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DEVELOPMENT OF A SMART HOME CONTROL SUBSYSTEM

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Abstract:

The concept of smart home appeared more than 40 years ago. In the definition of such a concept, the basic concept is associated with a complex system having a single control panel. The modern concept that describes a smart home is defined as a set of control systems that can respond to the presence of a person and the environment with a subsequent solution, which is aimed at creating favorable and comfortable living conditions. With this approach, to implement remote control of a smart home, one has to face a number of problems: it is necessary to be able to access the system from the outside. Almost all devices inside a smart home are connected to the Internet, from which it is easy to view their status, and also causes any action by sending a user command. The evolution and access of high speed internet has allowed humanity to bring comfort and security to their lives. In this paper the main results of research on the management of smart home are given. Under socio-technical system we refer to an organized collection of hardware, software and hardware, as well as individuals, in which each of these components has a strictly defined framework and limit of its activity. The factors of influence on the condition of the building are analyzed. The diagram of channels and the impact on the control object is shown. Data collection and storage can be divided into a number of relatively independent stages. To improve the efficiency of collecting the process control data it is advisable to divide all sensors into groups and each group of sensors is connected to the microprocessor.

Keywords:

Computer network, traffic loading, protocol.

ACM Computing Classification System:

Network protocols, network algorithms, network types.

Introduction

Currently there are varieties of active developed Smart Home Control Systems (SHCS). The overwhelming majority of the population in urban areas spends most of the time in buildings and other premises in the protected areas. Setting the right conditions in such objects significantly affects the quality of life of the population.

During business hours, the people are in offices, manufacturing facilities, classrooms, area organizations, etc. During off-hours they are in homes, sports facilities, construction of cultural-mass assignment, clubs, etc. There is a trend of consolidation and formation of these office, residential, commercial, recreational, educational, therapeutic, diagnostic and other spaces with the use of engineered systems for management of air temperature and humidity, physical and criminal security.

The growth of the number of storeys in city buildings leads to a complicated system engineering for support of their activities; It reinforces the importance of solving problems for tracking deformations of building structures; It requires the implementation of preventive measures against potential terrorist threats to individuals and organizations in buildings.

Therefore, the task of creating maximum comfort, safety and convenience of people staying in / on these sites is urgent. In particular, the working areas need to ensure conditions for effective work of the personnel; in the classroom the temperature and humidity conditions and other parameters should contribute to the effective conduct of the educational process; in a building the people must have the opportunity to relax, to have a good time and to be feeling safe [1].

The most effective way to address these problems at the moment is to develop and implement SHCS, including to provide full and continuous monitoring of all aspects of their operation to get current status of all components.

In addition, SHCS can provide and increase the energy efficiency of buildings. Monitoring systems of buildings and areas, including their protection, have existed since time immemorial. However, such systems were very expensive and therefore rare in the past. Scientific and technological progress (especially in the field of microelectronics and information technology) will automate many of the functions that have to be addressed within the framework of SHCS buildings.

This, in turn, led to a significant reduction in the cost of such systems. As a result, at least some elements of SHCS are becoming more common in the practice of building design, to control their operation. For example, a video surveillance system in large cities has become widespread. It is used not only in industrial and office buildings, but also in a number of residential buildings - including video surveillance of the surrounding area [2]. This significantly increased security in the building for all stakeholders, as well as the comfort of stay or residence in the building.

However, as the analysis of all the available sources shows, there is currently no overall concept and operation of technology SHCS, ie existing SHCS are loosely coupled sets of separate subsystems: water, gas and others.

To ensure a comfortable stay in the area of SHCS control, it is impossible without taking into account all internal and external natural, man-made, technological and social factors. The zone of SHCS control has a significant impact on the comfort of living (for residential buildings) or stay (for office and industrial buildings) in.

Thus, the need to consider a number of factors affecting the condition of comfort and safety, as well as a large number of control parameters, covering all aspects of the functioning of SHCS generate the need for an integrated system approach to formation SHCS based on a single concept and operation of the technology, a unified algorithmic and information programming environment.

The purpose of the paper is to build a smart home control system based on a single concept and technology of functioning and integrated information and algorithmic support. In accordance with the purpose of the set and the following tasks:

1. To form the overall concept and the functioning of the SHCS technology.
2. To construct a general algorithm for decision-making in SHCS.
3. To undertake a systematic analysis of the factors that may influence the condition of the building and its components and to form a subsystem of data collection and recording.
4. To develop a central functioning algorithm for building automation with intelligent control system.
5. To develop the algorithms of individual functional subsystems of SHCS.

1 The Main Results of Research on the Management of Smart Home

Note that the smart home is a term widely used in the scientific literature for the isolation of buildings with a developed system of automation of various processes associated with the operation of the building, above all, the various functional subsystems of the building, with the active use of modern information technologies.

Usually the word "intellectual" in relation to a system refers to the existence of a system of rational behavior of opportunities for any admissible conditions of system function.

It may be noted one important requirement that must be fulfilled for the full achievement of intellectualization of the building - it is necessary to cover the intellectualization procedures of all the processes occurring in the building, since all of these processes are interrelated and interdependent. All objects associated with the building and all subjects related to building can only be treated through a systematic approach to the problem of intellectualization of modern residential and office building.

Analysis of intelligent home control systems revealed that the building management system, previously developed on different principles is focused on management of various individual subsystems of an intelligent building. In this case, all of the studies have focused only on the technical issues, and the review of an intelligent building as a socio-technical object of attention is not paid. There is an identified need for scientific research to form technology and smart home control algorithms [3]. Currently, in many leading countries there are actively developing projects for new types of buildings, in which all communication facilities and other lines are managed by an automated system in a building.

This system also takes control and other functions for management of the house, in particular the control of living conditions, security system, information and notification system, together with the automation of many other functions.

When you automate multiple subsystems together, this can lead to a synergic effect for the entire complex.

Technology based smart house is formed and organized differently than a conventional building. Firstly, the intelligent building technologies are characterized by system integration process in layers.

One of the most important procedures is the construction of performance evaluation, to get a dynamic feedback within all subsystems of the building in order to ensure conditions for further improvement and development of building control systems.

Various models have been developed to estimate the performance analysis of intelligent buildings. Preiser and Schramm have built a model for evaluating the performance of building systems based on the evaluation of "integrative capacity building", which covers all the main phases of construction of the building, by proceeding various external resources and all stages of the life cycle management, including "planning, programming, design, construction, placement and processing." Many of these studies were related to the building of the level of intelligence assessment.

Preiser and Schramm developed a Building Performance Evaluation (BPE) model which was evolved from Post-Occupancy Evaluation (POE) model [8]. The post-occupancy evaluation model determines the level of intelligence of the building process. It is usually done in three steps. First step is a formation of procedures to collect data at a conceptual level, the second step is an application and testing assessment of tools in field studies by evaluating the level of intelligence of the building. The third step is a comparative analysis of the collected data and the development of recommendations and proposals for the use of data collection instruments.

Preiser and Schramm used their process model for the evaluation of intelligent building in cross-cultural context, and their model provides "improving the quality of performance evaluation in the intelligent building, especially in the long term." This evaluation system allows you to "monitor the performance of the new high-tech systems and their impact on the building, as well as the effectiveness of these systems as a whole." Without evaluation system it is difficult to classify and validate the level of intelligence buildings. Thus, a large number of studies is done on the problem of developing methods for constructing various estimates for the intelligent building.

One of the important methods of performance assessment of buildings is developed in 1995 DEGW method based on the "method of valuation of buildings IQ" and "evaluation of the quality of the building." The method uses five categories of factors that combined to produce overall estimates of the initial suitability of the information provided by the actors of the building.

On the other hand, Arkin and Patsiuk developed a measure of "systems integration value" and the method of its evaluation to characterize the degree of integration in the building, depending on the degree of integration of the building subsystems, the integration between the systems and structures of the building.

This evaluation methodology can be used to evaluate and compare the different options of intellectualization of the building and create an unified index for evaluating the degree of integration of the system in intelligent buildings. This model was adapted for Research on performance evaluations intelligent building construction and improving the structure building, Yang Pan 2001.

In 2012, the Asian Institute of Intelligent Buildings constructed a quantitative method of assessing the intelligent building an index. According to this methodology, the individual index is based on nine separate indices relating to individual modules, intelligent building, as well as the environment and the various aspects of quality. Index number is lying in the range 1 - 100. Depending on the grade level of general intellectual performance of building, it has rank in alphabetical order from A to E. However, some of the performance evaluation models have been criticized for inadequate result estimates of certain aspects of construction and operation of buildings, as well as for the use of partly subjective assessments.

2 The Concept of Building a Smart Home Control System

As noted above, the existing approaches to building SHCS despite presenting them as integrated systems have a number of existing shortcomings. First, they cover only the most important fields of activity SHCS; First of all, the sphere of life support and safety and its commitment do not affect the scope of relations between the various legal and physical entities in the control zone. Second, as part of the subsystem SHCS is regarded as virtually independent and this creates problems in the implementation of many activities. At the end, there is a separate dedicated subsystem or service responsible for the strategic development of intelligent building.

Thus, the most serious drawback of existing concepts of building SHCS is ignoring the subjects and, above all people. Complete controlled intelligent building must necessarily be based on a consideration of the building as a socio-technical system, harmoniously combines the building and all other technical services and LAN.

Under socio-technical scope of view, the system refers to an organized collection of hardware, software and hardware, as well as individuals, in which each of mentioned components has a strictly defined framework and limit of its activity.

Intelligent building as a socio-technical system is a set of controlled building spaces, combined in a single system based on a single concept of construction and operation of the technology - we call this as a symbiosis controlled area, the people and SHCS socio - intelligent buildings.

We highlight some of the principles of construction of socio-technical systems:

1. Technical equipment as part of SHCS should not cause problems for people to live and inconvenience of travel or stay in the control area.
2. Technical equipment must not disturb or cause problems for the realization of the rights of the people, and, above all, the right to privacy and personal privacy. We highlight from this standpoint the surveillance system, which is the source of collecting a variety of information of a confidential nature. Therefore, enforcement of this principle in SHCS is quite a challenge.
3. Information concerning the private life of individuals and other legal entities and individuals, should be treated SHCS in full compliance with the law.

3 Technology Operation Subsystem of the Strategic Management and Development

The subsystem of the strategic management and development is one of the most important, being responsible for all the problems associated with the development of promising SHCS, improving comfort of stay (residence) of people in it, increasing the efficiency of all its subsystems and services. Below is the general function of the technology strategic management and development system.

The principal difference between the strategic management of operational dispatch, which is realized in the dispatch center (one of the important pillars of management) is the use of forward-looking information on future states of all components of the operation process SHCS: of buildings, premises and control zone as a whole, the external environment, legal and regulatory base composition, people, financial and economic conditions of SHCS.

As a consequence, strategic management implies the existence of subsystems they predict future parameters of the functioning of the environment and planning, which generates and mostly forms action plans based on the projected state of the system, develops technologies of selection and decision, to generate specific plans to implement the actions and taken measures [4].

4 The Technology of Electricity Service Operation

As indicated above, the detailed description of the above SHCS technology and all its components in this paper is not possible. Therefore, to describe common technology in detail procedures for individual subsystems, in this paragraph we show an operation of a technology standard functional SHCS services: the services of power. As a general technology of SHCS operation, the power center operates continuously in cycles.

Key-controlled power system parameters are the voltage of the electric current and its frequency. Therefore, at the beginning of the algorithm values of these parameters are monitored. In case of deviations of at least one of the power parameters the supply facility must immediately take steps to solve these problems. In this case, all possible measures are divided into two groups. First group - measures taken immediately to eliminate deviations (faults in the devices, circuits and line breaks, etc.), when the sources of the problem are known or they can be quickly found on the site by an electrician expert. The second group - those deviations, the causes of which are unknown, or are not able to be eliminated by expert help immediately.

When the causes of deviations could not be determined or allocated (the complexity of the accident, the presence of interfering factors in the form of fire, confined spaces, etc.) more serious action must be taken. That is, if the situation is an emergency (for example, a fire in the place of occurrence of deviations), then first of all actions are taken to prevent the safety of people and property (eg, power off in the accident zone, the restriction of movement in this area), and process control runs for the elimination of accident [5].

5 Information Technology Used in the Composition SHCS

As follows from the algorithm of SHCS operation and its components, the processes associated with control have the most diverse nature, and therefore information technologies (IT), which were designed to support these processes comprise a wide variety of different software and information means.

Let us consider in more detail what information technology demands in SHCS. The initial phase of technology is related to the collection and data logging from a variety of internal and external (database) sources: from sensors, video surveillance, internet sources of clients and staff, web browsing history, as well as from a variety of document repositories and databases (for current situations, regulatory and legal documents from past situations and events in the building, etc.).

In addition, to make data processing from the sensors the microcontrollers may be used. Finally, the necessary means too, to control the correctness, completeness and adequacy. Thus, in the first step of collection and preparation of source data you need the following IT technologies:

1. IT data accumulation and processing from primary sensors, continuous measurement of various physical parameters that can interact with microcontrollers. The set of systems providing received data from sensors and issue commands to the actuators, based on wired and wireless technologies.
2. IT applied on the basis of embedded data acquisition board with a standard system interface.
3. IT on permanent, i.e. systematically in accordance with the regulations how to specify and search data in the global network [6] (internet).
4. IT support surveillance systems. Real-time monitoring and management software is used to manage the video surveillance system and the organization of the workstation operator to monitor and work with the archive.
5. The processing systems and storing documents.
6. Database storage of different types.
7. Information system to control qualitative characteristics [7] of different types of data.

6 Development of a Subsystem of Decision-Making in SHCS

SHCS - a key component is the process of implementing measures, actions and procedures related to the solution of various problems and management tasks, i.e. the system management process. SHCS management process is divided into two kinds of management - operational management and strategic management. Each of these types of control, in turn, is divided into a series of management steps that are common to both types of management, including the following steps:

1. Collection and preparation of raw data.
2. Procedure for making decisions.
3. Adoption.
4. Implementation.
5. Control of the process and results of implementation.
6. Analysis of the implementation of the results.
7. If necessary, adjust solutions and then repeat the entire cycle of described control.

This strategic management adds another initial (second-order) phase - SHCS prediction parameters.

7 Factors of Influence on the Condition of the Building

It is required to solve the formation of the data collection system. To do this, first of all we need to form part of the collected data which is necessary for the efficient operation of SHCS.

For this, we first conduct a systematic classification of all the factors that may affect the building manager or entities that are in it legally - we call the specified set of object management. Then, based on results of classification factors we form relatively complete composition of required sensors.

By analyzing the composition of all the possible types of impacts, there are allocated groups of factors associated with the following components and SHCS management objects shown in (Fig.1):

1. Direct constructions and their individual elements which form the house itself.
2. Infrastructure systems and their elements related to human life support systems (electricity, heat, water and gas supply, lighting), and standard public services (communications, internet, ventilation, and air conditioning).
3. Infrastructure systems that support the building in a state to satisfy all regulatory requirements, as well as to provide control over the state of all the elements, systems, structures, house and home management.

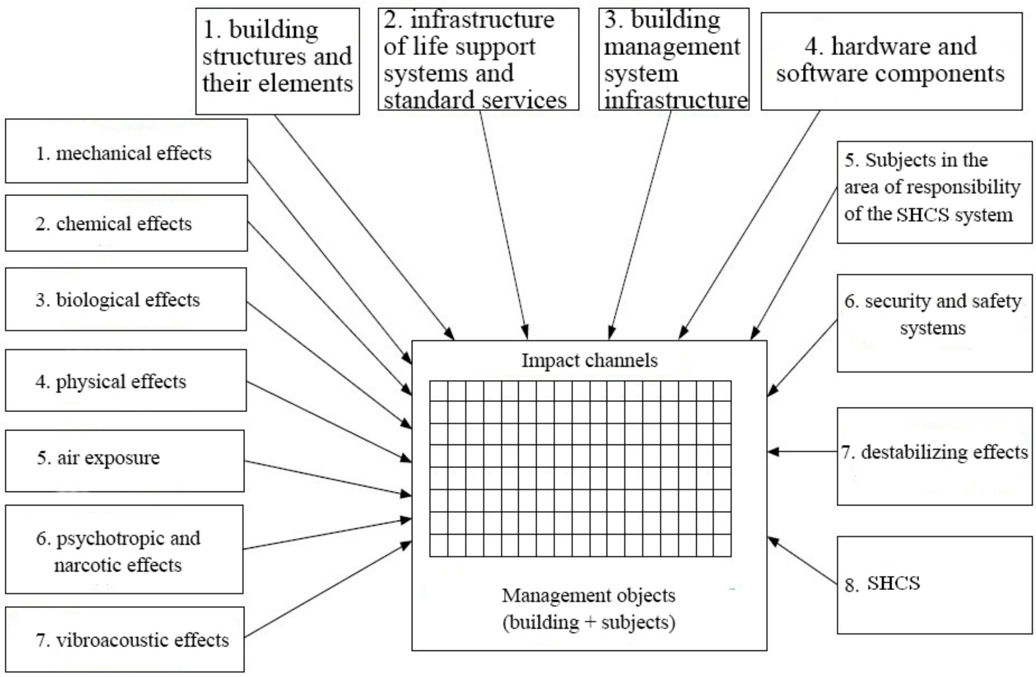

Fig.1. Diagram of channels and their impact to the controlled object.

4. Specifications and software and hardware components that make up the whole.
5. Entities that are in spaces, premises and areas of intelligent building legally or illegally.
6. Security systems and intelligent building security.
7. The various internal and external destabilizing effects of natural, man-made and subjective nature, they can upset the normal operation of intelligent building with its subsystems, and even destroy some of them.
8. SHCS directly as part of the controlled object.

Detailed view on these factors at the next level, it takes into account that a substantial part of each of these components is allowed to allocate more than 56 possible sources of influence on the controlled object.

Building and subjects located therein are exposed to various factors, both internal and external. Analysis of possible ways to influence the impact of the following classes of methods can distinguish:

1. Mechanical impact - the collapse or destruction of elements and structures of buildings and facilities, the fall of other objects in the area of displacement and finding subjects, slippery surfaces (such as ice), falling objects from a height (such as snow and heavy ice from the roof), suspensions, dusts, including carcinogenic and not deducible containing additives.
2. Chemical exposure - a substance harmful to human health or to the health of personnel, substances explosive, flammable, strong smelling, unpleasant, or dangerous for technical devices and allergens too.
3. Biological effects - microorganisms (bacteria, viruses, etc.) and macro organisms (plants and animals).
4. Physical impact (nonmechanical nature) - effect of physical fields and radiation: electromagnetic fields, X-rays, radioactive, ionizing and ultraviolet radiation, etc.
5. Smoke, dust and similar obstructions, gas leakage, a strong turbulent movement.
6. The psychotropic and narcotic effects.
7. Accustic impact - strong sound signals, a mechanical vibration feedback.

The combination of exposure to each source with each of the possible specific ways to influence one of the channels generates impacts on the control object as shown in (Fig.1).

The analysis shows that the total number of such channels is greater than the impact of several hundred influences. Each of channels requires ideally its specific used data collection devices at the appropriate exposure. Therefore, a complete analysis of the possible types of sensors required for the control object is a rather time-consuming and difficult task.

8 The Input Acquisition Subsystem

Data collection and storage can be divided into a number of relatively independent stages:

a) directly collect data using a variety of technical, software and hardware, as well as subjective sources
b) the registration of data on storage media
c) analysis of the data on criteria full notes, the adequacy, consistency, relevance, timeliness, no-rebound, trust, etc.
d) the adoption of adequate solutions for identifying violations of at least one of the following criteria and the implementation of decisions
e) transfer of received and analyzed data to the central control unit and the corresponding functional subsystems for performing their duties

From these data processing steps the most important one is the stage of collecting data directly. The general scheme of the input data stream is shown in (Fig.2). The diagram shows seven possible allocated input sources.

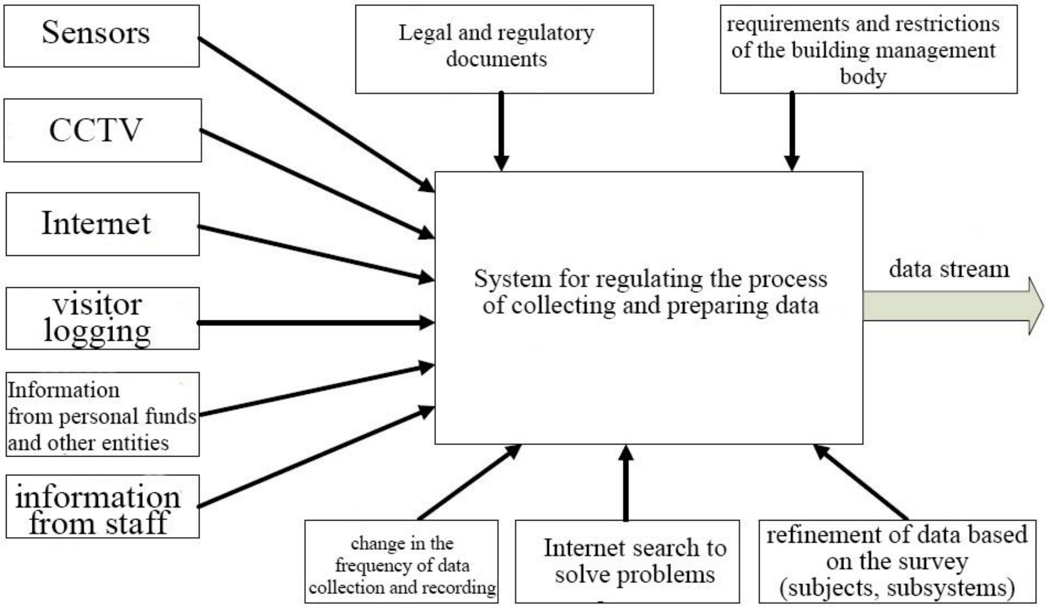

Fig.2. Diagram of inputs to building management systems.

1. The sensors and sensor devices, which are complexes comprising more than one sensor. On the basis of the sensor data collected on all technical elements of home life-support systems (such as water and energy, public services), many elements of the security system can work. This is the primary source of data for the effective functioning SHCS.
2. The video surveillance system, which is one of the main sources of information for security. This system also allows you to monitor many of the elements of smart home life support, the state of which can be identified on the basis of visual observation.
3. The Internet as a source of information that allows you to help, first of all, to find possible solutions to the various problems, as well as to obtain information about various natural persons who are or have fallen within the scope of professional tasks within SHCS security subsystem.
4. Event log, which should record all and any significant event in SHCS control zone, which allows on the basis of his analysis to identify possible problems, troubles, threats, trends, and to predict the next possible states of the entire system, including the building itself with the whole area control and SHCS.
5. Information about the people they are in the control zone SHCS legally - tenants, visitors, staff, employees, etc.), which can be supported with the help of a survey by the SHCS staff. This information can contribute to a more adequate and operational work of system.
6. Information from SHCS personnel, including the subjective nature relating to all aspects of the functioning of SHCS. This information allows you to identify potential and real problems that are still outside of the bounds with other data sources.
7. Legislative and normative documents regulating activity of SHCS in general and the activity of its subsystems, including the subsystem of data collection and preparation.

9 Technology of Data-Gathering and Processing Subsystem

The primary (center) block in (Fig.2) designed for system management of collection and preparation raw process data is described here - its function and technology.

Since this system should also implement a control function for input acquisition process, it is necessary to use sensors to get responses to control actions, that is, at a minimum they should be targeted. Furthermore, it is proposed (to the extent of available funding) to use "smart sensors" that have a large set of control parameters inside.

To improve the efficiency of collecting process control data it is advisable to divide all sensors into groups (according to the territorial location, by functional purposes, etc.) and each group of sensors connected to the microprocessor. It should carry out certain control and management functions for the respective group of sensors - in particular, control of the state of the sensors (the entire set of operating characteristics, and user).

In addition, in the case of event where sensor data are deviated from its normal procedural status, the software and microprocessor must immediately inform the dispatch center SHCS. The control actions of SHCS control center for the particular sensor or set of sensors are also advisable to pass through the respective channels. In the control center the complete information about the delivery and current implementation of the control action must be observed. Note that to enhance the exchange rate, all MK data are transmitted via a common bus.

The process of data acquisition and processing is performed continuously (cyclic) and may be partly or entirely blocked only by the direct impact from the control center or when the SHCS system is destructed.

Data collection and preparation of parallel generated control signals for the control of other systems belonging to it, is made according to the following algorithm:

1. The video surveillance system turns the nearest video cameras onto the heat source, and assigns the highest priority to these cameras, thus providing a continuous supply of video data from ignition zone. On the monitor, surveillance system forms enlarged image from these cameras. The priority mode for recording images is higher from fire zone.
2. The climate control system deactivates the supply air ventilation system in the zone of fire - to prevent the flow of fresh air (containing more oxygen) to the site with fire. To remove the smoke the corridors, hallways and stairs (along the evacuation routes) includes an appropriate subsystem of exhaust ventilators.
3. Automatic fire extinguishing system is activated - if the separate room or the whole building is equipped with such a system.
4. The power supply control system switches off the power circuit of the equipment and lighting devices in the fire area.
5. The lighting control system activates emergency lights.
6. Access system unlocks the controlled doors (for example, equipped with combination locks) for smooth evacuation.
7. The voice alarm system talks announcements in the relevant parts of the building.
8. Elevators go down on the first floor and, if necessary, they are turned off, etc.

Thus, the inclusion of all building systems into a single management system creates a new quality - integration. The system with a single platform (the concept and technology) management acquires new properties that are absent in the constituent subsystems (a synergic effect).

The technology described here with its operation of the data collection and preparation of the subsystem allows to solve many important problems relating to the function of the building and ensures a comfortable and safe stay for all the people in it at the higher level of quality.

Conclusion

1. The classification of factors they impact on intelligent building: seven groups of impact factors are identified. A procedure for the classification of systemic effects channels on two classification criteria: impact factors and the impact of the classes of objects.

2. A general algorithm of data acquisition and of the data preparation subsystem allows to increase the efficiency of operation due to more complete control of these channels in accordance with their large quantity.

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