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INTEGRATED SYSTEM FOR DISPATCHING ELEVATORS AND ENGINEERING EQUIPMENT OF HOUSES

Introduction. *The integrated system for dispatching elevators and other engineering equipment of buildings is a hardware and software complex that ensures interaction between individual elements of the system and the dispatcher's central automated workstation (AWS) through existing local and global Internet networks. This approach makes it easy to include already existing buildings in the control system and to reduce planning costs when designing new houses.*

Problem Statement. *The elevators cannot be commissioned unless they comply with the minimum requirements of the Regulations for Construction and Safe Operation of Elevators (RCSOE), according to which elevators and machine rooms must be equipped with communication devices and display several signals on the control panel. The cost of such equipment in comparison with the cost of the elevators is negligible, but the problem is the transfer of voice and technological information signals from the elevator to the control panel.*

Purpose. *To study the volume and nature of information flows to provide voice communication and transfer of technological information from the elevator and other engineering equipment of a modern house, as well as to create hardware and software for dispatching elevators based on the results of the study.*

Materials and Methods. *Applied engineering methods for electronic computer control and information systems for the development of an integrated system for dispatching elevators and engineering equipment of buildings have been used.*

Results. *Hardware and software tools (integrated system for elevator dispatching) have been created to ensure the timely response of utilities in the elevator dispatching system.*

Conclusions. *The research results can be used to construct real complex computer systems to support the activities of the communal and industrial sectors, as well as in various fields of science and technology.*

Keywords: voice communication, dispatching, UDP, RS-485, and dispatcher's AWS.

The first dispatching systems that met the minimum requirements of the Regulations for Construction and Safe Operation of Elevators (RCSOE) were based on wired lines connecting elevators with dispatcher's control room [1]. The dispatcher's control room (DCR) is a specially allocated premise in which selective signals from elevators of certain urban district arrive by means of wired communication lines. Such organization of the elevator dispatching gives rise to the main problems typical for all wired systems:

- high cost of laying service lines;
- significant dependence of cable tracks on the natural factors (thunderstorms, moisture, temperature difference);
- dependence of elevator maintenance organizations on leaseholders of service lines (unscheduled emergency situations and "planned" repair of cable tracks); and
- high cost of subscription (or lease) fee of communication lines.

Another important factor hampering the development of wiring systems in today's large cities with historically important buildings is the impossibility of laying new cable lines.

Taking into account the world tendencies towards a narrower specialization in the information technology market, elements of the dispatch system can be attributed to the competence of different organizations. Internet networks can be used as transmission link to ensure communication. This approach enables to use the entire available world infrastructure of the existing networks. For example, a dispatcher can be located in areas with a low average salary and serve districts of big cities. To do this, it is enough to have access to the Internet at dispatcher's automated workstation (AWS).

Therefore, the purpose of this research is to study the scope and nature of information flows for the provision of voice communication and the transfer of technological information from the elevator and other engineering equipment of buildings to the dispatcher's station, as well as for the creation of hardware and software for timely reaction of utility service providers in order to ensure uninterrupted operation of the engineering equipment of buildings.

INTEGRATED SYSTEM FOR DISPATCHING THE ELEVATORS AND ENGINEERING FACILITIES OF BUILDINGS

The integrated system for dispatching the elevators and other engineering equipment of buildings is hardware and software, which ensure the interaction between individual elements of the system and the central dispatcher's AWS through the existing local and global Internet [2]. This approach makes it easy to add already existing buildings to the dispatcher's system and to reduce dispatching costs when designing new houses. At the same time, voice and technology data transfer is ensured by providers that give access to the Internet in the locality.

Unlike an IP-telephone or a portable or stationary computer with an Internet voice-dialing program, the proposed system is based on end-user subscription device that is much cheaper and enables to call a dispatcher in a conventional way, using a single button. It starts significantly faster after power-up; has a low power consumption (in the case of a power failure, this allows the system to work autonomously); in addition to a voice channel, it ensures the transmission of information from a variety of sensors and the formation of commands for equipment control. The proposed system is protected against unauthorized remote access to the software. To modify the software, it is necessary to have a special hardware and a physical access to the printed circuit board with a single-chip microcomputer.

Using a standard Ethernet port in each system module simplifies commissioning works, repair, and diagnostics of equipment. It is customized and repaired by specialists who deal with common network equipment.

The integrated system for dispatching the elevators provides the following:

- the reliability of indicators determined, the system stability to the failure of equipment and the prevention of critical failures at its outputs;
- monitoring of performance and signaling of failures of any functional unit of the system and the system as a whole;
- transition to a standby state when the system equipment fails;
- anti-vandal functionality of the equipment and the system technical means;
- internal and external security of the system's operation.

The proposed approach enables to integrate most of the engineering equipment already installed in residential buildings into the Intelligent City promising technology.

The block diagram of the elevator dispatching system using the Ethernet as transmission medium, is shown in Fig. 1.

Technical characteristics of a single element (shield) system

Main interface	Ethernet
Network interface for work with equipment not included in the main system kit	RS-485
Maximum distance to the point of connection of equipment not included in the main system kit, m	1200
Data channel speed RS-48, bauds	57 600

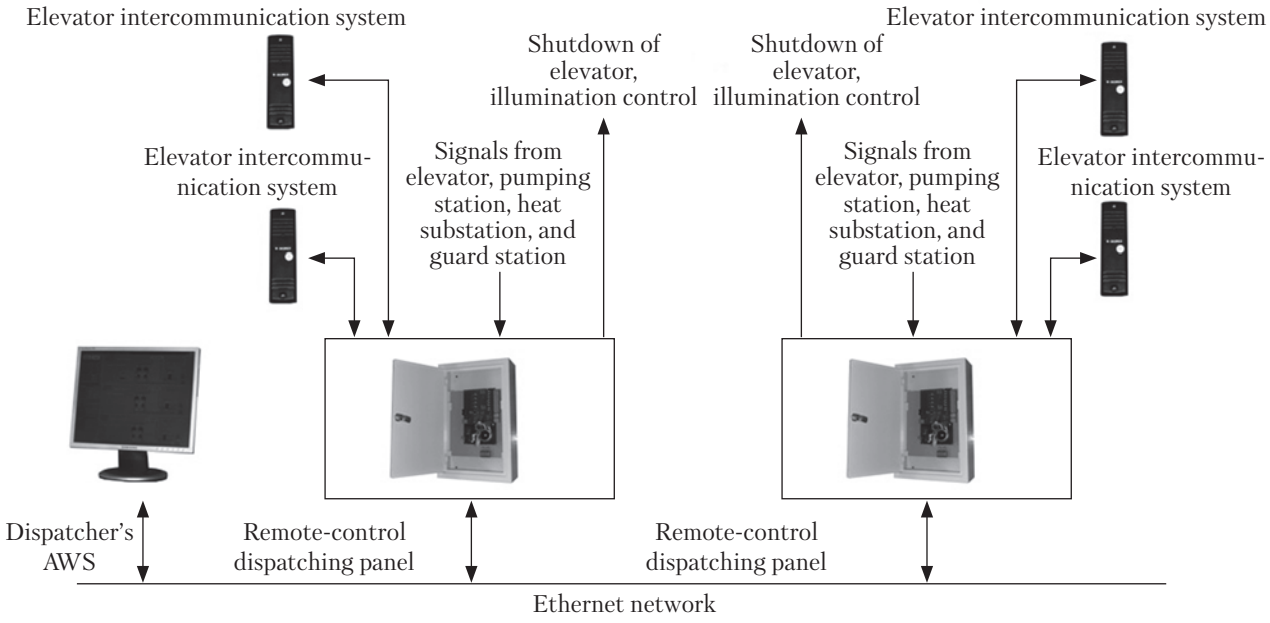

Fig. 1. Flow chart of the dispatching system

Speed of data transmission from peripheral devices (PD) to central processing unit (CPU), Kb/s	250
"Dry contact" inputs per one module , pieces	8
Analog talk-back modules , pieces	2

The arrangement of dispatching panel located near the elevator automatic equipment is given in Fig. 2.

Central communication controller (CCC)

The main node for building an integrated dispatch system [3] is the central communications controller (CCC).

The CCC is designed to:

- translate an analog voice signal into digital form;
- formation of analog voice signal from network packets;
- provision of two-way voice communication with dispatcher's AWS via local or global network;
- transfer of technological information to dispatcher's AWS;
- formation of control signals by command from dispatcher's AWS; and
- formation of a technological network based on the ANSI TIA / EIA-485-A:1998 standard with support of the MODBUS protocol.

The main features of the controller are as follows:

- CPU STM32F103VCT6;
- communication capacity: Ethernet, 2 RS-485 lines, USB support;
- memory capacity: 256 K program memory, 48 K RAM;
- user interface: based on an external desk via RS-485.

The printed circuit board of the central communication controller consists of the following units:

- processor unit;
- Ethernet support communication unit;
- communication unit for RS-485 support;
- Power supply unit;
- auxiliary equipment restart unit;
- analog voice line formation unit;
- dry contacts reception unit; and
- external device switch unit.

Processor unit

The processor unit is designed to execute the software of the central controller and is based on the STM32F107RX single-chip microcomputer.

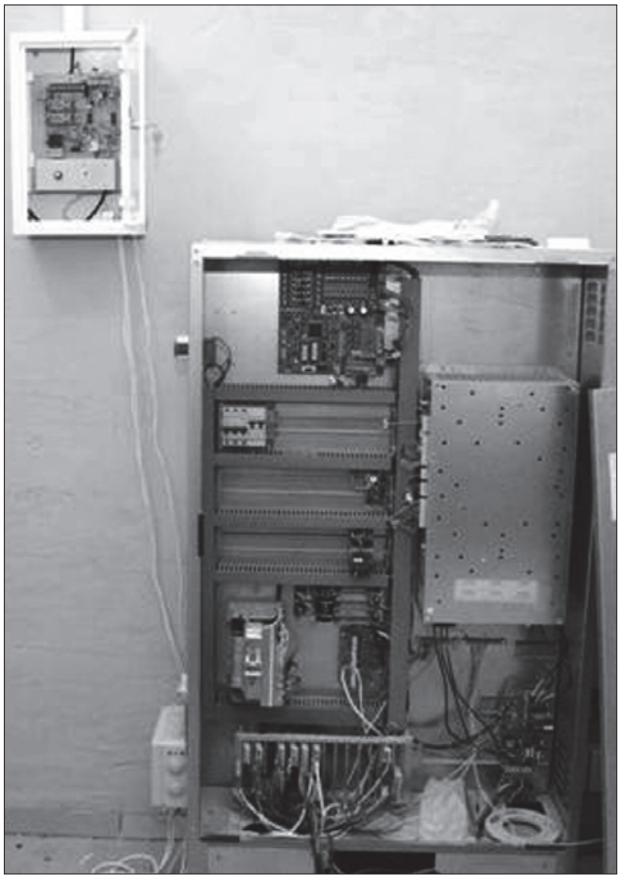

Fig. 2. Remote-control dispatching panel (to the left on the wall) near the elevator automatic equipment

The STM32F107RX single-chip microcomputer includes an Ethernet MAC peripheral. The basic peripheral properties are as follows:

- a complete MAC level with connection to the external physical level;
- operation at speeds of 10 and 100 Mbps;
- half / full duplex operation modes;
- a dedicated DMA controller with queues of reception and transmission of packets;
- support of packet time reference;
- control of input/output of low power consumption modes;
- an integrated set of interrupt vectors.

Ethernet support communication unit

The Ethernet support communication unit is intended for information exchange with dispatcher's AWS via a local or global network and based on the Ethernet interface RTL8201BL (single-port PHY-receiver from the Media Independent Interface). It realizes all 10/100 M Ethernet physical level functions, including physical coding sublayer (PCS), physical medium attachment (PMA), twisted pair physical medium dependent (TP-PMD) support, and 10Base-Tx encoding/decoding. The PECL interface is supported for connecting to an external optical transceiver 100Base-FX. This enables to improve the system and to work with fiber optic networks [4].

RS-485 support communication unit

The RS-485 communication unit is designed for measuring the consumption of energy resources (electricity, water, and gas, provided there are open-protocol meters) and for retrieving information from the elevator control station via the information port (OTIS stations). The RS-485 communication unit uses UART (Universal Asynchronous Receiver / Transmitter) built-in to the STM32F107RX. It is made in the form of a mezzanine card and provides a galvanic isolation of the RS-485 line.

Power supply unit

The power supply unit is designed to form a set of stabilized voltages required for operation of the controller. Given that the power is supplied to the central controller via the Ethernet network using the POE technology (power over Ethernet standard), the power supply unit must have a maximum efficiency and generate the necessary output voltages for a wide range of input voltage [5]. Therefore, the power supply is realized by means of the circuit of pulse converters based on the driver MC34063. Since the two levels of voltage (5 V and 3.3 V) are required for power supply to the central controller, the power supply unit is constructed according to a stepwise circuit with a consistent drop in voltage. First, the voltage from the Ethernet line (15—24 V) is reduced to a level that is slightly higher than the emergency battery voltage (13 V), then another pulse con-

verter generates a voltage of 5 V, and the linear stabilizer converts it to 3.3 V. The power supply unit is provided with a current stabilizer for recharging the emergency battery. In the event of failure of the main power line, the circuit automatically switches to the battery.

Auxiliary equipment restart unit

The auxiliary equipment restart unit is designed to control the voltage for third-party equipment (for example, a Wi-Fi router). When the central controller software detects that there is no information exchange with the auxiliary equipment, the supply line of the auxiliary equipment is disrupted for a short while. For this, the unit has a galvanic isolator and a power key.

Analog voice line formation unit

The analog voice line formation unit provides a two-way loudspeaker connection to the elevator cabin and is designed to normalize and to amplify the signals that come to an analog-to-digital converter and are retrieved from the digital-to-analog converter of the single-chip microcomputer STM32F107RX. It is made in the form of mezzanine card. This approach enables to connect a wide range of intercom devices, without changing the CCC circuit design, since it is enough to change the mezzanine card. The CCC provides two voice lines.

Dry contacts reception unit

The dry contacts reception unit is intended for reception of the following discrete signals:

- signaling of the absence of the power supply phase of the main drive;
- control of the passenger's presence in the elevator cabin;
- control of the condition of the elevator door;
- control of the safety chain of the elevator; and
- alarm system of the elevator engine room.

The dry contacts reception unit contains a voltage converter with a galvanic isolation. For each channel of the dry contact polling, there are circuits of normalization, protection, and galvanic isolation. This approach makes the system resistant to possible emergency modes of equipment that is not included in the main system kit. Even if unacceptable voltage falls into the input of the dry contact receiver unit, this will result in the failure of one channel, but prevent the failure of the whole controller or adjacent channels of dry contacts reception.

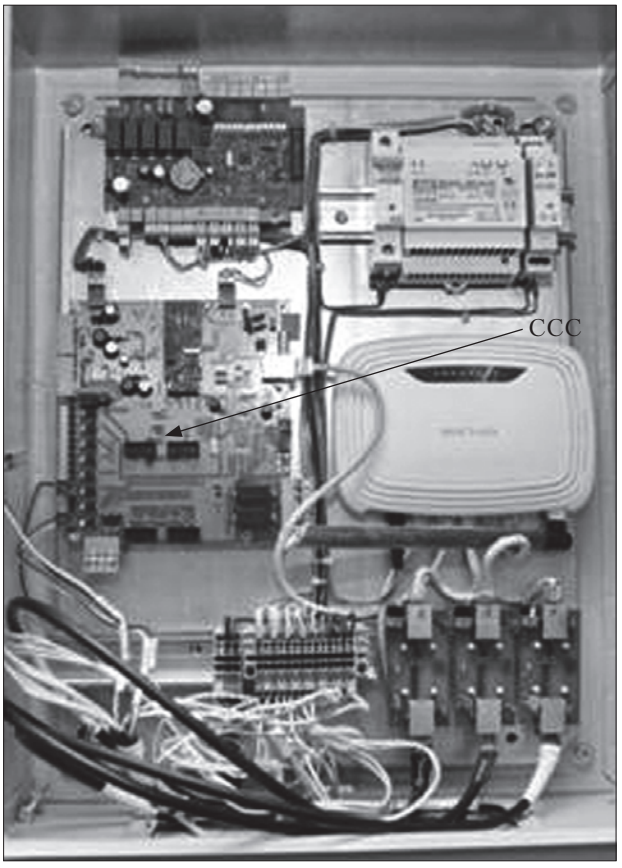

Fig. 3. Central communication controller as part of control cabinet

External device switch unit

The external device switch unit is designed to control the auxiliary equipment. It consists of keys that commute relay windings. The contact groups of the relay are led to the CCC external terminals.

The central communication controller as part of the control cabinet for receiving technological information from the heat substation is shown in Fig. 3.

CCC SOFTWARE

The CCC software realizes the following algorithms:

- converting the analog voice signal into the digital form and transferring it to the dispatcher's AWS in the form of UDP packets;
- receiving UDP packets with voice traffic from the dispatcher's AWS and converting them into the analog form;
- realizing the user interface for setting up the operation of the CCC as part of integrated dispatching system; and
- Realizing the local technological network using the MODBUS protocol.

The local technology network is implemented using the MODBUS protocol. According to MODBUS-IDA standards, it is an application-level protocol for client-server communication between applications of devices that are connected to different types of buses or networks [4].

The user interface provides the ability to configure the main system parameters, to get access to the archive of events, and to display the current state of the system. Information is displayed on a LCD text display. The keyboard is used to navigate around the menu. The central controller software has a user interface support module for work with the operator's station via the corresponding RS-485 channel.

The main menu of the control panel display consists of the following subdirectories:

1. **System**, a subdirectory that displays the current state of the system.
2. **Devices**, a subdirectory that displays the current state of the actuators that are part of the automatic equipment.
3. **Sensors**, a subdirectory that displays the current state of analog sensors.
4. **Measurement**, a subdirectory that displays the level of the input signal through the measuring channels.
5. **Settings**, a subdirectory of parameters that configure the operating modes of the system.
6. **Test**, a subdirectory for testing the elements of the automatic equipment.
7. **Messages**, a subdirectory for viewing the messages that are fixed by the system.

DISPATCHER'S AWS SOFTWARE

The dispatcher's AWS software realizes the following functions:

- display of mnemonic circuits of technological equipment;
- text and color display of information on the visualization elements;
- work with control elements (buttons, settings);
- archiving of information;
- configuration of elements of visualization, control, mnemonic circuits;
- help and reference information.

The dispatcher's AWS software also includes display and control of general configuration, window settings, connection settings, user configuration, installation, "cut, paste and copy" operations, display and database control, use of the UDP protocol for voice traffic transmission.

CONCLUSIONS

The developed hardware and software for the construction of integrated dispatching systems for elevators and other engineering equipment of buildings has been tested both in laboratory conditions and in a real residential complex. As a result, it has been shown that the dispatching system reliably performs its functions for the following options:

- transmission of data through a local area network with a large number of users;
- transmission of data via the Internet (the dispatcher's AWS and the CCC receive access to the Internet through different providers);
- transmission of data between individual nodes of the system using a local Wi-Fi radio channel;
- the dispatcher's AWS has access to the Internet via a Wi-Fi access point.

The compatibility of the CCC with any equipment with a standard 10/100 Mbps Ethernet port makes it possible to build integrated dis-

patching systems with virtually unlimited number of primary devices, information from which will arrive at the dispatcher's AWS. One CCC supports up to 254 devices for communication with objects via a RS-485-based network at a speed of 9.6—115.2Kbits. The CCC can operate with a speed of 10/100 Mbps via port of router that operates through the Gigabit Ethernet network. Thus, the integrated dispatching system for elevators and other engineering equipment of buildings has a tree-like structure with the accumulation of information when approaching the dispatcher's AWS. In this case, all available infrastructure for access to the Internet, from in-house network to transoceanic underwater optical communication cables can be used. The rapid development of resources with high-resolution video leads to a continuous increase in throughput capacity of the networks. The information flows circulating in the created dispatching system are practically unnoticeable in the current traffic and can be transmitted to the most remote settlements, where there are Internet providers.

The dispatching system has developed means of self-diagnostics. The malfunction of a particular CCC is fixed on the dispatcher's AWS in a few seconds after the failure. The CCC is made in the form of an electronic board with standard contact terminals and mounts. All settings for a particular object are stored in the non-volatile memory of a single-chip microcomputer. This approach significantly reduces the time of repairs, because it is enough to replace the faulty CCC board by a healthy one from a set of spare parts. There are no special requirements for a worker who makes repairs.

The system is easily scalable and has great potential for improving and introducing auxiliary functions. For example, a minor improvement in order to ensure support of the RFID contactless card scanner will enable to block the operation of the elevator for people who do not live in the building and to record in the dispatcher's AWS software the number of trips per each dweller to form a bill for the use of elevator for each apartment.

The large-scale implementation of the mentioned dispatching system will raise the overall safety of the operation of modern residential buildings, which will have a positive effect on improving the quality of life of citizens and push it closer to the European level.

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КОМПЛЕКСНА СИСТЕМА ДИСПЕТЧЕРИЗАЦІЇ ЛІФТІВ
ТА ІНЖЕНЕРНОГО ОБЛАДНАННЯ БУДИНКІВ

Вступ. Комплексна система диспетчеризації ліфтів та іншого інженерного обладнання будинків — це апаратні та програмні засоби, що зорієнтовані на взаємодію між окремими елементами системи та центральним автоматизованим робочим місцем диспетчера через існуючі локальні та глобальні мережі Інтернет. Такий підхід дозволяє легко включати в диспетчерську систему вже існуючі будинки та зменшувати витрати на диспетчеризацію при проектуванні нових будинків.

Проблематика. Введення в експлуатацію ліфтів неможливе без виконання мінімальних вимог Правил будови й безпечної експлуатації ліфтів (ПББЕЛ), відповідно до яких ліфти та машинні приміщення необхідно обладнувати переговорними пристроями та виводити на диспетчерський пульт декілька сигналів. Вартість такого обладнання, порівняно з вартістю ліфта, незначна, проте проблемним є передавання сигналів голосової та технологічної інформації від ліфта на диспетчерський пульт.

Мета. Дослідити обсяги та характер інформаційних потоків для забезпечення голосового зв'язку й передачі технологічної інформації від ліфта та іншого інженерного обладнання сучасного будинку, а також створення на їх основі апаратних і програмних засобів диспетчеризації ліфтів.

Матеріали й методи. Використано прикладні методи інжинірингу електронних комп'ютерних контрольно-інформаційних систем для розробки комплексної системи диспетчеризації ліфтів та інженерного обладнання будинків.

Результати. Створено апаратні та програмні засоби (комплексна система диспетчеризації ліфтів) для забезпечення своєчасної реакції комунальних служб в системі диспетчеризації ліфтів.

Висновки. Результати роботи можуть бути використані для побудови реальних складних комп'ютерних систем для забезпечення діяльності комунальної та промислової галузі, а також в інших галузях науки й техніки.

Ключові слова: голосовий зв'язок, диспетчеризація, UDP, RS-485, АРМ диспетчера.

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КОМПЛЕКСНАЯ СИСТЕМА ДИСПЕТЧЕРИЗАЦИИ ЛИФТОВ И ИНЖЕНЕРНОГО ОБОРУДОВАНИЯ ДОМОВ

Введение. Комплексная система диспетчеризации лифтов и другого инженерного оборудования домов — это аппаратные и программные средства, ориентированные на взаимодействие между отдельными элементами системы и центральным автоматизированным рабочим местом диспетчера через существующие локальные и глобальные сети Интернет. Такой подход позволяет легко включать в диспетчерскую систему уже существующие дома и уменьшать расходы на диспетчеризацию при проектировании новых домов.

Проблематика. Введение в эксплуатацию лифтов невозможно без выполнения минимальных требований Правил строения и безопасной эксплуатации лифтов, соответственно которым в лифтах и машинном помещении необходимо обустраивать переговорные устройства и выводить на диспетчерский пульт несколько сигналов. Стоимость такого оборудования по сравнению с стоимостью лифта незначительна, однако проблемной остается передача сигналов голосовой и технологической информации от лифта на диспетчерский пульт.

Цель. Исследовать объемы и характер информационных потоков для обеспечения голосовой связи и передачи технологической информации от лифта и другого инженерного оборудования современного дома, а также создание на их основании аппаратных и программных средств диспетчеризации лифтов.

Материалы и методы. Использованы прикладные методы инжиниринга электронных компьютерных контрольно-информационных систем для разработки комплексной системы диспетчеризации лифтов и инженерного оборудования домов.

Результаты. Создано аппаратные и программные средства (комплексная система диспетчеризации лифтов) для обеспечения своевременной реакции коммунальных служб в системе диспетчеризации лифтов.

Выводы. Результаты работы могут быть использованы для построения реальных сложных компьютерных систем для обеспечения деятельности коммунальной и промышленной отрасли, а также в других отраслях науки и техники.

Ключевые слова: голосовая связь, диспетчеризация, UDP, RS-485, АРМ диспетчера.