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Some aspects of automation of water consumption accounting

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Abstract. This article explores the integration of modern information technologies, such as Geographic Information Systems (GIS) and automated water meter devices, into daily water distribution practices. By leveraging these advanced tools, agricultural managers can significantly enhance their operational decision-making processes, especially in response to dynamic changes in irrigation circuit conditions. The implementation of GIS allows for detailed spatial analysis and visualization of water resources, while automated water meters provide real-time data on water consumption and availability. This combination not only improves resource management but also facilitates timely adjustments based on various factors, including water availability and weather parameters. As conditions change, such as rainfall or temperature fluctuations, operators are better equipped to make informed decisions that optimize water use and minimize waste. Ultimately, the incorporation of these technologies represents a transformative shift towards smarter irrigation practices, ensuring sustainable water distribution and improved agricultural productivity in an era of increasing environmental challenges.

1 Introduction

In recent years, within the framework of large -scale institutional reforms carried out in the country, measures have been taken to increase the effectiveness of public administration in the field of water economy. Analysis of water management revealed that [1]:

- Establishing ten-day (or weekly) and daily water scheduling and allocation, as well as setting limits and control measures, is particularly challenging;
- Automated water meters with real-time remote data transmission capabilities are needed to monitor and adjust water delivery schedules based on end-user needs;
- Provision of basic services such as cleaning, repair and maintenance and keeping the entire water supply network infrastructure in good working order is also a paramount archival task.

In accordance with the Decree of the President of the Republic of Uzbekistan No. 3226 dated March 24, 2003, the transition to hydrographic water resources management was

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implemented and Basin Irrigation System Administrations (BISA) on water resources were established, which are organized by river basins and systems [2].

The main tasks of BISA are the organization of targeted and rational use of water resources based on the introduction of market principles and mechanisms of water use, pursuing a unified technical policy in the water economy based on the introduction of advanced water -saving technologies.

First of all, in order to improve and enhance the functioning of BISA it is necessary to:

1. To carry out uninterrupted functioning of communication between BISA volumes and provide them with automation, telemechanization and computerization systems.
2. To carry out reconstruction and modernization of BISA canals, reservoirs, pumping stations and facilities.
3. To improve water resources accounting and equip water allotment points with hydrometric posts.

2 Methods

The management information system (MIS) is a set of information, economic and mathematical methods and models, technical, software, other technological means, and designed for information processing and management decision-making [3].

The MIS should allow for remote production of:

- accounting of water consumption;
- counting of water given for a control period (day, decade, month, etc.);
- user-friendly operator interface;
- logging of events;
- archive storage;
- significant reduction of maintenance costs and increase of efficiency of operational services by remote parameter control;
- total water metering;
- automatically generated reports for management without employee involvement.

The MIS is especially necessary for managing surface water resources in the basin as a whole and irrigation systems, organizing their targeted and rational use, and coordinating all elements of the complex system from a single center - the management center [4]. Implementation of full automation and unified control of all processes will allow reducing water losses, making the system operation more efficient, reducing the number of personnel and improving the efficiency of their work, thus obtaining significant savings, as well as significantly improving the reliability and quality of services for the end user. At the same time, it is quite important to select the right equipment. The main classification features of MIS are [5]:

- the area of functioning of the object;
- types of control processes;
- the degree of automation of information processes;
- the level of structuring of solved tasks;
- the nature of the use of information.

The classification in the field of functioning of the facility is focused on the production and economic activity of enterprises and organizations of various types. These include the MIS of industry, reclamation and agriculture, geology, transport, communications, banking information systems (IS), etc.

According to the types of IS management processes can be categorized into:

- process control ISs are designed to automate various technological processes (flexible technological processes, power engineering, etc.).

- IS of organizational and technological process control are multi-level, hierarchical systems that combine process control and decision-making [6].

Water resources MIS can be referred to the second class, which is a multi-level, hierarchical system combining technological process management and decision-making IS, since only a multi-level approach can cover several levels of water resources management hierarchy - starting from end water users to the main BISA management and beyond.

The solution to the problem of creating a multi-level, hierarchical system is a geographic information system (GIS) designed to provide processes for developing optimal spatial solutions based on geoinformation and spatial analysis of relevant, reliable and complex geoinformation and geoinformation data processing methods [7].

Geoinformation analysis - analysis of location, structure, relationships of objects and phenomena using spatial analysis and geomodeling methods.

Spatial analysis - a group of functions providing analysis of location, connections and other spatial relations of spatial objects, including analysis of visibility zones, neighborhood analysis, network analysis, creation and processing of digital elevation models, spatial analysis of objects within buffer zones, etc. [8].

Geomodeling (geoinformation modeling) is a creative process of creating a computer simulation model of spatial objects, processes or phenomena, as well as studying the relationships between them using geographic information systems.

One of the main directions of using GIS in the implementation of activities, includes the study of:

- socio-economic condition of territories;
- economics and finance;
- ecology, water resources and nature management;
- agriculture.

An important tool for water resources management is automation of water distribution systems based on modern information technologies, which will improve the quality, flexibility and reliability of water distribution management, as well as reduce unproductive losses of water resources, namely, it will allow to remotely:

- control all processes occurring at the facilities;
- change the parameters of devices included in the object;
- receive all the necessary information;
- view operation protocols;
- create reliable information archives;
- increase the reality of water use plan fulfillment;
- create conditions for sustainable, equitable, fair water allocation, guaranteeing water supply stability and uniformity, and excluding unproductive water consumption [9].

At present, there is a deficit of water resources in our republic, which causes limited water use. Therefore, each water user is interested in correct accounting of water distributed to him. For this purpose, it is necessary to have a well-established water accounting system. However, this system should take into account not only water supply but also drainage from the irrigated area, which is necessary for determining the water balance, non-compliance with which leads to deterioration of land reclamation state and, consequently, to low crop yields.

With the transition to market relations, each water user is interested in correct accounting of water used by him, as he will have to pay for each cubic meter of water from his pocket.

Water accounting and related distribution of water resources has a direct relation to the ecological situation. After all, incorrect water accounting leads to salinization, waterlogging and desertification of vast areas of our region [10].

Therefore, development of measures on irrigation systems to improve water-metering facilities is extremely necessary at present, when there is an intensive process of mass construction of water-metering facilities on on-farm irrigation network.

Accurate operational water accounting and water distribution form the basis for rational use of water and land resources, ensure normal ameliorative condition of irrigated lands and high crop yields, and contribute to the improvement of farming culture.

Introduction of full automation and unified control of all processes will allow reducing water losses, making the system operation more efficient, reducing the number of personnel and improving the efficiency of their work, thus obtaining significant savings, as well as significantly improving the quality of services for the end user. The general concept has shown in Figure 1.

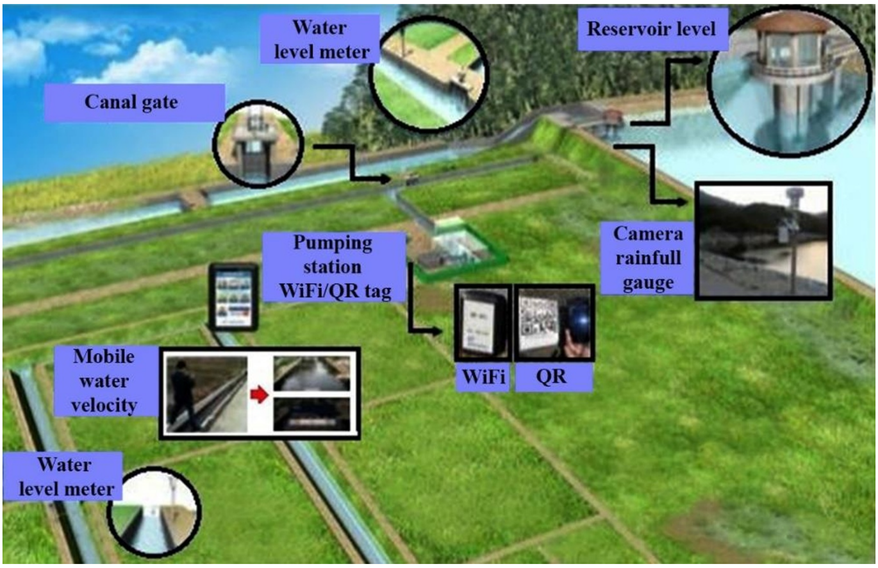

Fig. 1. General concept of water resources management automation based on modern information and communication technologies.

When creating water automation systems, it is not always possible to organize wired communication lines. As a rule, in such cases, data transmission is carried out via wireless canals. One of the most common methods is data transmission through distributed networks via GSM-channel [11]. In this case, there is a need to choose such means of communication, which would have a certain set of functional capabilities and at the same time would be reliable in operation and convenient to use.

The system uses three methods of transmission of teleinformation by GSM channel: data transfer by GPRS, direct connection of CSD and transmission of SMS messages. The maximum remoteness of controlled objects from the control point is limited only by the zone of coverage of mobile operators. It is such that is GSM/GPRS modem, which is designed for remote data exchange through wireless GSM communication systems with equipment equipped with a consistent RS-485 interface (Figure 2).

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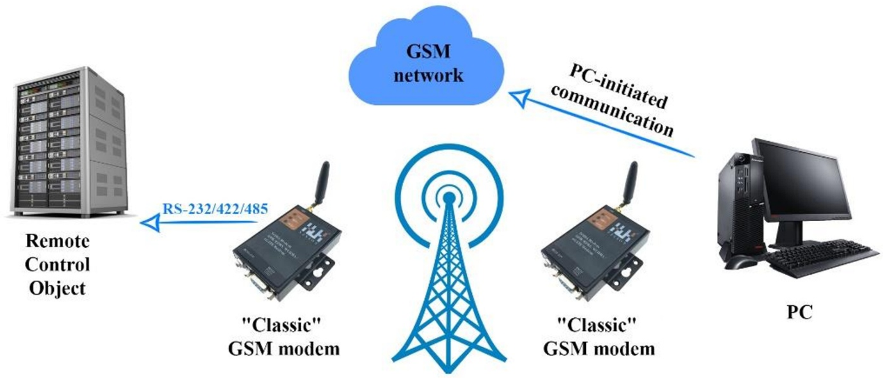

Fig. 2. The topology of the remote-control system via GSM networks.

The technology of exchange of short SMS messages is simple in setting and provides a transparent data transfer canal without the need to pre -set the connection. The restrictions on the use of this function are related to the transmission of SMS messages, as It implies a portion of data up to 140 bytes and secondly, large volume data (i.e., not accommodating in one SMS message) will be divided into several messages. When testing modems, a situation has repeatedly arisen when the procedure for receiving messages differed from the procedure for sending them (Table 1).

When using GPRS technology, information is collected in packages and transmitted through the currently unused voice canals. As a rule, GPRS packages have an IP format, so the addressing of GPRS devices is carried out not by the subscriber's phone number, but by IP address, but data tariffing is carried out in terms of data transferred. GPRS technology allows you to use several voice canals at the same time, i.e. transmit data at speed much larger than in SMS [12].

Table 1. The results of testing of data transmission technologies.

	CSD technology	SMS technology	GPRS Real Com technology	GPRS Client-Server technology
Channel delay (average)	0.6 sec	7.6 sec	0.5 sec	1.3 sec
Channel delay (minimum and maximum)	0.5 sec (min.) 0.9 sec (max.)	5.9 sec (min.) 9.4 sec (max.)	0.3 sec (min.) 1.5 sec (max.)	0.1 sec (min.) 3.9 sec (max.)
Channel capacity (average)	1021 bytes/sec.	-	644 bytes/sec.	613 bytes/sec.
Channel capacity (minimum and maximum)	940 bytes/sec. 1120 bytes/sec.	-	190 bytes/sec. 1787 bytes/sec.	42 bytes/sec. 1190 bytes/sec.

A clear water distribution based on the proposed automation and monitoring system should be based on a reliable water training. For this purpose, it is necessary to carry out calibration and metrological support of all nodal structures, balance hydroposts, installation of automatic water measuring devices Gauger GSM (Figure 3).

Fig. 3. A Gauger flow meter with integrated GSM modem.

At each remote object there is a flow meter, which polls sensors, provides creation of archives of measured parameters and controls GSM-modem (Figure 4). GSM-modem provides remote data transmission between objects. Two modems are used in this system: main and emergency. The central control center is a PC designed for round-the-clock monitoring of the situation, information from which can also be viewed by other services via the Internet, delimited by access level.

The flowmeter sends the measured and calculated data to one, predetermined addressee. The information is transmitted via GSM network in the form of GPRS messages. Supported GSM frequencies: 850, 900, 1800, 1900 MHz. Each message contains details of one measurement result. The recipient of GPRS messages from the flowmeter is usually a personal computer or server. The user can see the received data with the help of monitoring program in tabular or graphical form [13].

In normal mode, the device constantly consumes power and makes continuous measurements, sends periodic messages, as well as, emergency signals in case of abnormal situations. The periodicity of message transmission is set during initial device setup and can range from 3 minutes to 45 days [14].

In the low-consumption mode, the device is in the standby state and is periodically turned on to transmit measurements. This mode does not support the transmission of emergency signals. It is possible to select one of three standby intervals, including the shortest standby period in case of monitoring a rapidly changing level.

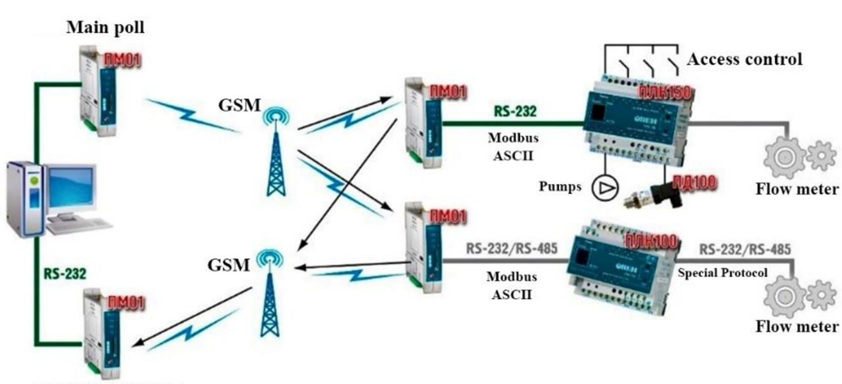

Fig. 4. The functional scheme of automation canal water.

This water metering device on irrigation and drainage systems takes into account operational, design and construction and technical-economic requirements [15]:

-provides automated accounting of water consumption and runoff during distribution in the irrigation system to fulfill the water use plan and rational use of water resources;

- conformity of design elements, technology and simplicity of construction of water-metering structures, devices. Possibility of installation of metering devices, automation and telemechanics facilities, provision of their industrial and polygon (block) manufacturing, transportability, uncomplicated installation, as well as simplicity of start-up and adjustment works and uncomplicated operation;

-universality and typization of water-metering devices designs. Their use at re-equipment of existing structures of various purposes into water-metering (with small reconstruction costs) structures. Unification and interchangeability of elements of water-metering device designs;

- reliability of operation under different conditions and canal operation modes, sufficiency of application range, independence of operation of water-measuring structures and devices from the character of flow outflow into the downstream (including backwater-variable regime), possibility of their operation with insignificant loss of head, etc. Possibility to protect structures from water overflowing into embankments;

- simplicity and reliability of protection of water-measuring devices from unauthorized interference. Convenience of inspection, checking of operation, repair, replacement of parts, installation of devices, automation means, their interchangeability, blocking;

- safety of works and their operation;

- operation of water-metering facilities and devices should not be disturbed due to sedimentation, debris, floating objects and other factors of both the measured and external environment.

3 Results and discussion

In 2020, a system of automation of water management automation was started in order to improve the quality, flexibility and reliability of control, as well as reduce unproductive losses of water resources. As an experiment, it was installed on the canal in the Tashkent region (Figure 5).

Fig. 5. The location map of the automatic flow meter in the Tashkent region.

Gauger GSM monoblock ultrasonic level gauge with built-in GSM cellular modem is installed as a flow meter (Figure 6). The device measures the distance to the flow surface and converts it into level or volume. Data transmission is provided by the modem, which is structurally combined into one unit with the controller.

The software of the controller provides [16-20]:

- measurement of controlled parameters;
- reception of control commands;
- availability of service programs providing:
- *program recording;*
- *recording of the structure of measured parameters, output power signals;*
- *input of coefficients for calibration for each measured parameter;*
- *input of parameter variation ranges;*
- *recording of settings for each monitored parameter.*

The water distribution automation system on the canals allowed:

- to increase the accuracy of measuring levels, water flow due to the use of modern automatic technical instruments and accounting of water resources;
- to improve information support due to continuous collection, storage and processing of measuring values of the levels and water costs in computers (Figure 7);
- to increase the efficiency and accuracy of water management by increasing the speed of obtaining and processing information about the technological process and making a decision;
- to reduce unproductive expenses of water resources;
- timely detect and eliminate malfunctions of the equipment system and hydraulic structures.

It should be noted that the installed systems have increased the level of operation, significantly facilitating the labor of operation personnel, and improved the quality of water distribution.

Based on this, it is possible to establish a real system of water use control, as well as reliability, openness and accessibility of information on water resources for all interested organizations and water users.

Fig. 6. The installation of automatic flow meter.

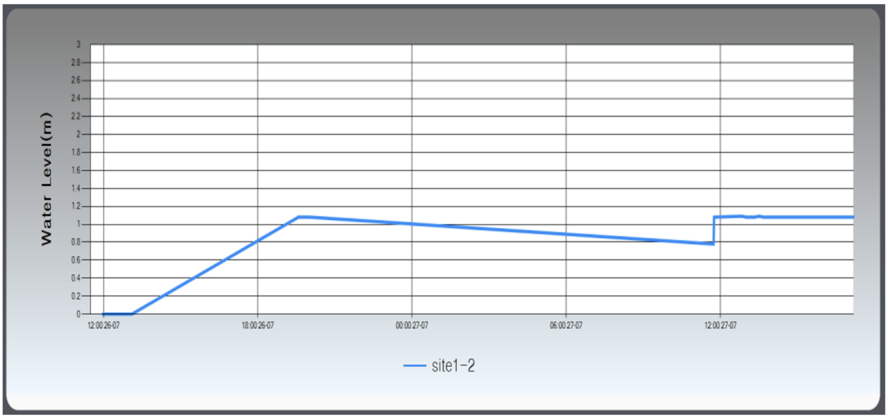

Fig. 7. The graphs of issuing results.

4 Conclusions

The automation and monitoring system of water distribution on the canals allowed:

- increase the accuracy of measuring levels, costs through the use of modern technical instruments and accounting of water resources;

- improve information support, due to continuous collection, storage and

- processing measuring values of levels and water costs in computers;

- to increase the efficiency and accuracy of water management by increasing the speed of obtaining and processing information about the technological process and making a decision;

- to reduce unproductive expenses of water resources;

- timely detect and eliminate malfunctions of the equipment system of hydraulic structures.

It should be noted that the established automation systems increased the level of operation, significantly facilitating the work of operational personnel, improved the quality of water distribution in the canals.

Based on this: it is necessary to create a real control system to increase the reliability, openness and accessibility of information about water resources for all interested organizations and water users.

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