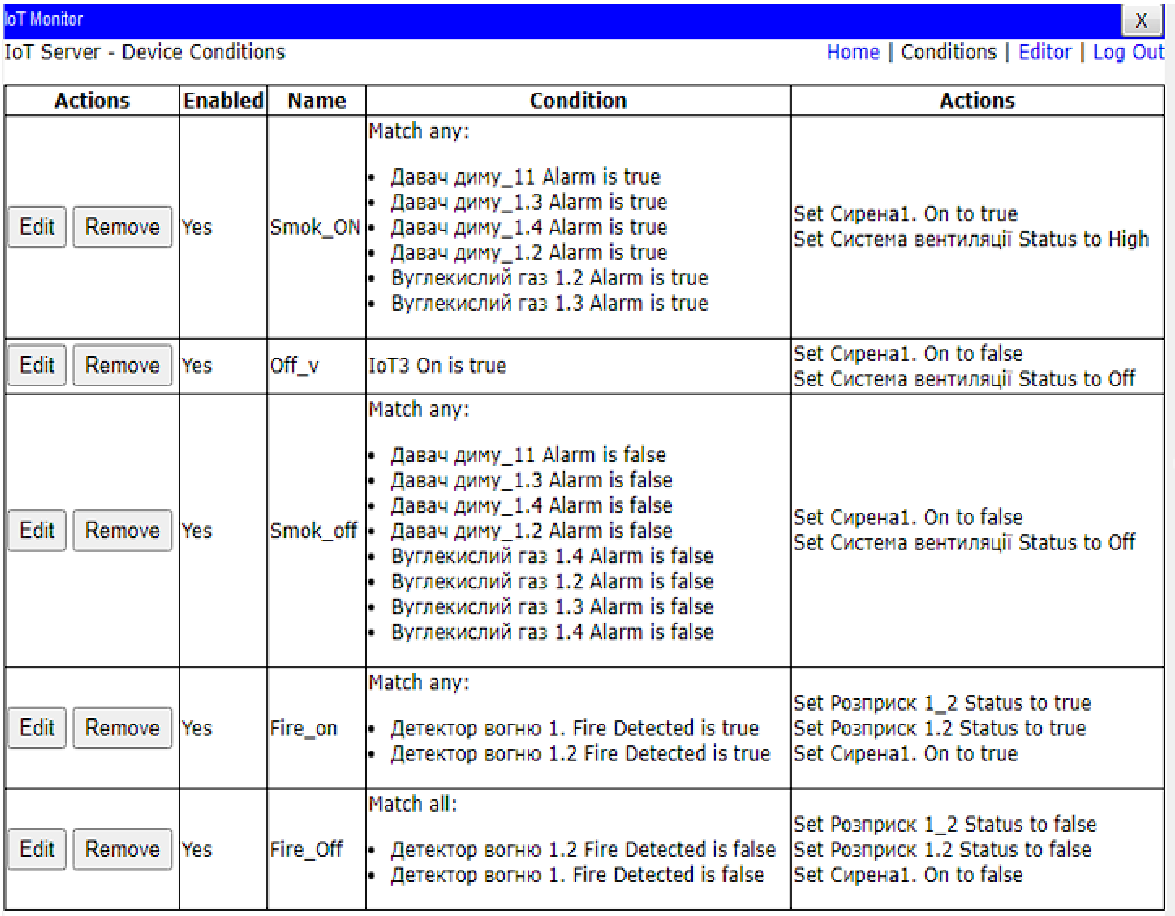
When receiving a signal from a smoke or carbon dioxide sensor, the ventilation system and siren are activated. Upon receiving a signal from the fire detector, water sprinklers and a siren are activated.

The fire detector detects the flame, checks the value of the "IR" property in the appropriate range, and the detector examines the fire and outputs a digital signal.

A carbon dioxide detector detects the level of carbon monoxide. It will work when the level of carbon monoxide in the surrounding air is 20%.

The smoke detector will trigger when it detects the smoke environment variable at 40%.


IoT Monitor

IoT Server - Device Conditions

Home | Conditions | Editor | Log Out

Actions	Enabled	Name	Condition	Actions
Edit Remove	Yes	Smok_ON	Match any: • Давач диму_11 Alarm is true • Давач диму_1.3 Alarm is true • Давач диму_1.4 Alarm is true • Давач диму_1.2 Alarm is true • Вуглекислий газ 1.2 Alarm is true • Вуглекислий газ 1.3 Alarm is true	Set Сирена1. On to true Set Система вентиляції Status to High
Edit Remove	Yes	Off_v	IoT3 On is true	Set Сирена1. On to false Set Система вентиляції Status to Off
Edit Remove	Yes	Smok_off	Match any: • Давач диму_11 Alarm is false • Давач диму_1.3 Alarm is false • Давач диму_1.4 Alarm is false • Давач диму_1.2 Alarm is false • Вуглекислий газ 1.4 Alarm is false • Вуглекислий газ 1.2 Alarm is false • Вуглекислий газ 1.3 Alarm is false • Вуглекислий газ 1.4 Alarm is false	Set Сирена1. On to false Set Система вентиляції Status to Off
Edit Remove	Yes	Fire_on	Match any: • Детектор вогню 1. Fire Detected is true • Детектор вогню 1.2 Fire Detected is true	Set Розприск 1_2 Status to true Set Розприск 1.2 Status to true Set Сирена1. On to true
Edit Remove	Yes	Fire_Off	Match all: • Детектор вогню 1.2 Fire Detected is false • Детектор вогню 1. Fire Detected is false	Set Розприск 1_2 Status to false Set Розприск 1.2 Status to false Set Сирена1. On to false

Figure 4 – System operation scenario

When the conditions specified in the scenario for triggering the system's sensors are met, the corresponding executive devices are activated.

Conclusions. The development of the components of the cyber-physical system for fire safety of the company Megamart was carried out, which is based on the use of standard components of modern RFID technology with the development of a computer network based on CiscoTM network equipment for the main network nodes.

The settings for the given network topology were calculated, standard interfaces for communication channels and exchange protocols were selected, the topological scheme of the computer system was calculated, the routing settings of the computer network were calculated, and the simulation and verification of the operation of the cyber-physical fire safety system was performed.

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Розробка кіберфізичної системи моніторингу пожежної безпеки

Спроектовано нову мережу для підрозділу фірми «Megamart», яка буде застосовувати у якості компонентів підмережу на основі RFID-технології. Для цього розроблено необхідну специфікацію для використання апаратних засобів комп'ютерної системи, у тому числі з набору стандартних пристроїв, необхідних для збору і передачі даних. Виконано вибір відповідного фізичного середовища, яке використовується для реалізації комп'ютерної системи, фізичних портів з'єднання ліній зв'язку, необхідних для організації підключення мережевих пристроїв до інших пристроїв у мережі і додаткових вузлів, які входять до складу комп'ютерної системи. Здійснено вибір мережевих пристроїв і компонентів, необхідних для задоволення технічних вимог для проектованої комп'ютерної мережі.

Виконана розробка компонентів кіберфізичної система для пожежної безпеки фірми «Megamart», яка основана на використанні стандартних компонентів сучасної RFID-технології з опрацюванням побудови комп'ютерної кіберфізичної системи на основі мережевого обладнання фірми CiscoTM для основних мережевих вузлів.

Виконано розрахунок налаштувань для заданої топології мережі, обрано стандартні інтерфейси для каналів зв'язку та протоколи обміну для них, розрахована топологічна схема комп'ютерної системи, розраховані налаштування маршрутизації комп'ютерної мережі, а також виконане моделювання і перевірка роботи кіберфізичної система пожежної безпеки для фірми «Megamart» на основі RFID-технології.

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