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IMPLEMENTATION OF INTELLIGENT CONTROL SYSTEMS IN WATER SUPPLY NETWORKS

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Abstract

When developing and implementing control systems for technically complex objects, special requirements are imposed on the technical means of the system. Including coordination of data transmission channels, selection of the optimal sensor to ensure correct operation of the system and timely data transfer, development of system software, ambient temperature, humidity, etc. This article discusses the problems of implementing an intelligent control system that meets the requirements for water supply networks sufficiently analyzed. Based on the analysis, the advantages of the SCADA system for continuous monitoring of the technical parameters of water supply networks are highlighted.

Keywords: *hydromelioration object, dispatcher, intelligent control, sensor, operating system, software, protocol, SCADA.*

Introduction. The development and improvement of intelligent control systems is of great importance in controlling the technological processes of hydromelioration objects in agriculture and water management, as well as in many industrial sectors. But there are some problems in introducing the intellectual system to objects. In particular, the main part of the technical equipment in the system is brought from abroad, there is a lack of experts who know how to install the system and its working principle. When developing control systems for technically complex objects, special requirements are placed on the technical means of the system. Therefore, there are many technical problems in the development and implementation of an intelligent control system [1].

The main problems in the development of an intelligent control system for technically complex objects are the following [1]:

1) selection of sensor-transforming equipment (STE);

2) coordination of data transmission channels;

3) To determine the number of optimal sensor-transforming equipment (STE) selection to ensure proper system operation;

4) developing software for the system.

When choosing a sensor changing device, it is necessary to pay attention to its dimensions, technical characteristics, functionality and price. Most existing sensors do not have self-diagnosis and automatic calibration functions. This factor is the most important for creating intelligent systems. However, the use of improved wide-band STEs is more expensive in some cases. Working conditions (ambient temperature, humidity, resistance to vibrations) are also important in technically complex objects.

The main part. Components of intelligent control systems can be geographically located in the same building or far away from each other. In order for system elements to interact, it is necessary to use various communication channels, including cable lines, radio channels, wireless communication channels.

A more serious problem arises when the data transfer protocols of STE from different manufacturing companies are interoperable. Modern equipment manufacturers do not have a single protocol for data transmission in industrial networks. The most common protocol is the MODBUS protocol, and many manufacturing companies use proprietary protocols. Although it is not difficult for an experienced programmer to develop and implement a single protocol, implementing multiple protocols within a single system can significantly increase development time and cost. Bundan tashqari, barcha xususiy protokollar ma'lumotlarni uzatishning 100% ishonchliligini ta'minlamaydi. In addition, not all proprietary protocols provide 100% reliability of data transmission. At the same time, not all manufacturing companies implement their protocols in the "question-answer" mode, but prefer cyclic transmission. The use of STE in the cyclic transmission mode forces companies developing intelligent control systems to use additional data transmission channels, which increases the amount of work and, as a result, the cost of the system.

One of the main issues in the design of intelligent control systems is to determine the range of monitoring parameters of the controlled object. An important issue is to determine the necessary and sufficient number of STEs and their installation locations. It is also important to ensure that system elements work reliably as required. The time it takes to receive information from the STE in cyclic transmission mode depends entirely on the settings provided by the manufacturer. When using STE in the "question-answer" mode, it is possible to reduce the time of receiving data to a minimum, use separate data transmission channels, reduce the amount of equipment on one channel, and reduce the time between requests for important parameters..

When applying intelligent control systems to objects, software tools play an important role in controlling the necessary parameters and ensuring correct decision-making. Before starting software development, it is required to have sufficient information about the parameters of the operating system (OS) of the device in the intelligent control system. There are two types of OS: general purpose OS and real-time OS (RTOS). General-purpose operating systems, especially widely used operating systems such as UNIX and Windows, aim to optimally allocate computer resources between users and tasks. The main task for RTOS is to perceive and respond to events happening at the facility in time [1].

RTOS's user interface may be similar to a general-purpose OS, but its structure is completely different. In addition, the use of RTOS is always unique. If the general-purpose OS is usually perceived by users (not developers) as a set of ready-made applications, RTOS serves only as a tool for creating a certain hardware and software complex in real time. Therefore, the widest category of RTOS users are developers of real-time systems, developers of control and data acquisition systems [2].

The main requirement for RTOS is to ensure the

predictability or determinism of system behavior under the worst external conditions, which is sharply different from the requirements for the performance and speed of universal operating systems.

Comparative characteristics of RTOS and general-purpose OT are presented in Table 1 [1,3].

Table 1

Comparative characteristics of RTOS and general purpose OS

Characteristic	RTOS	General purpose OS
The main issue	Timely response to processes occurring in the equipment	Optimal distribution of computer resources between users and tasks
Orientation	Processing of external influences	Processing user actions
The goal	A tool for creating a specific real-time hardware and software complex	It is considered as a set of ready-to-use applications by the user
User	Skilled programmer	Intermediate user

The most common operating systems in intelligent control systems [4,5]:

- Windows Server (Microsoft, USA);
- Windows XP/7 (Microsoft, USA);
- Windows Embedded (Microsoft, USA);
- VxWorks (Wind River, USA);
- Wind River Linux (Wind River, USA);
- RTOS QNX (SWD, Rossiya);
- RTOS «Neytrino» (SWD, Rossiya)
- MSVS (VNIINS, Rossiya);

The operating systems of the Microsoft Windows family are the most popular groups of operating systems designed to work on IBM personal computers and include all the necessary tools for creating intelligent control systems based on them. Many practical computer programs that work on these operating systems have been developed. In the OS data environment, the most powerful and universal SCADA (Supervisory Control And Data Acquisition) class systems have been developed, for example, FIX, PCP Virgo, Genesis32, InTouch, etc.

Level of learning. SCADA is defined by the progress of the development of the control system of the concept and the results of scientific and technical progress. The use of SCADA technologies allows to achieve a high level of automation in the development, collection, processing, transmission, storage and reflection of information management systems. [6,7].

Dispatcher service provides general centralized management of water supply systems, stable and uninterrupted operation. The dispatcher and the dispatcher service are needed to adjust the work of some parts of the water supply. Individual parts - networks and structures make up the sum total of general production and constant control of the necessary parameters of water supply. Water supply systems are divided into 3 groups depending on the level of automation of dispatcher management [6]:

1. If the water supply is fully automated, in this case, the operation of the units is not provided by the dispatcher service.

2. When the water supply is fully automated and the work of units is repeated using the dispatcher service.

3. When the water supply is partially automated and the work of the main units is controlled by the dispatcher.

Types of dispatcher service:

1. One-stage - DDSM - district dispatch center manages the work of all facilities and networks;

2. Two-stage - CDP - central dispatching point and LDP - (local dispatching point) - coordinates the work of local dispatching points;

3. Three-stage - CDP, DDP, (controlled by CDP) TDP - separate facilities.

One-stage dispatcher service is used when the network length is up to 50 km. Two-stage dispatcher service when the network length is more than 50 km. When the length of the network is 50-400 km, local dispatching points (LDP) of CDP and main facilities and other facilities are established. If the length of the network is more than 400 km, CDP is organized for the networks and is located in the center of the district.

If the length of the network is more than 400 km, CDP is organized for the networks and is located in the center of the district.

Modern ACTP (automated control of technological processes) consists of a multi-level man-machine control system. It implements complex technological processes using automatic information systems and computing systems for the creation of automatic control system (ACS), which are constantly improved according to the level of technical means and software evolution.

The development of ACTP, which is continuous in time, can be divided into three stages, which are qualitatively related to the emergence of new scientific ideas and technical tools. Throughout history, the description of objects and management methods, automation tools and other components that make up the content of a modern management system changes. [6]:

- The first stage represents the introduction of the automatic adjustment system (AAS). At this stage, some parameters, devices, aggregates are considered as control tools; stabilization, software control, tracking issues are transferred from human to AAS. Tasks for calculating tasks and setting parameters for regulators appear in the person.
- The second stage — the automation of technological processes becomes an object of spatially concentrated system management; with the help of automatic control systems (ACS), more complex control laws are implemented, optimal and adaptive control issues are solved, object and system state identification is carried out. A distinctive feature of this stage is the introduction of telemechanics systems to control technological processes.
- The third stage—automated systems of technological process management—is characterized by the introduction of computing techniques to technological process management.

From stage to stage, the range of issues to be resolved by the tasks of the person (operator/dispatcher) who must ensure the regulated operation of the technological process is expanding; the set of issues limited by the need for direct management of the technological process is being filled with qualitatively new issues that previously had an auxiliary character or belong to another level of management.

In the multi-level automated system of technological process management, the dispatcher affects objects located at a much greater distance from the exposure monitor or the electronic information display system, using telecommunication systems, controllers, and intelligent execution mechanisms.

The basis and prerequisite for the effective implementation of dispatch management with a clearly expressed dynamic nature is working with information, that is, collecting, transmitting, processing, displaying, and presenting information.

From the dispatcher, not only competent knowledge of the technological process is required, but also the

experience of working in information systems, the ability to make decisions in emergency and emergency situations (dialogue with EC) and many other things. The dispatcher remains the main participant in the management of the technological process. Technological processes in the water supply system, energy, oil and gas, and a number of other industries are considered to be truly dangerous and, in the event of an accident, lead to the death of people, as well as great material and environmental damage.

According to statistics, the number of disasters recorded for thirty years increases approximately twice every ten years. In addition to natural disasters, human error is the basis of any accident.

One of the reasons for this situation is the old traditional approach to the structure of complex control systems, that is, it cannot correctly assess the need to try to use new technical and technological achievements and create the necessary effective human-machine interface for the dispatcher.

Thus, the requirement to increase the reliability (accuracy) of the dispatcher management system is one of the reasons for such systems: operators targeting the dispatcher and a new approach to the development of his tasks.

Analysis and results. SCADA — friendliness of the human-machine interface (HMI/MMI) provided by the systems, completeness and clarity of the information displayed on the screen, ease of management, ease of use of the reference system, etc. — increases the efficiency of the dispatcher's interaction with the system and zeroes out critical errors in its management.

It should be noted that the concept of SCADA, which consists in the automated development of the main control systems, allows solving a number of issues that were considered intractable for a long time: the duration of the development and preparation of automation projects and the direct financial costs for their production reduce costs.

Currently, SCADA is the main and most promising method of automated control of complex dynamic systems (processes).

It is very important to solve the following issues when implementing modern dispatch management systems:

• Choosing a SCADA system (based on the requirements and characteristics of the technological process);

• staffing;

Selecting a SCADA system is a difficult enough task, similar to multi-criteria decision-making, which is complicated by the impossibility of quantifying a number of criteria due to a lack of information.

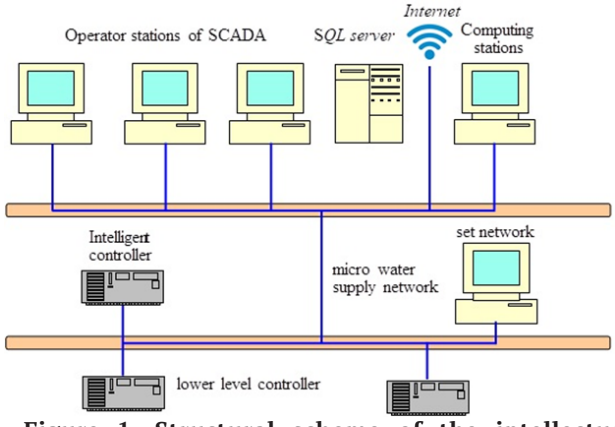


Figure 1. Structural scheme of the intellectual control system.

The structural scheme of the automated intelligent control system recommended for management systems of hydromelioration objectes is presented in Fig. 1. This system is called a two-level system, and direct management of technological processes is carried out at these levels. The unique feature of each control system is determined by the software-hardware platform used at each level.

The lower level - object level (with controller) - includes various sensors for collecting information about the progress of the technological process, electrical circuits and executive mechanisms for performing corrective and controlling effects. Sensors provide information to local programmable logical controllers (PLC-Programming Logical Controller), which can perform the following tasks:

• collection and processing of information about the parameters of the technological process;

• control of electric drives and other executive mechanisms;

• solving automatic logical control problems, etc.

Strict requirements are placed on the accuracy of hardware and software management at the controller level, on the time of exposure to performance devices, sensors, etc. Programmable logic controllers must respond in a guaranteed way to external events coming from the object within a specified time for each event.

From this point of view, it is recommended to use real-time operating system (RTOS) controllers for critical objects. Controllers in RTOS management operate strictly in real time mode.

This class of Instrumental DT includes open architecture packages such as ISA GRAF (Cd International France), In Control (Wonderware, USA), Paradym 31 (Intellution, USA).

Information received from local controllers can be sent directly to the network of the dispatch center, as well as through higher-level controllers. Depending on the problem at hand, higher-level controllers (concentrators, intelligent or communication controllers) perform different tasks. Some of them are listed below:

• collect data from local controllers;

• data manipulation, which can include scaling;

• keeping the only time in the system;

• synchronizing the work of subsystems;

• creating archives according to the selected parameters;

• information exchange between local controllers and higher level;

• work in autonomous mode when communication with the higher level is broken;

• backup of data transmission channels, etc.

A high-level dispatch point (DP) consists primarily of a dispatcher/operator's automated workstation (AW). A database server, workstations (computers) for specialists, etc. can be placed here. Computers of the Core I5 type are often used as workstations. Control stations are designed to reflect the progress of technological process and operational management. These issues are handled by these SCADA systems. SCADA is a special software that is designed to provide an interface between the dispatcher and the control system, as well as to communicate with the outside world.

The spectrum of functional capabilities is determined by the role of SCADA in control systems and is implemented in almost all packages:

• automated processing that allows you to create the DT of the automation system without real programming;

• tools for executing application programs;

• collecting primary information from lower-level devices;
• primary information processing;
• recording (registration) of alarms and data;
• subject to further processing of the information (usually carried out in databases);
• visualization of information in the form of mnemonics, graphs, etc;
• the ability to work with a collection of parameters considered as a "single whole" ("recipe" or "devices") of the application system.

When embarking on the development of custom application software (AS) to create a control and management system, a system integrator or external user usually chooses one of the following paths.:

• Programming using "traditional" tools (traditional programming languages, standard tools for editing, etc.);
• Available, ready-to-use instrumental problem-oriented tools from COTS (Commercial off the shelf).

Choosing a SCADA system is a difficult enough problem, similar to the search for an optimal solution in a multi-criteria environment.

Below is a sample list of SCADA system evaluation criteria that should be of primary interest to the user. Three large groups of indicators can be distinguished in it:

• technical specifications;
• value descriptions;
• usage descriptions.

Conclusions

When creating intelligent control systems of water supply networks, the developer always faces a number of difficulties and must be ready to find solutions to them. From the point of view of creating intelligent monitoring and control systems for technically complex objects, the following should be taken into account:

- Using STE in "question-and-answer" mode;
- using the minimum number of data exchange protocols;
- Application of SCADA systems for MS Windows OS based systems;
- only using proprietary software when off-the-shelf solutions are not available.

Taking into account these circumstances, the development and implementation of an intelligent control system will further increase the efficiency of hydromelioration facilities.

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