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BUILDING MANAGEMENT – MODERN TENDENCIES

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Abstract: Modern buildings are equipped with various technical systems and devices in order to achieve the greatest possible safety, comfort and convenience. Very important components in these facilities are heating, ventilation, cooling and lighting. Fulfilling the set requirements means ensuring the compliance of these components, while considering changing external conditions, which act as disturbances on the space in which a certain object is located. Buildings are permanently exposed to constant changes in influences such as the temperature of the external environment, the amount of solar radiation, moisture content in the air, wind strength, etc., so these factors must be taken into account when designing control systems. In order to realize the set tasks, the construction of the central system for supervision and control (CSSC) using PLC (programmable logic controllers) and SCADA systems (supervisory control and data acquisitio). The advantages of introducing such a management configuration are: monitoring the status of all installed devices and equipment, the possibility of management from one place, synchronization of integrated subsystems, implementation of control algorithms in order to achieve greater savings, prevention and reduction of the consequences of potential accidents.
Keywords: building, control, supervision, SCADA, HVAC

1. INTRODUCTION

The goal of every construction is to provide conditions for living and working in comfortable and economically acceptable conditions, with complete harmony with nature. The environment in which we live with its climatic conditions, the culture of housing and living, as well as the construction and cultural traditions, imposed high demands on the builders. The requirements become greater if we take into account the growing awareness of the need for sustainable development and environmental protection. Despite the strict requirements, the intensive development of science, technique and technology enables the application of modern materials and new solutions in the construction of buildings, while designers and contractors have exceptional opportunities for creative work and professional affirmation [1]. Recently, along with the increasing construction of buildings, the question of managing those buildings, improving the comfort and preserving the value of both newly built buildings and old ones that have been restored or will be work on them for the purpose of revitalization inevitably arises. Management of facilities such as large business centers, hotel facilities, sports facilities, etc. is not at all a simple and easy task for designers and contractors as well as for the owners themselves. Facility management plays a strategic role in meeting the set goals, a term that is increasingly popular in our country and which is a starting point for a successful business, for preserving the value of buildings, using energy–efficient technologies, modern materials, advanced communications and intelligent control. [1 – 3]. Modern buildings must meet the following criteria: use of alternative sources of energy, enabling maximum personal comfort, minimization of exploitation expenses, the highest degree of automation, high level of security, integration of all subsystems. Technological and technical progress is the basis of the construction of modern buildings, especially when it comes to the so–called "green" and "passive" buildings. For the first ones, the emphasis is on preserving the environment and the beneficial effect on people's life and work, and when it comes to second ones, the emphasis is on the application of energy–efficient technologies. Today, the so–called are experiencing great development BAU (Building automation) systems, i.e. building management systems. They have become indispensable in the design and construction of various types of facilities such as business facilities, industrial, sports, shopping centers, hotels, and even individual facilities. Before investing and building a certain object, an extensive analysis is carried out, whose aim is to look in detail at the possibility of achieving maximum profit with minimum expenditure. It should be noted that the industry of shopping centers and retail general, in recent years has become one of the most important drivers of development in all countries, especially in developed ones [1, 4].

2. ARCHITECTURE OF THE CONTROL AND SUPERVISION SYSTEM

Building management is multidisciplinary in nature and requires from the designer of the management system solid knowledge of thermotechnics, mechanical installations, devices and equipment related to those installations, new materials used in modern construction and modern control systems. Adequate technical equipment is also needed to achieve the required quality. For the successful implementation of the mentioned buildings, constant mutual coordination between designers of all professions, contractors and users of the facility is necessary. Facility management can be divided into three functional units, which are interconnected: commercial building management, infrastructural building management and technical

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building control. Commercial management has a role in creating the conditions for maximum use of the facility's capacity, renting of the facility and the realization of related financial transactions. Infrastructural management includes the organization and control of all services required for the normal functioning of the facility, such as cleaning service, maintenance service, etc. Control of technical systems installed in facilities ensures the constant functionality of those systems with adequate preventive, current and investment maintenance of them. The three aforementioned elements form a unique unit of the building's management system and they are interconnected and dependent [1]. The configuration of the BAU system is shown in Figure 1.

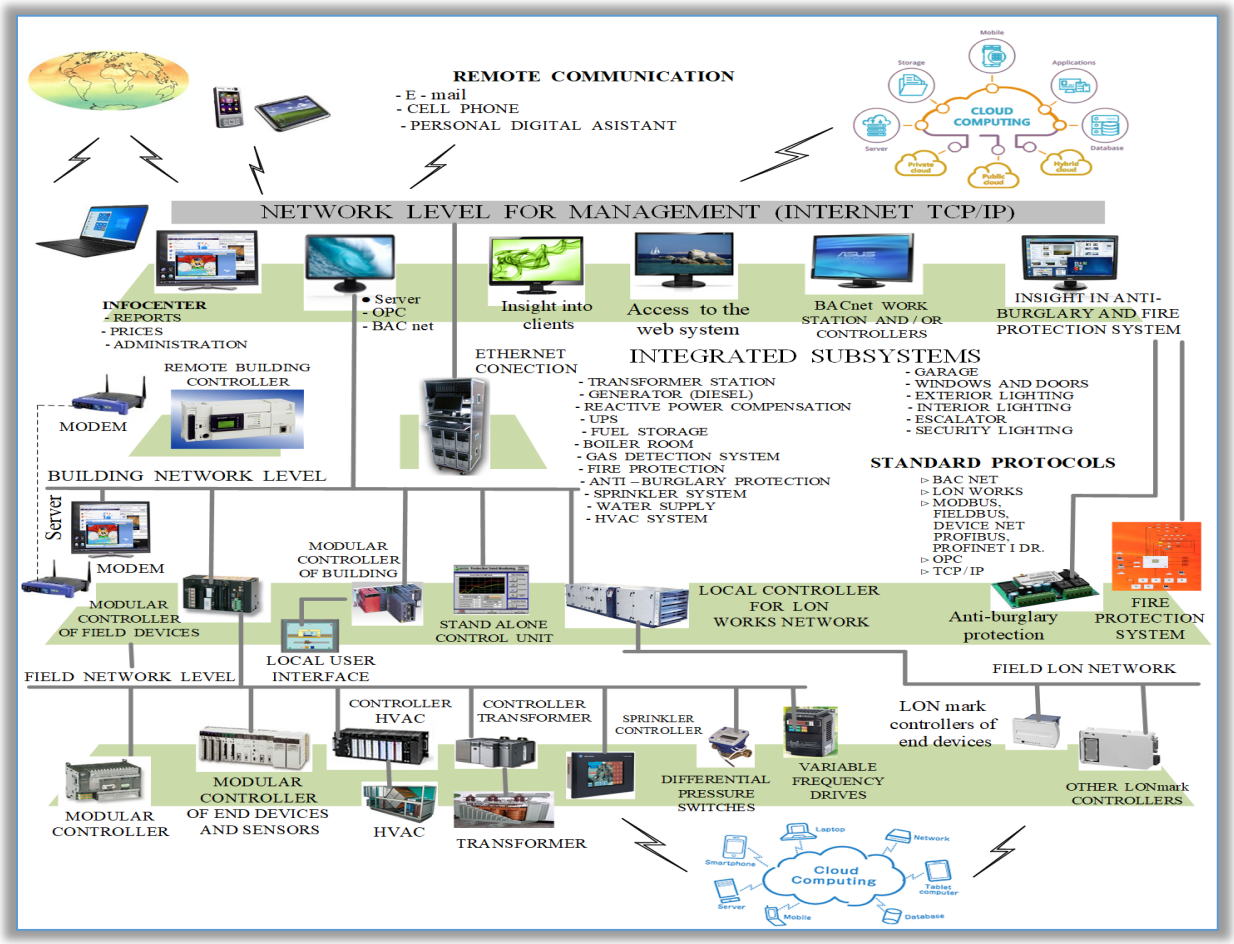

Figure 1. Configuration of the building control system

The structure of these systems has three levels: the highest level of management (Management level), device and equipment controller level (Automation Stations level), device level in the field (Field level). On the highest level are dispatch computers, connected by fiber optic cables. For security reasons, a double connection (Hyper ring) is performed. The communication protocol at this level and at the device and equipment controller level is Ethernet TCP/IP or BACnet TCP/IP. At the level of devices and equipment in the field, standard protocols such as Modbus, Fieldbus, Devicenet, Profibus, Profinet, etc. are used. The basis of the management system of the modern facility is the Central System for Supervision and Control (CSSC). It is a SCADA computer on which the operator sees the entire facility and monitors all relevant parameters related to the facility's functionality and defined criteria [5]. When it comes to large and complex facility, there are several such computers, on the one hand due to data security, and on the other hand due to the need for a larger number of operators, at various locations in the facility, to access the system. Control and supervision of the facility ensures: visualization of the drive status and measurement of important parameters in the facility; reception, processing and display of process measurements; measurement trend display; chronology of events and analysis; monitoring and processing of warning and alarm signals; the possibility of remote automatic and remote manual control of the facility; generation and presentation of daily and periodical reports; lists of prerequisites by individual functional units; additional functions at the user's request. The supervisory control system consists of a PLCs with appropriate analog and digital input and output modules and SCADA systems. Some manufacturers have developed

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specialized PLC devices and SCADA intended for BAU systems. The PXC family of compact and modular control units with the DESIGO SCADA system, a product of the Siemens company is an example of that. Realization of the supervision and control system is a relatively complex task, especially when it comes to a complex object where there are various measuring – acquisition and control devices and signals, which should be connected into a functional unit. The designer of this system should have insight into all technical and technological requirements, into the functionality of all equipment and devices, as well as insight into all technical installations and technical systems, which will be managed from one center. At the beginning of the project, the designer must, in a clear and concise way, review all analog and digital inputs and outputs, so that he can have an overview and more easily design the supervisory control system. Figure 2 shows the organizational structure of the building management of the renowned DESIGO system. Desigo owns complete suite of cloud applications, building management systems, building automation controls for primary and room and field devices to improve the operations of building at all levels [6].

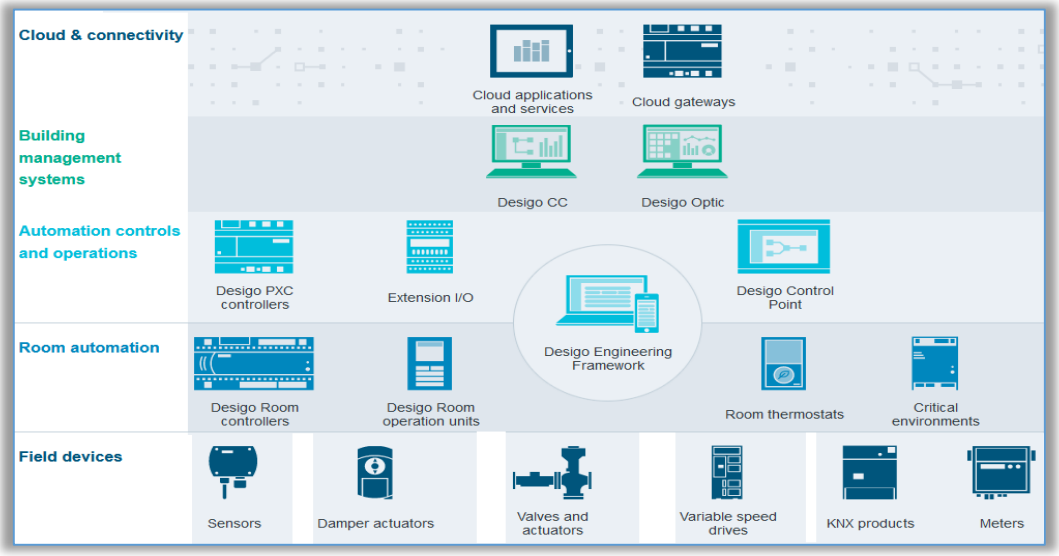

Figure 2. Desigo building automation system – Desigo system at a glance [6]

3. A SCADA review

The SCADA review is a very important option that provides the operator with information about what is happening in the facilities being monitored. This representation depends on the type of object it refers to and its complexity. Those options that are not available for a specific object are gray and their activation is disabled. The options are sorted from the most frequently used to the least frequently used. When opening applications from the menu, Windows access is supported for each of the selected options. Each application opens in a new window, with the ability to zoom in or out and move them around on the screen, and drag them down to the line. SCADA software is simultaneously required, on the one hand, to enable simple specification of functional units of system and individual elements within them, as well as an optimal operator interface, and on the other hand, to provide a graphic interface, animation of processes, real time and chronological monitoring of relevant values, alarming in case certain values and parameters go beyond the defined limits, acquisition and storage of data and analysis of that data. Along with the development of the SCADA system, there was a need to protect the data that is transmitted, both acquisition and control information. When looking at building monitoring and control systems, several relatively complex objects are encountered. These are: boiler room, air conditioning chambers, chiller, heat pump, fire extinguishing system (sprinkler), transformer station, diesel generator, distribution cabinets, then connectors, external, internal and security lighting, escalators and elevators, doors, blinds on the windows etc. [2–4].

— Communication protocols

When designing a building management system, the question of choosing a communication protocol arises. The dilemma is whether to choose an open protocol or a protocol with limited access. Previous experience shows that the advantage is on the side of the open protocol. Here again the question arises: what to choose: LonWorks (Local Operating Network) or BACnet (A Data Communication Protocol for Building Automation and Control Networks). Leading world companies, which, among other things, are involved in the production of building management systems, such as Siemens, Honeywell, Invensys,

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Johnson and TAC, are the biggest sponsors of LonWorks. On the other hand, BACnet is supported by ASHRAE (American Society of Heating, Refrigerating and Air–Conditioning Engineers – an association of engineers in America, who deal with problems related to HVAC systems). BACnet is now the globally accepted standard in building management systems [1].

4. BUILDING INTERNET of THINGS

With the increase of Internet of Things (IoT) applications in the field of building automation and the mass integration of IoT solutions in the public, commercial and residential sectors, more and more is being talked about a new or rather expanded concept – Building Internet of Things (BIoT). It is based on the idea of connecting to the network all components of the housing that can provide Internet connection, with an overall increase in the efficiency of the upgraded systems and installations, reduction of energy consumption and improvement of comfort for the residents. One of the most current technological trends in the building sector is precisely the transition from Building Automation Systems (BAS) to building IoT platforms, in which devices and services are interconnected in a single IP platform with an open communication protocol. The establishment of partnerships between manufacturers of building automation systems and providers of IoT solutions creates conditions for the formation of research consortia that further accelerate the development of technologies in this area. The new BIoT products are based on the latest innovations in the field of building automation, including devices with IoT connectivity capabilities and specialized software platforms. Collaboration between companies developing IoT and profiled BIoT products is key to creating advanced smart building solutions with integrated cloud–based analytics capabilities and based on the full potential of the Internet of Things [6]. The advantages of remote monitoring and management capabilities of BIoT technologies for building automation are increased physical security of locations through remote monitoring of installed video cameras and security systems, activation of alarms, notification of security companies, etc. IoT technologies in buildings enable complete and efficient management of the building, simplifying the user's life and eliminating the need to visit all available rooms in a huge hotel, for example, to check if there is a light that is not turned off or an HVAC unit that is not turned off. The large volume of data (big data) collected and processed in the virtual environment, as well as the integration of control commands and functions in the cloud system, further increase the potential consequences of a targeted hacker attack and make the security of modern smart buildings vulnerable. Unfortunately, in our time such scenarios are quite possible. Therefore, developers of IoT and BIoT solutions should seriously focus on cyber security to convince consumers that their products are safe enough and do not carry risk [7]. In fact, the smarter a building system becomes, the more complex and multi–layered security technology it needs. Security expectations are especially high for Building Internet of Things platforms, which cover literally all aspects of daily activity in buildings.

5. CONTROL OF THE HVAC SYSTEMS

HVAC (Heating, ventilation and air conditioning systems) have an important place in the equipment and devices, which are integral elements of modern buildings. Control of these systems is one of the most important aspects of building management, because the energy "waste" in these systems is high. The task of the BAU system is the optimal use of installed devices and equipment, saving energy, protecting and preserving the living space and the environment, providing maximum comfort and a pleasant feeling to the people who live in these buildings [2].

— Boiler room

The boiler room is intended for the preparation of hot water, which serves primarily for room heating. Various technological processes often require hot water heating. Within the boiler house there are boilers, burners, storage and daily fuel tanks, gas supply, transfer points, boiler pumps, transport and circulation pumps, electromagnetic and electric valves, expansion vessels, measuring elements for level, pressure, temperature of supply and return water, calorymeters, encoders, etc. With the SCADA display of the boiler room, the monitoring of thermal, electrical and hydraulic parameters is of interest. One SCADA screen of the boiler room is shown in Figure 3 [1].

In this sense, the SCADA application has three parts, one with electrical, the second with hydraulic, and the third with thermal parameters. They can be displayed side by side on a third of the screen, or individually. The parameters that are measured or recalculated are displayed on the SCADA images (but only the basic ones that are sufficient for the dispatcher so as not to overload him with unnecessary data). Of the parameters that are displayed on the electrical diagram, the following stand out: pump motor parameters (current–order value of phase currents), active (sum of phase powers), reactive (sum of phase powers)

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and apparent power, cos φ. Among the hydraulic parameters, the following are displayed: water levels in the expansion vessels, water pressure, fuel levels in the storage tanks and the day tank (fuel oil or light heating oil), gas pressure, fuel temperature, outgoing and return water temperature, water pressure. Depending on which probes are submerged, the current fuel level in the tanks is displayed. The display of thermal parameters gives a picture of the temperature of the fuel in the storage tanks and in the daily tank, the temperature of the water in the boilers, the temperature of the water in the discharge and return lines, the room temperature and the outside temperature. Certain data are also given in tabular form.

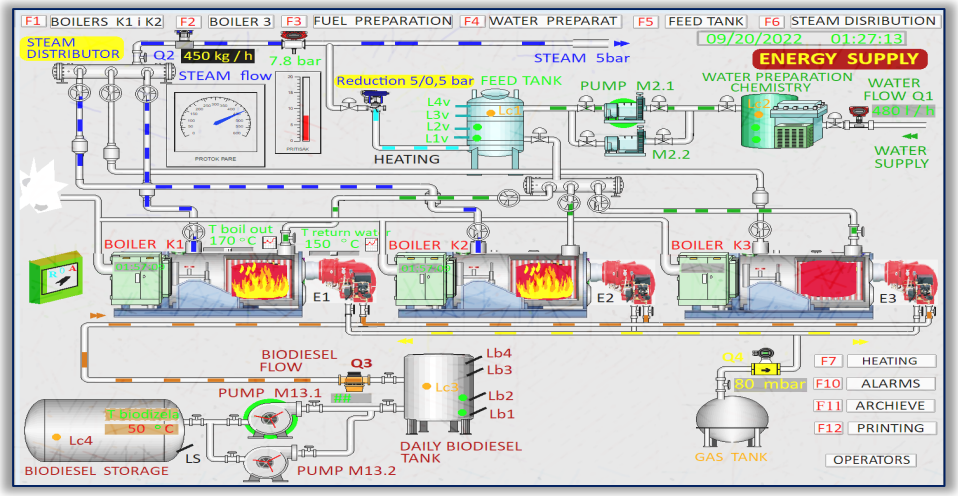

Figure 3. Display of one SCADA screen of boiler room

— Chamber air conditioning

Air chamber is one of the key elements of the HVAC system. This complex device provides: temperature and humidity regulation of the air – conditioned space with limitation of maximum and minimum temperature (temperature and humidity sensors – spatial type and channel type); damper control (fresh and recirculation air with the damper actuator) with options "free cooling" and "free heating"; exhaust and pressure ventilator with a two – speed motor, or with frequency regulation of the number of revolutions; water heater or electric heater with pre – heating control; regulation of the valves of coolers, heaters and recuperators; regulation of the pump of cooler, heater and recuperator. Figure 4. shows the SCADA screen of the air conditioning chamber is provided, where the set and current values of characteristic values and parameters (heating and cooling temperature, fresh and dirty air temperature, statuses of the variable frequency drives that regulate the operation of the intake and exhaust fan) and the operating mode can be monitored (summer/winter) [1, 2].

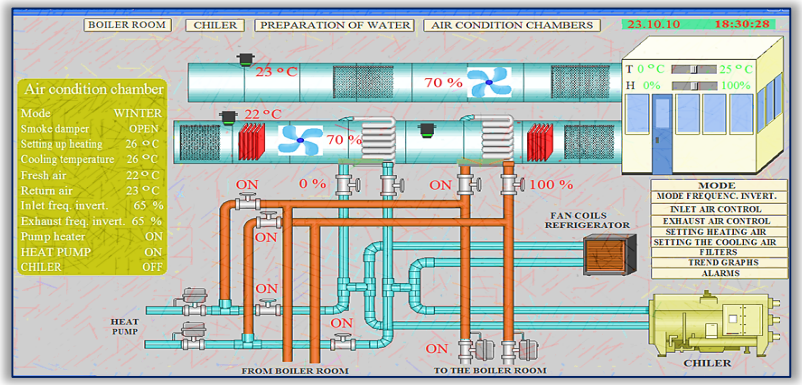

Figure 4. The one SCADA screen of Air conditioning chamber

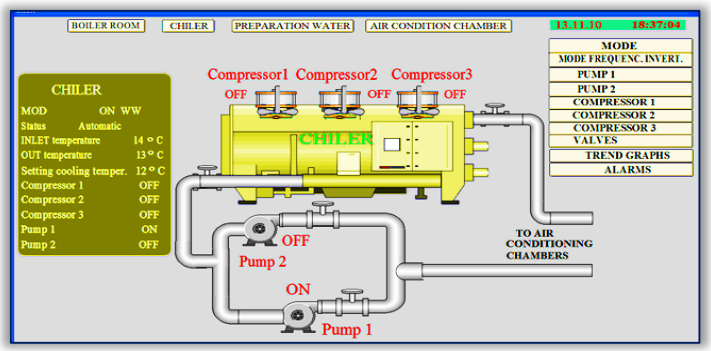

Figure 5. The SCADA screen of the Chiller

— Chiller

Chillers are devices of exceptional performance in terms of efficiency, especially the new series, which can use low ambient temperatures throughout the year. They provide high reliability in residential, technological and industrial applications. Although the level of maximum energy

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savings is achieved in continuous operation, chillers allow significant energy savings during short periods of operation, while also guaranteeing a longer lifespan and reduced need for maintenance compared to conventional chillers. The SCADA screen of the chiller is given in Figure 5 on which the compressor and pump statuses, inlet and outlet temperature are displayed. It is possible to adjust the cooling temperature [2].

6. SAFETY SYSTEMS

Security systems, intended to ensure the safety of people and the facility itself, through constant monitoring and supervision of parameters that indicate excessive events and immediate alarming and notification of responsible persons for certain segments are of great importance for the functioning of the facillity. In addition to physical security, security systems include: fire protection, burglary protection, video surveillance, access control [1].

— A fire protection

Since in a short period of time a fire can take away the material resources invested over the years, maximum attention fire protection (FP) must be paid during the construction of buildings, and in addition, it is also a legal obligation, whereby the buildings are divided into categories and based on the degree of danger, fire protection system is designed. Mobile fire extinguishers, fire early detection and alarm systems and automatic fire extinguishing systems are foreseen for these purposes. On the basis of the elaboration on fire protection, a suitable FP switchboard with a certain number of zones is selected, to which detectors for early fire detection are connected. CSSC is in constant communication with the FP central, to which the HVAC system is also connected. The electric motor drives of the FP flaps, certain electrical sockets and the smoke extraction system are also related to the conditions of the FP control unit [1].

— Video surveillance

The video surveillance system, together with the alarm system, enables the facility's physical security service to work more efficiently, thanks to the fact that it can have insight into critical points of the facility from one place. This system also performs continuous recording, which makes it possible to review the recorded material and use it as evidence in case of extreme situations. At the same time, the control of physical security is carried out. The video surveillance system includes the following elements [1, 8]:

- Cameras (fixed and mobile) that are placed outside and inside the building.
- Computer system used for displaying images from cameras on appropriate monitors, selecting images to be displayed, recording and reviewing the recorded material, which is stored on the hard disk, for a certain period of time.
- Monitors that enable physical security to continuously monitor protected zones. On a larger monitor, multiple cameras can be seen, and on a smaller monitor, images from all or selected cameras can be displayed sequentially, or an image from only one camera can be selected. In the event of an alarm, an image of the zone where unauthorized access has been detected can be displayed on the smaller screen.
- Camera control keyboard.

— Access control

This system provides control of access to vital parts of the facility, detection of movement through the facility and records of working hours. Access control is controlled by a computer with appropriate software, which is usually installed in the video surveillance room. The software can support a large number of cards (typically several thousand) and a large number of controllers (several dozen). Access control is usually carried out through identification cards, the holder of which, based on the possession of the card, has access to certain parts of the facility. In addition to the computer, the access control system includes a corresponding number of other elements: controllers, expansion modules, magnetic readers and cards.

— Biometric Readers

This technology leverages physiological characteristics unique to each individual to enable identification. It's both more convenient for users and a more secure way for organizations to authenticate individuals to permit access. Fingerprint recognition is the most widely used biometric control today, but it is by its nature a touch technology. Iris scans are a popular alternative: a camera captures the iris – the eye's colored part – and compares the photograph with an authentication database.

— Facial Recognition

Facial recognition is a touchless technology that examines the subject's face and compares it to profiles stored in a database. It looks at different characteristics like the 3D profile of the face (size, shape, and

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position of the eyes, jaw, and cheekbones), skin texture, and vascular and heat patterns that in combination are unique for each person. The system then converts the data into a composite and compares it to a database of known faces to find a match. Facial recognition contributes to a frictionless and touchless user experience. Users only need to show their face at a scanner and no longer need to keep track of access cards, key fobs or other physical devices.

— Cloud–Based Access Control

Advantageous security tech developments for businesses is cloud based access control systems (Figure 6) [8]. From a business perspective, they reduce the need to manage on–site servers, and help convert capital costs into more manageable (and predictable) operating costs. But the big advantage is in your physical security. They offer greater flexibility to expand or change features in response to an increasingly dynamic environment, and make it possible to manage system users and access privileges from anywhere at any time. Protection against data lose is increased, because are stored in multiple locations to mitigate the risk of natural disasters, fire, etc.

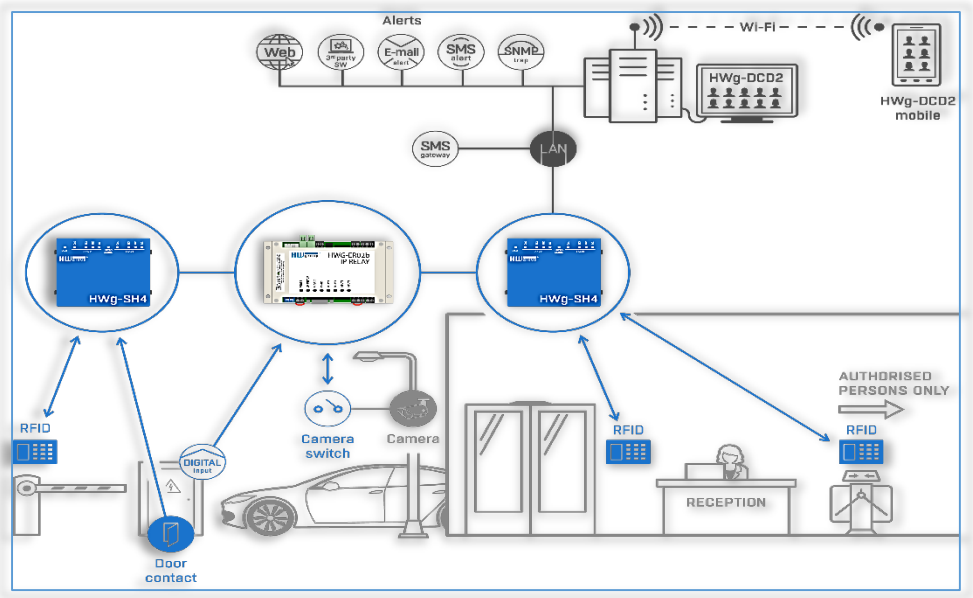

Figure 6. Building security and access control [8]

— Alarms

Alarm protection is a function of the physical security of the building and is usually realized in several segments: protection of the outer circle of the building, indication of the opening of the front door of the building, protection of certain parts of the building (energy part, warehouses, administrative part, etc.). The alarm protection system includes: microwave barriers with a certain range, magnets or microswitches on the entrance door, coders, addressable sensors and an addressable alarm control panel to which the aforementioned elements are connected. The control panel is connected to the CSSC. With the help of the control panel, access to the door is controlled (via magnets or microswitches), alarming or acknowledgment of alarms using a code, motion detection in protected zones (via sensors and barriers). The switchboard is controlled using codes. It is usually sufficient to install two coders: one in the reception unit (doorman) and the other in the video surveillance room. The perimeter of the facility is protected by microwave barriers. In addition to the light alarm (LED) and sound alarm (siren), there are displays with messages that are printed according to the specific situation, with automatic display of images of the protected zone of interest on the alarm monitor. The following systems are connected with alarm protection: gas detection, evacuation system, automatic control systems, control of air conditioning, heating and cooling systems, contol of rooms, control of systems for powering the building with electricity [1].

7. CONCLUSIONS

The central system for monitoring and control has become a standard in the construction of facilities of various purposes, but not only as an obligation but also a sound economic logic, whereby the effect of reducing costs is achieved, from energy consumption to efficient maintenance and extending the life cycle of equipment, preserving the environment and increasing the safety and comfort of living in the space.

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Fulfillment of the requirements regarding the high level of comfort and safety of these facilities is provided by complex technical systems. The effects of installing cheap energy and control systems are short–lived. Problems in maintenance and manual monitoring appear very quickly, along with user dissatisfaction. The integration of all systems (thermal energy, electrical energy, telecommunications, water supply, safety equipment, etc.) that are part of the building and the introduction of central management and supervision are recognizable features of modern buildings. Although such systems do not yet have a place in all buildings, the depletion of conservative sources of energy and drinking water, the constant rise in energy prices and world trends and efforts to preserve nature oblige investors and designers to accept a modern approach to building management. In fact, the smarter a building system becomes, the more complex and multi–layered security technology it needs. Security expectations are particularly high for Building Internet of Things platforms, which cover virtually all aspects of daily activities in buildings. Among the benefits that BIoT technologies provide is the improved efficiency of corporate, office and commercial facilities. It is related to optimal management of the energy consumption of the largest consumers – HVAC systems, lighting, computer and server rooms, by means of intelligent controllers, thermosensors, sensors for presence, movement, daylight, etc.

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