Value-Based Concept in the Architecture Model of a Water Supply Company

Dmitry Serov, Igor Ilin, and Sofia Kalyazina

Abstract The article analyzes the activities of a water supply company, builds an existing model of enterprise architecture, gives suggestions for reengineering the model, and builds a target model of enterprise architecture. When building the target model, the goals of achieving maximum value for the end consumer were taken into account simultaneously with the achievement of maximum results of the enterprise's efficiency. This work required significant changes and modernization at the application level and the technological level. As a result, a unified system of automated active monitoring and control of the water supply system is being formed.

Keywords Resource-supplying organization · Model of the enterprise architecture · Value-oriented approach · Water supply and sewerage enterprise

1 Introduction

Water is an important natural resource; the availability and quality of which directly affect the functioning of various sectors of the national economy. Stabilization and development of the country's water supply and sewerage system are components of ensuring sustainable economic growth and improving the living standards of the population. Effective management of water resources is necessary to maintain the quality and availability of water, and in a broader sense—to form optimal social, economic, and environmental health [1]. In this case, the changing conditions of the environment and climate should be taken into account. It is also important that the water sector operates in a complex interplay between water resources, socio-economic, and ecological systems.

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Optimization of investment and operational activities and the management system of water supply and sewerage enterprises require the correct definition of criteria and quality indicators, standardization, and implementation of modern information and analytical systems.

In accordance with the federal legislation of the Russian Federation [2], water supply includes "water treatment, transportation, and supply of drinking or industrial water to subscribers using centralized or non-centralized cold and hot water supply systems".

The expanded water supply chain includes such technological stages as water intake from water supply sources and supply to treatment plants, water treatment (drinking water preparation), transportation of treated water to the consumer (through water supply networks using booster pumping stations), and transfer purified water to the consumer.

Water management aims to meet the increasing demands of different consumers. For example, the main values of the end consumer are the provision of water in the required volume, with the necessary pressure, with the proper quality, 24/7, at commensurate tariffs and with an understandable calculation, as well as general quality service for the subscriber. In this case, it is required to consider the values of the consumer taking into account the existing contradictions between them [3–5].

The article examines the case of a water supply organization, which set the task of implementing the value approach. A personalized, value-based approach to working with consumers requires the preliminary collection and analysis of consumption data, the design of a personalized value proposition [6]. The implementation of this approach requires the use of modern information and communication and digital technologies. Building a value proposition model requires reengineering the enterprise architecture. In this regard, the article discusses the necessary changes that need to be made during the transformation.

2 Materials and Methods

In this article, the following approaches are used as a methodological basis for the study:

1. An architectural approach. Enterprise architecture is considered as an integrated approach to the integration of heterogeneous elements (business processes, functional structure, organizational structure, information systems and technologies, digital technologies, production technologies, and assets) into an effective business system [7–10].
2. Service-oriented approach as a means of harmonization (coordination) of requirements and capabilities of business and IT elements of a single system [11–13].

When building an enterprise architecture, the following levels are distinguished: the business level (describes the activities of the enterprise and its development), the application level (describes applications, data, and their relationships), and the technological level (describes the hardware and system software) [14].

In this article, a water supply organization was investigated. Based on the results of considering the current activities of the organization, a model of the enterprise architecture AS-IS was built and a TO-BE model was proposed.

An architectural approach to water supply/water use management provides a number of advantages and allows to optimize the whole process. Additional opportunities are provided by the use of modern key digital technologies. The construction of specialized platforms using these technologies makes it possible to take into account a number of factors affecting water use [14].

3 Results

At the beginning, an analysis of the architecture of the resource-supplying organization was carried out in order to build an AS-IS model.

When analyzing the current activities of the company, the following main business processes were identified:

- Water supply (water supply control, water intake, and purification) includes "water treatment, transportation and supply of drinking or industrial water to subscribers using centralized or non-centralized cold and hot water supply systems" [2].
- Water consumption (use of water associated with its withdrawal from localization sites with partial or complete irretrievable consumption or with return to water intake sources in a changed (contaminated) state), assessment and rationalization of consumption, accounting, setting standards, and quality assessment
- Quality control
- Collecting data from measuring devices
- Analysis, aggregation, and further use of data collected from measuring devices
- Automatic billing for water users
- Management of technological facilities—monitoring the parameters of the water supply network; water quality control; dispatch control; control and management of automation objects, and engineering centers of water supply zones
- Risk management—identification of losses and unaccounted expenses; prevention of failures at peak loads; support of staff work in emergency; and emergency situations.

The Business level is shown in Fig. 1.

The resource-supplying organization under study uses the following application level services:

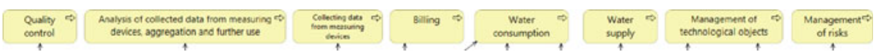

Fig. 1 The business level

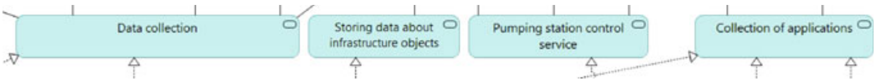

Fig. 2 Application level services

- Data collection service—designed to collect data on water quality indicators obtained from an automated water quality control system, data on meter readings, charges, etc., received from the Information system of the center for settlements with subscribers, as well as to transmit the received data for further use in the company's business processes.
- Storing data about infrastructure objects—designed for backup, storage, synchronization of technological information at all levels without data loss and with the formation and storage of archives.
- Pumping station control service—designed to collect information about the parameters of pumping stations to calculate the water balance.
- Collection of applications—designed to collect information about received applications on the Hotline, information on the work schedules of repair teams, schedules and plans for work and maintenance, as well as for transferring the received data for further use in the company's business processes.

Application level services are shown in Fig. 2.

Further, the applied information systems and their functions were analyzed:

- Automated water quality control system—designed for continuous measurements of water quality indicators, water quality monitoring for solving problems of environmental monitoring, and control of technological processes [15].
- Information system of the center for settlements with subscribers—maintains a unified database of clients and their requests, permits, contracts with clients, meter readings, charges, invoices, payments, accounts receivable, allows to analyze the interest of potential subscribers in the company's services; plan the volume of water supply (wastewater disposal) services; efficiently manage accounts receivable; ensure timely and reliable accounting and reporting; and increase revenue collection [16].
- GIS—a geographic information system that contains information about networks, buildings, structures, and property rights. It provides information exchange with government authorities, makes it possible to determine the location of network objects, coordinate the boundaries of land plots, control the executive documentation of contractors, and allows you to organize prompt access to the necessary information in real time for all departments and services of the enterprise [17].
- Hotline—an information system that allows a company to quickly analyze the quality of services; to efficiently process citizens' appeals about emergencies; control the elimination of emergency situations; coordinate the work of operational units and emergency teams in real time.
- Integrated Dispatch Management System—designed for automatic collection, processing, accumulation, display, and analysis of technological information from

automated process control systems of all technological objects of the enterprise [18].

- Maintenance and repair information system—designed to optimize and control processes related to the repair and maintenance of hardware, units of the enterprise [19].
- An information system designed for planning, organizing, and optimizing the work of teams and their visits (denoted as IST in the model).
- Accounting system—designed to maintain the accounting of the organization [20].
- Meteorological automated information system (designated as MAIS in the model)—consists of automated observation posts in different areas of the city as part of a rain gauge and a meteorological complex. The installed meteorological systems automatically measure atmospheric pressure, wind speed and direction, air temperature, and humidity and regularly transmit information to the resource-supplying organization and meteorological services. It allows you to quickly regulate the filling of sewer networks during rains, to accurately calculate the volume of surface runoff for specific territories, and to prevent flooding of city areas with the highest intensity of atmospheric precipitation. The data received from MAIS helps to improve the performance of not only the sewage system but also all municipal services in the city [21].

Application components of the application level are shown in Fig. 3.

At the technological level, the following main services are distinguished:

- Collecting water quality data—designed to collect information from peripheral devices, water analyzers on biological, physical, chemical, organoleptic, radiological parameters of water, and transfer the collected data to the Automated water quality control system.
- Collection and transmission of data—designed to collect information from water meters and pumping stations on water consumption by consumers and transfer the collected data to the Information System of the center for settlements with subscribers.
- Consumption data transmission—performs a similar function, collecting data from automatic flow meters.
- Transmission of data on precipitation and climatic parameters of the environment—designed to collect data from meteorological sensors and regularly transmit the collected data to the MAIS.

Services of the technological level are shown in Fig. 4.

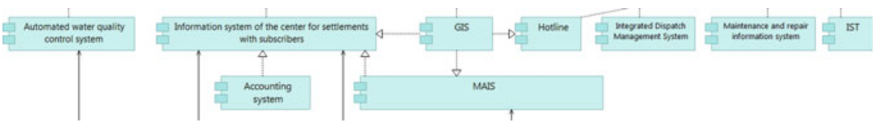

Fig. 3 Application components of the application level

Fig. 4 Services of the technological level

These services receive information from the following basic pieces of equipment:

- Analyzers;
- Disinfectants;
- Pressure Sensors;
- Water meters with remote data transmission;
- Pumping stations;
- Low-error electromagnetic flowmeters;
- Meteorological sensors.

Equipment of the technological level is shown in Fig. 5.

The resulting overall enterprise architecture model in the AS-IS state is shown in Fig. 6.

The development of the considered system should be aimed at creating a unified system of automated active monitoring of the state of the water supply system and control of technological objects of the water supply system; immediate informing of personnel and the formation of recommendations on actions in emergency situations.

The main task is to implement a value-oriented approach, in which the tools of value-oriented water supply management are especially important: water balance, hydraulic modeling, balance of income and expenses, and water-chemical balance.

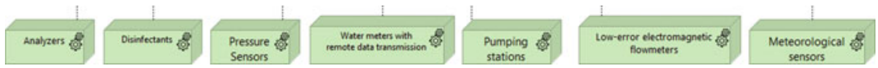

Fig. 5 Equipment of the technological level

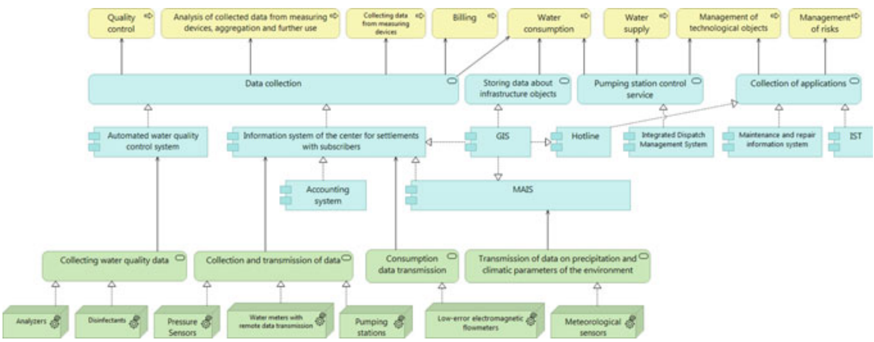

Fig. 6 AS-IS model of the enterprise architecture

This task requires the introduction of significant changes at the level of information systems—both the addition of new information systems and the modernization of existing ones. In addition, modernization of equipment at the technological level is required.

The main proposed changes are as follows:

1. Modernization of information systems and equipment.
2. In the AS-IS state, local control of the equipment takes place. The task was set to move to a single management. For this purpose, it is planned to introduce a monitoring and control subsystem.
3. It is planned to introduce CRM, which will carry out information exchange with other systems.
4. It is planned to introduce a measurement and accounting subsystem.
5. Modernization of the outdated Integrated Dispatch Management System.

The monitoring and control subsystem should ensure the solution of the following tasks:

- implementation of centralized management of technological objects and centralized control of technological parameters, operating modes, and equipment condition directly from engineering centers and a water supply control center;
- active monitoring of technological water supply facilities to support the work of personnel in emergency situations, identify, early warning and inform personnel about problem situations and formulate recommendations for personnel to prevent them or eliminate negative consequences for the process of water supply to consumers;
- information interaction with the duty units and external structures;
- information support and coordination of actions in the elimination of abnormal, emergency situations.
- In addition, the monitoring and control subsystem should provide:
- automated analysis of incoming telemetric information from objects of the water supply system and control points on the water supply network;
- automated construction of an assessment of the severity and forecast of further development of the accident;
- automated recording of the actions taken to eliminate the situation.

The measurement and accounting subsystem should provide means for receiving, storing, processing, and analyzing data from instrumentation and automation in order to provide information about the state of the water supply network.

The subsystem should assess the mismatch between the volumes of water supplied to the water supply network and consumed (received) by subscribers, identify time intervals with unusual values of supply and consumption volumes, and also carry out other calculations to assess inconsistencies caused by unaccounted water costs and losses, as well as assess probable causes and places of their occurrence, within the area defined by the nearest key points. When such cases are detected, the subsystem should automatically generate notifications to inform users. The subsystem should record water quality according to the Automated water quality control system. The subsystem should record the consumed energy resources according to the data of the automated system for commercial metering of electricity.

To ensure monitoring of the water supply network, the subsystem must track the statuses of instrumentation and communication equipment during the entire period of operation. The results of the analytical work of the Measurement and accounting subsystem in terms of control of unaccounted water consumption and losses, forecasting water consumption, operational monitoring of the state of the water supply network should also be displayed in the Visualization and decision support subsystem.

Configuration data for the Measurement and Accounting Subsystem is integrated data, including data on water supply and consumption facilities, water supply networks and inputs, lines, metering devices, subscribers, their statuses, and location from the GIS and the Information system of the center for settlements with subscribers.

The Integrated Dispatch Management System, interrogating water quality devices on the network, requires modernization. It is planned to add functionality for automatic tracking of exceeding the values of water quality indicators, to include the addition of information on laboratory control and informing personnel about exceeding the values of indicators.

The final proposed TO-BE model is shown in Fig. 7.

The following requirements are imposed on a unified information system in this model:

1. Functional.

    1.1 Business Requirements:

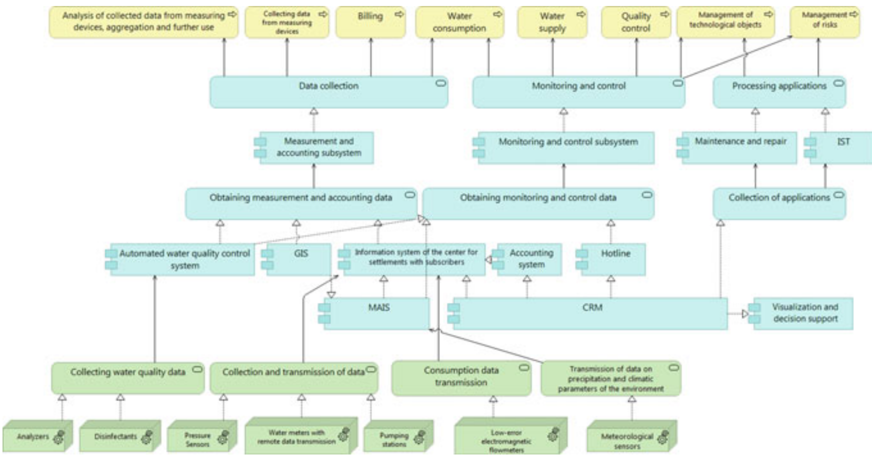

Fig. 7 TO-BE model of the enterprise architecture

- Measurement, accounting, monitoring, and management of water supply;
- Increased efficiency;
- Elimination of losses;
- Increased user satisfaction;
- Identification of theft;
- Leveling of non-standard peak loads.

1.2 User Requirements:

- Accuracy of charges;
- Automatic invoicing without the influence of the human factor;
- Application for mobile devices;
- Notifications;
- Consistently high water quality.

1.3 Requirements for the Collection and Processing of Data:

- Monitoring of unaccounted water costs and losses;
- Forecasting of water consumption;
- Data analysis.

2. Non-Functional.

2.1 Business Rules:

- Possibility of transition to unmanned (automated) production based on means of remote monitoring, control, and video recording;
- The maximum possible use of automation systems already implemented at the enterprise, if there is a technical possibility of their effective integration.

2.2 System Requirements:

- System of sensors connected to the IoT;
- Installation of flow meters;
- Support for Big Data operation;
- Preferred use of communication channels based on wire technologies;
- Use of a single hardware and software platform and software;
- Possibility of using servers and stations of automatic control systems of the software complex based on open-source operating systems.

2.3 Requirements for Design and Usability:

- Use of the Russian language in interfaces;
- Interfaces for monitoring, billing, troubleshooting, and data storage;
- Interface of administrator, operator, and consumer;

2.4 Requirements for Safety and Reliability:

- Protection against unauthorized access;
- User identification;
- Checking the user's authority when working with the system;
- Differentiation of user access at the level of tasks and information arrays;
- Data backup.

2.5 Requirements for Destination Indicators:

- Mandatory preliminary selection of "key points" (automated metering stations).

2.6 Other Requirements and Restrictions:

- Flexible interfaces for adjacent enterprise systems;
- Data synchronization with adjacent systems;
- Adaptation to the business processes of the enterprise;
- Integration with a video surveillance system for technological water supply facilities;
- Replication of the solution.

4 Discussion and Conclusion

As part of further research, a more detailed consideration of the direct implementation and deployment of the proposed model of the enterprise architecture with the calculation of the results achieved is expected.

The article deals with the case of a resource-supplying organization that has set the task of implementing a value-based approach to activities. In the course of the research, a model of the AS-IS enterprise architecture was built, an analysis was made of what functional areas should be automated, what changes should be made to the enterprise information systems, what services and for what purpose should be added. As a result, a target enterprise architecture model TO-BE was built, and the requirements for a unified information system in this model were identified.

The implementation of a value-oriented approach in building a model of the enterprise architecture for a resource-supplying organization makes it possible to increase the efficiency of decision-making on the management of the water supply system by aggregating all possible information from both related services, and about the state of the network and equipment. Active automated monitoring and control become possible. The quality of planning of production processes is improved. All this increases the efficiency of the organization and contributes to more complete satisfaction of the needs of the end consumer and the delivery of value to the consumer without contradicting the goals of achieving the main performance indicators of the organization itself.

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