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Technology of Structural Optimization for Subsidiary in Enterprise Information Systems

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ABSTRACT

This article demonstrates the development of structure optimization technology for technical means of subsystems designed for solving susidiary problems in information and control system of an arbitrary enterprise. This technology based on modification of existing technology on structure optimization for technical registration of enterprise energy resources. Changes in the technology steps are mainly stipulated by constant enhancement and improvement of technical characteristics of wireless networks. Secondly, it is stipulated by emerging of sensors with custom interfaces for acquiring and measuring physical values, consequently enabling interaction with different networks, as well as emerging of a wide spectrum of interface converters.

Key words: Sensor, Wireless Network, Control Point, Optimization.

1. INTRODUCTION

Problem statement: Currently, information systems or information control systems (ICS) in an enterprise or an organization should solve not only the main functional problems connected with specificity of an enterprise functioning, but also they should enable solving numerous other subsidiary problems. These subsidiary problems may include environmental climate monitoring, control of access to some apartments, metering of energy resources that consumed in different compartments. The main characteristic of such subsidiary problems consists in acquiring information from automatic sensors and (or) creation of control actions directed to executive devices at periodic time intervals as well as arbitrary moments of time after querying from a user or an operator. Solution to problems is performed by corresponding ICS subsystems in an enterprise. With this, to increase data authenticity, repeated acquisition and processing of necessary information can be provided as well as control action accomplishment. These subsidiary subsystems are characterized by slight amounts of transferred information, which do not influence the working traffics during solution of the main functional problems of a system. Time characteristics of information acquisition, transfer and processing during automated processes are comparable to the time of a user or operator reaction. During the mode of automatic information acquisition with the preset time period, it can be changed according to the dynamics of measurable process or a process being under control.

Technical implementation of ICS is performed based on information networks in an enterprise, which may include wired and wireless segments. In turn, wired segments may include Ethernet lines, telephone channels, power lines, etc. Wireless segments may be implemented using Wi-Fi and/or Bluetooth technologies. By taking the aforementioned factors into account, the implementation of subsystems that solve the subsidiary problems is reasonable to be made with maximum utilization of existing information networks in an enterprise. The appearance of numerous types of sensor and executive devices with custom interfaces, including wireless interfaces, enables considering structure optimization problem of such subsystems as a problem of comparison of several variants synthesized based on existing information networks in an enterprise.

2. ANALYSIS OF THE LATEST PUBLICATIONS AND RESEARCH

One of the most developed areas of enhancement of information system structure from the point of enrichment of its functionality by subsidiary subsystems consists in creation of specialized systems for technical registration of energy resources [1, 2]. Along with traditional approach that assumes analysis of requirements from users, estimation of possibilities of existing enterprise network utilization, development of variants of subsystem structures with criterions for their estimation in order to find the best suited one, currently, an important role is played by an approach based on expert decisions. Expert estimations are especially important along with choosing the best variant among available cases when dealing with complicated and heterogeneous architectural solutions. With this in mind, existing expert experience on the best practices for automation of subsidiary tasks in an enterprise may decrease time needed for decision making concerning the variant of technical implementation for subsidiary subsystem development. The increase in quality of data transfer in wireless networks nowadays enables considering them of highest priority for solving subsidiary problems. Moreover, it is reasonable to modify existing technology [3] by including preliminary works into the main technology stages. Focusing the search in the literature of subsidiary problems, several works were demonstrate in the characteristics of wireless networks related to this research in the articles [4, 5, 6, 7 and 8].The effects of acquiring, processing, and communicating compressive sensing based measurements on wireless sensor network lifetime are analyze in comparison to conventional approaches presented in [9]. In

[10] showed that the optimal data packet length on network lifetime is the maximum allowed length. A realistic wireless sensor networks lifetime optimization framework where transmission power levels for both data and acknowledgement packets optimally selected. The authors in [11] analyzed the effects of path loss models on the wireless sensor networks lifetime.

In this article, the authors propose a technology, which include expert analysis stage on sensor applicability from the point of measuring and exploitation characteristics as well as from the point of necessary interface availability to ensure interaction with particular enterprise, networks.

3. THE MAIN MATERIAL AND RESULTS

Formal solution to the problem stated above can presented the following way; if the total number of control points with operator's terminal equals M, m of which can be already connected to existing wireless subnets of an information net in an enterprise, then the total cost of connection of the rest (M –m) points should be minimized.

The total cost, then, will include the cost of peripheral and commutation equipment with communication lines:

$$C_o = \sum_{i=1}^{m} C_{pe_i} + \sum_{j=m+1}^{M} \left(C_{pe_j} + C_{se_j} + C_{cl_j} \right) \quad (1)$$

where C_o is the total cost; C_{pe_i} is the cost of peripheral equipment (sensors, executive devices, modems) used for connection with existing networks; C_{pe_j} is the cost peripheral equipment used for connection with newly developed networks or their segments; C_{se} is the cost of commutation equipment which includes the cost of design and installation; C_{cl} is the cost of communication lines.

The proposed technology of structure optimization for technical means of subsystems designed to execute subsidiary functions in ICS of an enterprises described below in a form of a sequence of steps.

Step 1. According to functions of subsidiary subsystem in an enterprise IS determine locations of control points (places to apply control actions) in apartments or at the territory of an enterprise. Determine locations of terminal equipment of data receivers (operators). Mark these locations on the scheme of a building.

Step 2. Prepare a list of networks utilized at the enterprise, which can be used for data transfer from the control points (places of control action application) or a list of networks to be potentially deployed. Determine the zones of clear data transfer for each access point in wireless networks; determine the ability to install additional commutation equipment for wired networks. On the scheme of building, mark locations of wired networks, commutation equipment and zones of clear data transfer for wireless networks.

Step 3. If there are wireless networks at the enterprise, determine the control points located at the zones of clear signal transmission from the access points. Record information about these control points for carrying out expert estimation of connection reasonability. It is assumed that experts use ratings for estimation. Experts obtain initial information needed to perform their estimations from the enterprise specialists: network administrators, electro technicians, radio engineers, etc.

Step 4. Assuming that the total number of connection points for acquiring information (sensor installations) and/or control (executive devices installation) equals M. The number of wireless connections is assumed to be m points in the system, perform expert estimation of connection reasonability of the rest of (M – m) sensors and/or executive devices as well as operators' terminals to wired networks of data transfer, where physical connection is possible. Expert estimation also assumes using ratings.

Step 5. Based on expert estimations, create several variants (from 3 to 5) of structure for technical means of the subsystem that perform subsidiary functionality in ICS of an enterprise. First, structures are needed to be formed that are based on organization of additional wireless networks with access points connected to existing wired networks of the enterprise. Locations of additional access points are determined by maximum coverage of control points.

Step 6. Formally present each variant of structure by a model which is a set of graph structures. Graph vertices represent existing commutation equipment or equipment planned for installation, specific modems, wireless network access points, equipment for control points and terminal equipment. Graph ribs represent corresponding lines or wireless communication channels used for information transfer.

Step 7. Based on the variants of the obtained graph structures, compute the cost of each variant, assuming that the cost of equipment is considered while weighting graph vertices, and the cost of communication lines assume their design and installation while weighting ribs respectively. For structures based on organization of additional wireless networks, the cost is not considered for rib weightings. Determine a reasonable variant by minimum total cost.

Step 8.Based on the data (from 3 to4)and computational results obtained from step 7, collected information about connected equipment for all the control points and operator's terminal to the existing and planned enterprise networks in order to implement additional functions for ICS.

Step 9.Based on the required technical and exploitation characteristics of equipment for each control point and assuming data from table 2, choose sensors (executive devices) and a modem for operator's terminal. Choose additional commutation equipment. The steps mentioned before provide description of how to design structure of technical means for subsidiary subsystems in ICS.

4. IMPLEMENTING AND TESTING

This section describes in detail how tests were performed to structure optimization technology for technical means of ICS subsystem designed to solve subsidiary problems is based on priority use of wireless networks. Simplified example of structure design for technical means given below. The problem of subsidiary subsystem design is considered for automatic temperature measurement in five apartments of an enterprise with indication of the acquired information at the operator's desktop located in another apartment. An enterprise information system solves basic functional problems, while data transfer is fulfilled based on two information networks in the system: EthernetandWi-Fi. Before automation, the process of information acquisition about the temperature in apartments assumed visual perception and acquisition of information by an operator using thermometers mounted in each apartment with further manual input to the computer, data utilization in the information system (Figure.1).

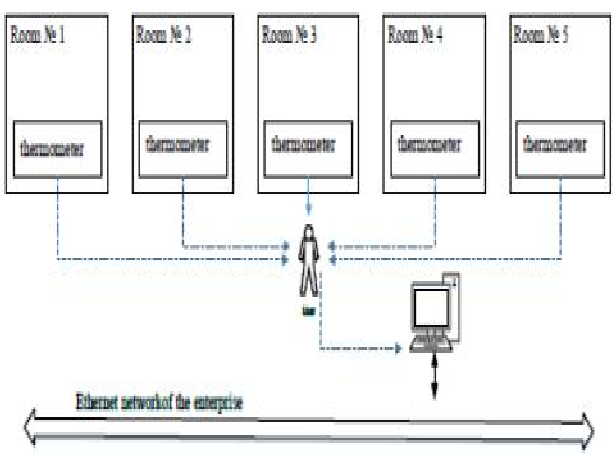

Figure 1: the process of information acquisition before automation

After completing automation, data from temperature sensors should transmitted to operator's terminal mounted in a definite apartment. The structure of subsidiary subsystem will look as follows (see Figure 2)

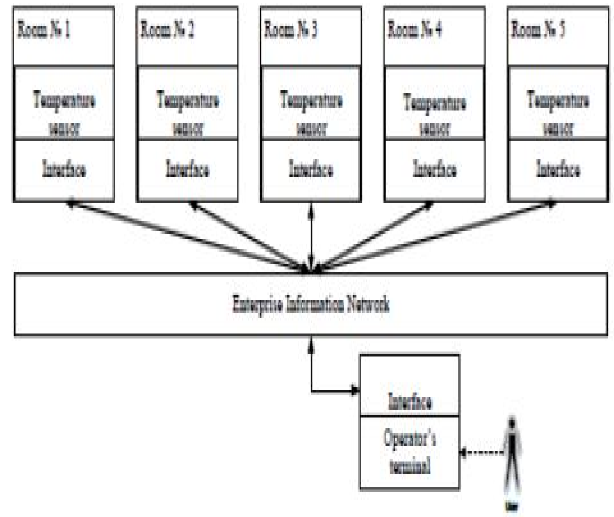

Figure 2: Subsidiary subsystem structure after automation.

Figure 3 shows apartment plan with location of temperature control points and operator's terminal (corresponds to the first step of the technology process).

Figure 4 illustrates Ethernet lines location with commutation equipment as well as location of existing access point of Wi-Fi network AP1and the zone of clear data transfer (corresponds to the second step of the technology process).

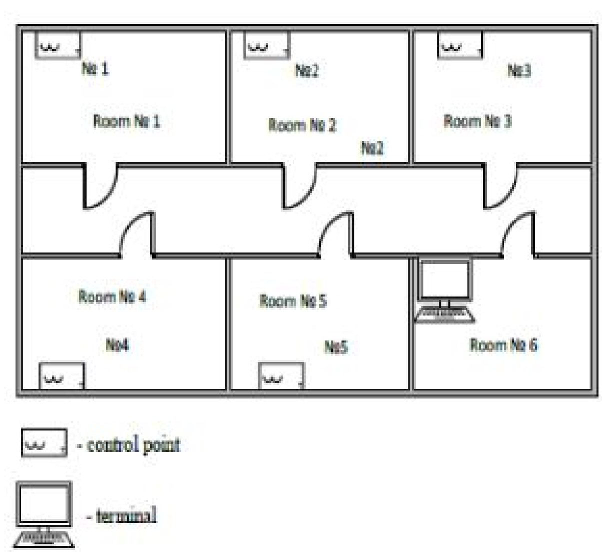

Figure 3: Apartment plan with location of temperature control points and operator's terminal

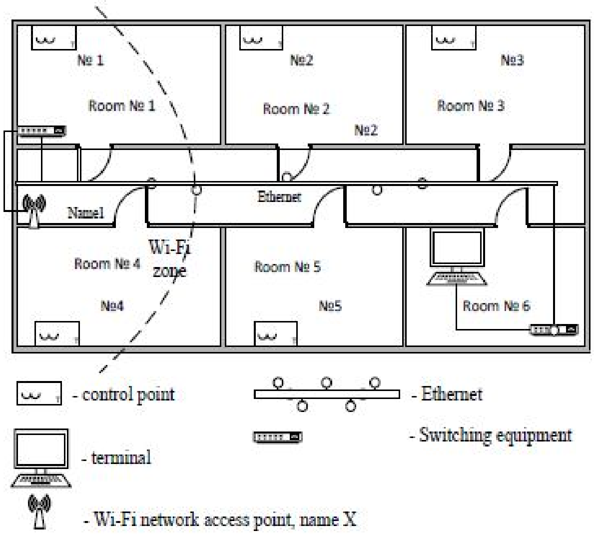

Figure 4: Apartment plan with equipment location in Ethernet and Wi-Fi networks.

Analysis of control point location and operator's terminal location in respect to the existing networks shows that temperature control points CP1 andCP4 located in room No 1 and room No 4 belong to the zone of clear data transfer of the access pointAP1. This enables to fill table 1 (corresponds to the third step of the technology process).

Table 1: List of control points connected to wireless networks.

No of CP	Location of control point, operator's terminal	Network types to which physical connection is available	Peculiarities s of connection *	Expert estimation of connection reasonabilit y y (rates)*
1	Room No1	Name1	Resides at the zone of clear transfer (Wi-Fi). Noise level is minimal.	10
4	RoomNo 4	Name1	Resides at the zone of clear transfer (Wi-Fi). Noise level is minimal.	10

* The interval is from zeroto 10 scores.

For the rest of the temperature control points'CP2, CP3, CP5 and operator's terminal, and expert estimation is make concerning reasonability of temperature sensor connection operator's terminal connection to data transfer networks. Data inputting to the table 2. (Corresponds to the fourth step of the technology process).

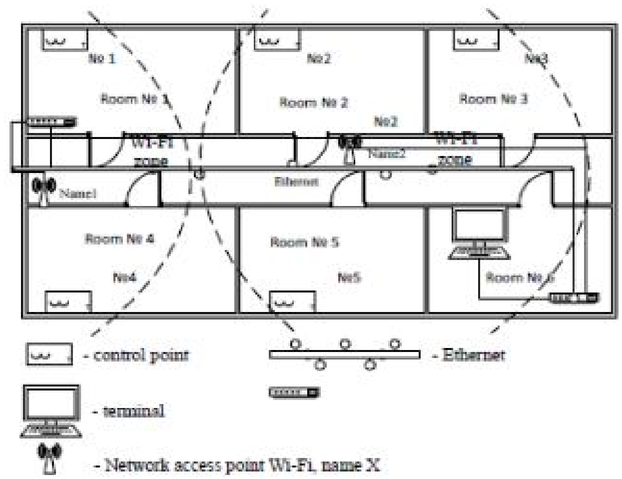

Figure 5-a: Structure variants of subsystem technical means.

Table 2: Expert estimation of connection reasonability of temperature sensors and operator's terminal to the data transfer networks.

No of CP	Location of control point, operator's terminal	Name of wireless network, commutation equipment	Location of access points and commutation equipment	Equipment interface needed at the control point
2	Room No 2	Ethernet	Connection to switch A	6
		Ethernet	Connection to switch B	5
		Wi-Fi	Access point installation with connection to switchB	7
3	Room No3	Ethernet	Connection to switch A	4
		Ethernet	Connection to switch B	5

		Wi-Fi	Access point installation with connection to switchB	7
5	Room No 5	Ethernet	Connection to switch A	5
		Ethernet	Connection to switch B	5
		Wi-Fi	Access point installation with connection to switchB	7
T	Room No 6	Ethernet	Connection to switch B	9
		Wi-Fi	Access point installation with connection to switchB	7

Structure variants of subsystem technical means are forms based on expert estimations (see table2). These variants are shown in the Figure 5a – 5c. (Corresponds to the fifth step of the technology process).

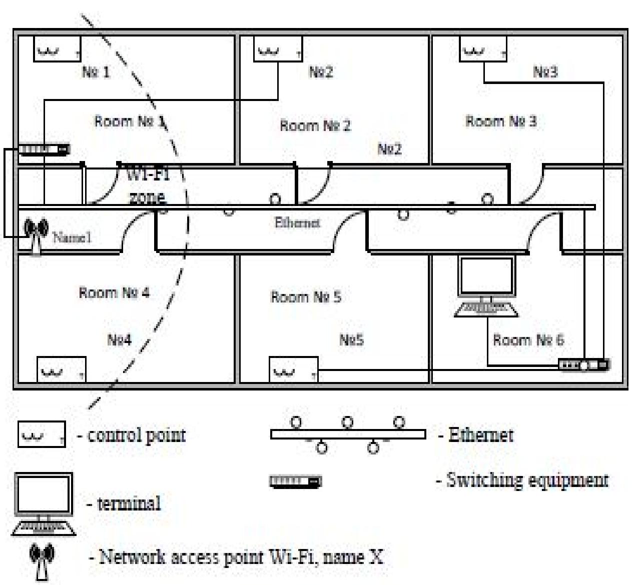

Figure 5-b: Structure variants of subsystem technical means.

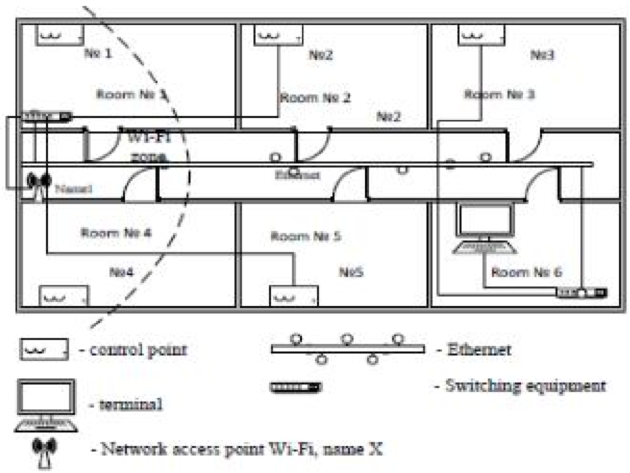

Figure 5-c: Structure variants of subsystem technical means

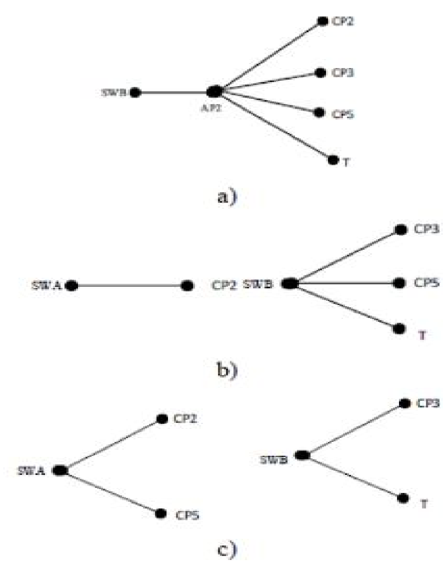

Figure 6: Graph-based presentation of structure variants for subsystem technical means

Graphs shown in Figure 6a – 6c are correspondent to structures shown in Figure 5a – 5c. (corresponds to the sixth step of the technology process).

In order to choose reasonable variant, cost computation is performed for the technical means. Minimum cost criterion is used for choosing the best suited variant (corresponds to the seventh step of the technology process).

$$C_{o1}=C_{cl(SWB,AP2)}+C_{AP2}; \quad ...... (2)$$

$$C_{o2}=C_{cl(SWA,CP2)}+C_{cl(SWB,CP3)}+C_{cl(SWB,CP5)}+C_{cl(SWB,T)};$$

$$C_{o3}=C_{cl(SWA,CP2)}+ C_{cl(SWA,CP5)}+ C_{cl(SWB,CP3)}+ C_{cl(SWB,T)}.$$

Analysis of the total cost of expenses for each variant under consideration enables to form the following relations:

$$C_{o1}<C_{o2}, C_{o1}<C_{o3}. \quad \ldots\ldots (3)$$

Determining the reasonable variant enables to form a complete list of terminal equipment connected to enterprise networks, as shown in table 3 (corresponds to the eighth step of the technology process).

Table 3: Connection of terminal equipment to enterprise networks

No of CP	Location of control point, operator's terminal	Name of wireless network, commutation equipment	Location of access points and commutation equipment in existing and planned networks	Equipment interface needed at the control point oroperator's terminal
1	Room No 1	Name1	Corridor (P1)	Wi-Fi
2	Room No 2	Name2	Corridor (P)	Wi-Fi
3	Room No 3	Name2	Corridor (P)	Wi-Fi
4	Room No 4	Name1	Corridor (P1)	Wi-Fi
5	Room No 5	Name2	Corridor (P)	Wi-Fi
T	Room No 6	Name2	Corridor (P)	Wi-Fi

Data from table 3 gives an ability to choose specific sensors and modem for user's terminal (corresponds to the ninth step of the technology process). The goal of the article is the development of structure optimization technology for technical means of subsystems designed for solving subsidiary problems in information and control system of an arbitrary enterprise. The results of the proposed technology of structure optimization provide an elegant solution to minimize cost criterion, which used for choosing the best-suited variant. The advantage of the technology to solve subsidiary problems based on priority use of wireless networks is simple and efficient.

5. CONCLUSIONS

Thus, the proposed structure optimization technology for technical means of ICS subsystem designed to solve subsidiary problems is based on priority use of wireless networks for data transfer with minimum cost of construction and installation. Technical characteristics of contemporary wireless networks, including modem hardware for various devices and data transfer equipment as well as trends of their perfection, guarantee complete fulfillment of subsystem functionality. Specialized software is reasonable to be developed for the technology implementation. Such software may include modules to solve optimization problems. Expert analysis stage on sensor applicability from the point of measuring and exploitation characteristics and necessary interface availability to ensure interaction with particular enterprise, networks have been presented.

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