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# BIG DATA IN WATER SUPPLY AND SEWERAGE SYSTEMS

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**Abstract:** Digitization in the field of water supply and sewerage is associated with the concept of processing extremely large amounts of data (big data) and processing and analysis of these data (data mining). In essence, the significance of the mentioned data for water supply and sewerage systems is huge, but in order to understand their role, it is necessary to assess the possibility of using and applying these data. In conditions in which data from various sensors and equipment in the field of kai and data related to customer needs are permanently obtained, the amount of this data increases significantly. Replacing classic water meters with smart ones also significantly increases the amount of information. New trends in the management and supervision of water supply and sewerage systems enable operators to make maximum use of this data, and management to undertake activities at the tactical and strategic level. Modern SCADA (Supervisory Control and Data Acquisition) systems significantly contribute to the rapid detection of infrastructure failures, reduction of losses by detecting leaks, overflows in tanks. Based on the collected data, operational efficiency is improved, opportunities for proactive maintenance of water and sewage resources are identified, as well as preparation for long–term investments.
**Keywords:** data, acquisition, control strategy, supervision

## INTRODUCTION

Information related to the needs of clients in the water supply and sewerage sector is one of the most important data, which can be used to predict the required amount of water for a certain part of the water supply area in order to achieve optimal efficient network control. In the individual sense, the data can indicate whether there is a leaking in a particular client [1]. The information acquisition from the water meter can be used to detect zones in which e.g. pressure control and in which unusually high consumption occurs. The data can also be used for the implementation of complex algorithms that calculate in which regions the lowest revenues are achieved during the exploitation of water by customers [1], [2].

The data obtained, especially from smart water meters, can be useful in many ways. This data is collected for a month or more and is mainly used to bill users. By increasing the frequency of collecting this data via smart water meters, the amount of this information increases by an order of magnitude. The temporal character of the data is extremely important, since medium–term information is vital for the daily activities of the water supply system, and long–term data play a role in creating a control strategy [3].

The analysis of operational data in the field of water supply and sewerage leads to the knowledge of current situations. This data has great potential for the big data sector. Knowledge of the situation is crucial for operators in management and control centers and for maintenance services to respond in a timely manner.

Operational data enables the identification of risks related to a specific consumer or a specific zone in which efficiency is relatively low, while process optimization would lead to savings for both the company and the client. Operational data is usually used on a daily basis or within a week. In the long run, data on parameters and process values can be indicators of the periodicity of maintenance of specific equipment and indicate the need for investment in order to improve the existing infrastructure [4], [5].

## SUPERVISION AND EFFICIENCY

In companies whose activity is the development, construction and maintenance of water supply and sewerage systems, there are a large number of sensors and automation elements in the field that send large amounts of data to supervisory control centers with a high frequency. These data are of interest for the functionality of water supply and sewerage systems, and data analysis provides an opportunity to optimize operation, preventive, current and investment maintenance of the systems themselves, correction of management algorithms to increase efficiency and reduce operating costs. Operators in the management system can e.g. to reduce the dosing of activated carbon in wastewater treatment plants, precisely by analyzing the large amount of data coming from the sensors in the filter fields [6].

Due to the fact that the activated granular coal changes in a timely manner, the concentration of trihalomethane is maintained in the allowed range. Further improved efficiency can extend equipment life. With the help of quality data, you can e.g. in wastewater treatment plants, reduce the dosage of chemicals and maintain the essential parameters of the treated water (e.g. pH value). In this way, reducing the amount of chemicals can limit or delay the deterioration of the most important equipment of these plants [7].

## PREDICTIVE ANALYSIS OF DATA

Water and sewage systems can have a significant benefit from the large amount of data generated by various equipment, especially when creating predictive models that lead to more precise and detailed results. The application of big data in water and sewage systems is reflected in the preparation of predictive maintenance strategies [7].

IoT sensors, which are an integral part of the equipment, provide information on key parameters such as temperature, vibration, speed, level, etc. Algorithms for big data analysis find a correlation that allows a fault prediction to be made very quickly for a particular device operating in a mode outside the nominal range. Predictive maintenance strategy can increase the service life of equipment and increase the efficiency of maintenance programs, which allows to avoid costly delays by timely signaling the potential failure of a particular device.

Some modern supervisory control systems can turn off a certain device, which is on the edge of failure, with the appropriate message, light and sound signaling [8]. Big data can combine inside information with information from third–party sources to improve the quality of the predictive model. It is possible e.g. combine data from multiple wastewater treatment plants, which allows for thorough analysis to detect trends and forecast inlet flow balances and enables operators to take appropriate action. Improved procedures for the acquisition, processing and use of large amounts of data can be of great importance for companies whose activities are water supply and sewerage. Wastewater treatment plants in this sector often have problems with depreciation and equipment that is difficult to maintain due to extreme operating conditions and inaccessibility [9].

Precisely on the basis of big data, it is possible to act preventively and perform the necessary interventions in a timely manner, which preserves the equipment and avoids costly delays. Water supply and sewerage systems began to use the benefits of big data relatively late, which increases the reliability and optimization of services provided to customers. Some of the big data solutions available on the market enable integration with sensor and communication technologies, modeling procedures and SCADA systems.

With the accelerated application of advanced computer systems, cheap sensors that measure various process quantities and parameters, data is collected and sent to control devices. Cost–effective data warehousing systems and water companies can get much more real–time information at reduced costs, and in some cases, data from hitherto unavailable zones [10]. Smart technologies such as big data allow operators to optimize customer service.

According to the analyzes, despite the fact that the road is relatively long, the water supply and sewerage sector has taken the right direction in its further development. However, in order to fully justify investments in smart technologies, it is necessary to have a clear idea and vision of organizational and strategic goals, while implementing and adapting business plans.

The main task and ultimate goal of the system for data collection, processing and analysis in companies dealing with water supply and sewerage problems is to provide quality services in the field of information, which facilitates the work of operators and helps managers develop new opportunities for cost monitoring and risk management improving all service levels [11–13].

Implementation of intelligent systems so–called AMI (Advanced metering infrastructure) in the field of water supply and sewerage is growing. Smart grid solutions are widely represented in electricity distribution companies, and they are also finding their way into the water supply sector, so that today we can talk about intelligent networks in water supply [14].

## SMART TECHNOLOGIES

Smart technologies are aimed at solving key challenges in the water supply and sewerage sector, such as water and energy losses, lack of water resources on a global level, management of current and operating costs, etc. There is already a wide range of reliable intelligent devices on the market, such as AMR (automatic meter reading) and complete solutions that can be applied in solving problems related to water supply and sewerage. This is also the case with the more recent AMI technology, which is increasingly available in financial terms [14].

## AMI INFRASTRUCTURE

AMI infrastructure is an automated two–way communication between a measuring device (e.g. a water meter) with an IP address and a water supply company.

The basic idea for the application of AMI applications in utility systems is to obtain basic real–time data on water needs, status and energy consumption of installed equipment in the water supply and sewerage system, based on which forecasts can be made about accidents, downtime, and losses in system, etc. [14]. Both water supply systems and customers benefit from the introduction of intelligent technologies. The key is in the data that AMI systems operate with.

Possibilities for monitoring and analyzing the behavior of water supply networks and equipment, as well as identifying various problems justify serious investments in the construction of intelligent water infrastructure. In the future, data from intelligent measuring devices and sensors will be increasingly used in the water sector not only in solving operational tasks such as registration, localization and troubleshooting (leaks, failures, etc.) but also in strategic goals such as reducing operating costs, predictive maintenance of devices and equipment, improving the quality of services, efficient forecasting of infrastructure investments, etc. [15].

## AMI PLATFORMS IN FUNCTION OF INCREASING THE EFFICIENCY OF WATER SUPPLY SYSTEMS

Thanks to AMI systems, the need for manpower is reduced, data acquisition related to users and account generation is fully automated and remote. Based on the data collected from smart water meters, the processes of water storage, transport and distribution, timely detection of water leaks and reduction of losses can be improved.

Two–way communication enables better provision of services to users through precise and adequate calculation of consumption, as well as efficient preventive, current and investment maintenance of resources. The systems for segmentation and analysis of customer bases that are the basis of modern AMI platforms can help identify the needs and requirements of customers of water companies, as well as activate various programs that will reduce losses in water supply [14]. Based on these capabilities, water utility companies can achieve various goals related to efficient management, optimization of equipment operation, planning, forecasting and proactive control of capital investments.

## WATER SUPPLY SUPERVISION

Nowadays, the application of supervision and control of water supply is increasing, in urban and rural areas, where individual users and industrial consumers have an insight into water consumption. Because water resources are limited, there are two main objectives of monitoring:

- reducing water losses and
- rationally control of needs [6], [7].

Although various strategies and programs are applied in the world to reduce water losses, primarily through the use of modern supervisory control systems, water losses due to irrational use and leaks in various places are a very serious problem in the water supply system. The European Environment Agency gives a forecast until 2030. That the need for vision, on a global scale, will increase by as much as 40 % [8], [9].

## SENSORS IN FUNCTION OF EFFORTS TO REDUCE WATER LOSSES

With the technological development of sensors and with the reduction of their price, they become an integral part of supervisory control systems in water management.

Wireless sensor networks can be implemented both independently and as part of complex platforms for water resources control in individual, commercial – business and industrial facilities [6], [7]. Modern supervisory control systems used in plumbing systems are connected to flow sensors usually in the range of 0.15 to 60 L/min. The sensors send data to the center, which activates an automatic alarm, if the flow has certain values higher than the set threshold. This allows operators to register local leaks and undertake appropriate overhaul activities on the water supply network to combat water loss.

According to Libelium, a Spanish supplier of sensor technology and IoT applications, the use of sensor technology in water management in Japan saves $ 170 million annually [16]. In the floors of individual buildings, shopping and business centers and in various industrial facilities, sensors are installed that can register the existence of leaks in water pipes. In open water supply networks, soil moisture sensors installed at an appropriate distance from each other can signal a drastic increase in soil moisture, which is a warning of possible water leakage and a signal to optimize irrigation.

Strategic deployment of sensors in the entire area of water supply provides sufficient data necessary for the functionality of the supervisory control system. The data is sent wirelessly and at certain intervals to the control center where it is processed and analyzed. They can also be applauded on a cloud server or over the Internet where they are publicly available to citizens or industry.

## WATER SUPPLY SYSTEM – EXAMPLE

An example of a complex water supply system, which consists of a number of technical – technological units is the water factory Mediana 2 in Nis.

The supervisory control system is based on programmable logic controllers and operator panels, which are interfaces between the operator and the plant. The control system is also connected to the SCADA computer in the control room (CR). Nominal factory mode is automatic. For special purposes, individual technical units can be switched to manual control mode, which is suitable for testing equipment during overhauls and maintenance. The block diagram of the factory management is shown in Figure 1.

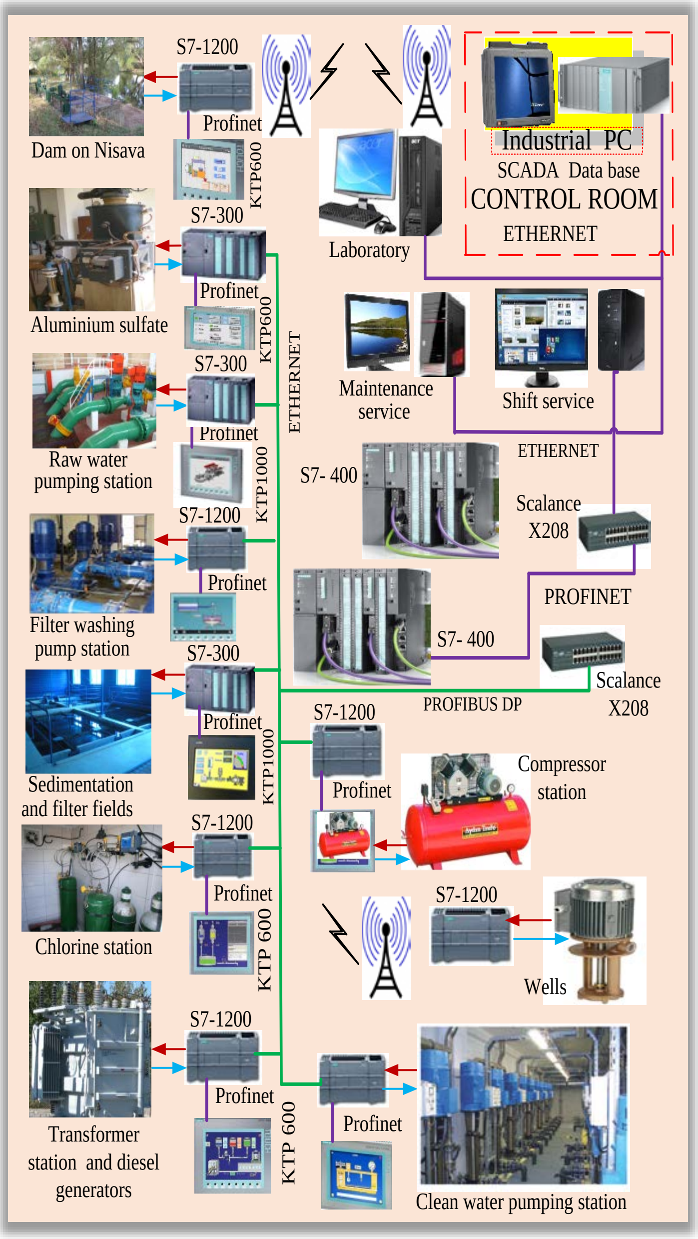


Figure 1. Block diagram of supervisory control of Mediana 2 water supply system

A large amount of data is generated, acquision and processed here [6], [7]. Basically, the control of the Mediana 2 water supply system is a central supervisory control system installed in CR.

The system architecture is based on a master–slave configuration consisting of PLC controllers:
- the master PLC is Simatic S7–400 (redundant pair);
- S7–300 (Al sulfate preparation and dosing plant, PS of raw water, sedimentation and filter fields, PS for washing of filter plant, clean water pump station);
- S7–1200 (transformer station, diesel generator, dam, system for mechanical water purification – mechanical rakes and sieves; compressor station, chlorine station) [6], [7].

Each local controller is connected to the operator panel KTP communication protocol PROFINET. The connection of the master controller to the slave controllers and servers was done via the ETHERNET network. A real–time database server has been installed in CR, which distributes data to workstations – clients (CR, maintenance service, chemical laboratory, management) [6], [7].

SCADA is organized in the form of menus and submenus, showing the functionality of the system with certain animations (e. g. operation of pumps, electromotor valves), the change of a quantity in real time in the form of a trend graph or in digital form (level values, flow, turbidity, residual chlorine, etc.), reaching the limit values is signaled as an alarm message with sound and light signaling. The main tasks set before the SCADA system are:
- acquisition of real–time digital and analog data from all objects connected to the system (a large number of tags);
- archiving relevant information obtained on the basis of collected data in a relational database;
- presentation of real–time and archived data via synoptic screens, trends, charts and tables;
- real–time control and supervision of water intake, mechanical water purification, chemical preparation, well plants, pumping stations.

The master redundant tandem system of PLCs S7–400 in conjunction with a SCADA computer in CR dictates communication with all remote stations, sends queries, commands and accepts and archives all messages arriving from controled objects [6 – 9].

## DISPLAY OF FILTER WASHING PUMP STATION

Figure 2 shows one SCADA screen of a pump station (PS) for washing filters. It is one of a number of technical units of the Mediana 2 water supply system. Within this PS there are 3 pump units whose power is 75 kW – two working pumps and one spare which, if necessary, works in alternation with the main pump [6], [7].

The pumps are powered via frequency inverters. Each inverter at the input has semiconductor fuses and compact switches with the possibility of remote shutdown in case of failure or blockage of a particular pump.

The control of the PS for filter washing is from the PLC system which, based on the obtained sequence and the state of openness/closure of individual valves in the filter fields, includes and gives permission for switching on the drive of a certain pump. Pumps provide a set flow value in the discharge line to the filter fields. A flow meter (Fp) is installed on the pressure pipeline. The maximum set flow is 125 L/s. The flow rate information (analog signal 4–20 mA) is input to the analog input of the PLC from where, according to the number of active pumps and the selected operating mode, the reference flow values for each of the pump units are transmitted as analog values to the inputs of frequency inverters.

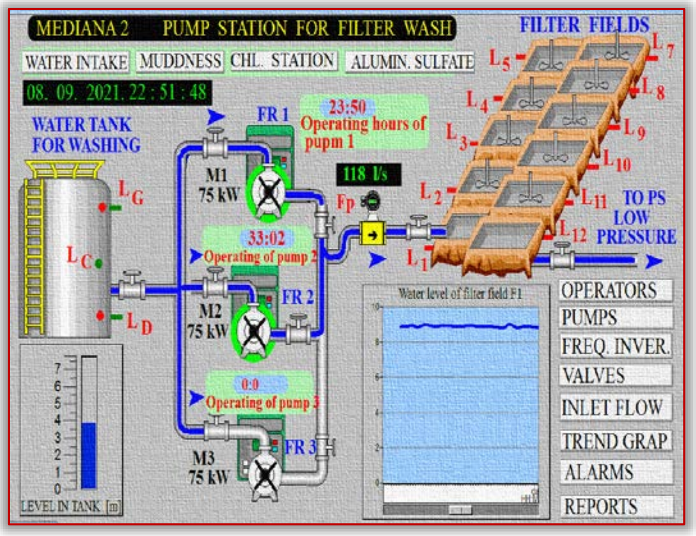


Figure 2. SCADA screen in CR of water pump station, for filters washing

Protection against dry running of PS pump units is via built–in hydrostatic probes for continuous level measurement. Control of the operation of the PS for filter washing and regulation of the flow of washing water in the discharge line was realized using the Siemens S7–1200 PLC [6 – 9].

## CONCLUSION

It is obvious that an extremely large amount of data is generated in water supply and sewage systems. The paper describes the control – monitoring system based on PLC and SCADA configuration with decentralized distributed control of technological units, which are integral parts of the water factory.

The control units perform program control of the plants and regulation of technological quantities and parameters such as levels, flow, speed, pressure, pH value, turbidity, dosing of aluminum sulfate, chlorine, etc. Various situations in the work of installed machines and devices are considered and they are protected from technological and electrical accidents. Graphical display of components using dynamic screens allows the operator to monitor the process.

The transformer station and diesel generator, dam, mechanical water purification process, preparation and dosing of aluminum sulfate, chlorine dosing, processes in filter fields, sedimentation tanks, raw water pumping stations, filter washing water and clean water are controlled. The control system identifies changes in the state of the process, diagnoses and evaluates errors, enables prediction of the behavior of control objects in the conditions of changing input variables and generates optimal values of control signals in order to achieve the prescribed water quality. In addition, the system performs the acquisition, processing and archiving of data related to the values of process quantities and the state of the installed equipment. It is possible to create and print shift and periodic reports on the functionality and availability of individual technological units and the course of production, based on which analyzes and necessary corrections are made in order to increase efficiency. Alarm states that occur in case of failures or exceeding the set values of certain quantities are also monitored.

The proposed supervisory control system enables:

- periodic reading of characteristic sizes and working hours of devices and equipment,
- archiving of changes on all digital and analog inputs and outputs of control units,
- long–term archiving of all actions of the operator,
- assigning flexible work schedules.

Visualization of controlled objects with graphical and tabular display of relevant physical values and parameters is of great importance for the maintenance sector. On the SCADA system screen, through dozens of intuitive screens, there is an insight into the functionality of the water factory, and the appearance of alarm signals enables faster localization of faults, which significantly increases the efficiency of maintenance. Light and sound signaling of reaching critical values (alarms) is enabled, during which appropriate control logic activities take place.

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