Design and development features for domestic water consumption information system

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Abstract. It is our contention that research is relevant insofar as it addresses the issue of irrational water consumption by humans in their household activities. The development of a software product that offers monitoring and management of water consumption processes could help foster a more thoughtful approach to water. The paper presents a description of the functional capabilities of the corresponding information system and develops prototypes of the graphical user interface. The software product offers a number of functional capabilities, including the monitoring of water supply, consumption, and filtration systems. Based on current indicators of these systems' states, it can also create recommendations. It is our hope that the developed information system will be scalable and able to be integrated with the "smart home" system.

1 Introduction

Water consumption can be classified into specific categories, which include household and drinking water consumption, water consumption in the communal and domestic sector and in technological processes of production, water use for firefighting needs and consumption for own needs [1, 2]. Depending on the category, water must meet certain sanitary and hygienic requirements, which are regulated by standards, or other specific requirements determined by the nature of consumption (for instance, water for firefighting should not observe mechanical impurities and chemical substances) [3].

Water consumption is increasing every year (for instance, water requirements for agriculture are projected to increase by 50% globally by 2050, following the growing needs of the population [International Atomic Energy Agency: https://www.iaea.org/ru/temy/upravlenie-vodnymi-resursami-v-selskom-hozyaystve]). Water scarcity or poor water quality pose serious threats to food security and environmental safety and sustainability [4]. To solve such problems, it is necessary to improve the system of land and water resources management, to develop and implement technologies aimed at minimizing water losses during transportation, its balanced use in agriculture and households, to improve technological and other production processes [2, 5].

With the modern development of digital technologies, the use of information systems with elements of artificial intelligence is a universal means of solving a wide range of informalized problems [6, 7]. Such technologies make it possible to support human activity

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by forming a system of recommendations for process management based on data from the natural environment and the functioning of a set of software, linguistic and logical-mathematical tools [8-10].

Water resources consumption management is a specific task characterized by uncertain and constantly changing input data, non-systematic and random processes. Based on this, the aim of the work is to create an information system. monitoring of water consumption. The tasks to be solved include setting the characteristics of objects and subjects of the water consumption process; creating the concept of the information system that provides water consumption management; creating a prototype of the user interface of the corresponding software product.

Theoretical significance of the research is the systematization of objects and subjects of the water consumption process, setting their qualitative characteristics and rules of interaction. *Practical significance* of the research is the creation of a software tool to monitor the technical condition of water supply systems in private homes or farms, the formation of a careful attitude to the consumption of water resources.

2 Materials and Methods

The basis of any software development is a life cycle model, which is a set of certain stages realized in time according to the established requirements. For the formulated tasks it was required to perform actions related to the analysis and formalization of requirements and features of the problem domain, as well as the design of a software product.

In works related to the creation of information systems, to determine their functional requirements, methods of interviewing experts involved in the transformed process, structural analysis, observation and synthesis are used [6, 11, 12]. With the help of the above methods, it was possible to establish all key objects and connections between them, factors influencing changes in their internal states and possible external influences.

Object-oriented design methods were used to formalize the obtained results. With their help, a model representing data at the logical and physical levels, statically and dynamically was created. The basis of such a model are objects with characteristics of state, behavior and individuality, transformed into specific fragments of program code.

3 Results

The information system, which corresponds to the formulated goal, continuously monitors water consumption by the consumer, generates a list of recommendations for careful water consumption and notifies about changes in the water supply system status.

To ensure such work, two modes are provided: manual and automated. In manual mode, the user is required to enter certain data into the system to process them and generate a list of recommendations (for instance, current readings of water meters). In the automatic mode, data is received from sensors that are installed in the water supply system (for instance, leak indicators, pressure indicators, water meter readings). Such sensors can be wired or wireless [13]. The completeness of the system is determined by the user and sensors can be purchased in addition to the software.

The main functions of the information system include:

Recommendation of works for individual water supply system installation. It is possible only if there is an individual land plot. In this case, according to geolocation, the system will show information about the state of aquifers, determine the approximate list of works and equipment required for installation of the supply system, and contractors

performing such types of works. Figure 1 shows the prototype screen of the mobile application with a map of aquifers.

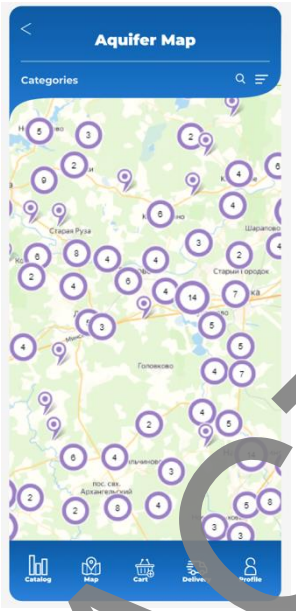

Fig. 1. Aquifer Map screen of the prototype mobile application

Water consumption monitoring. It is performed on the basis of relevant metering devices. The user can set the desired water consumption limits for the month and specify which meters are installed in the water supply premises to refine the system recommendation list. If meters are equipped with automatic readings transmission, the system receives data in the background and updates the list of recommendations on a daily basis. At the same time, it additionally requests the user to confirm his/her actions. In the absence of such meters, the user will need to manually enter the relevant readings (at least once a month). In this case, the recommendations are of a general nature.

Monitoring of water supply system condition. Possible only if there are sensors installed. For this purpose, the user will need to add sensor data (identification name, location, installation date and operation period), if the system will use third-party sensors not recommended by the software developers. Once the sensors are installed and synchronized with the system, their status will be monitored in the background. If an abnormal situation is detected, the user will be notified of the potential problem and how to solve it. In specific cases, as a recommendation, the system will generate a list of masters and organizations that perform work on the profile of the detected problem.

Monitoring of the filtration system status. Possible for both filtration systems and filters. For relatively correct operation of the information system, it is necessary to enter data on the filter (name, type, manufacturer and date of installation). Based on the current water consumption, information about the current condition of the filter (approximate) and the terms of its replacement will be generated.

Fig. 2 shows prototypes of mobile application screens demonstrating the listed main functionalities of the information system.

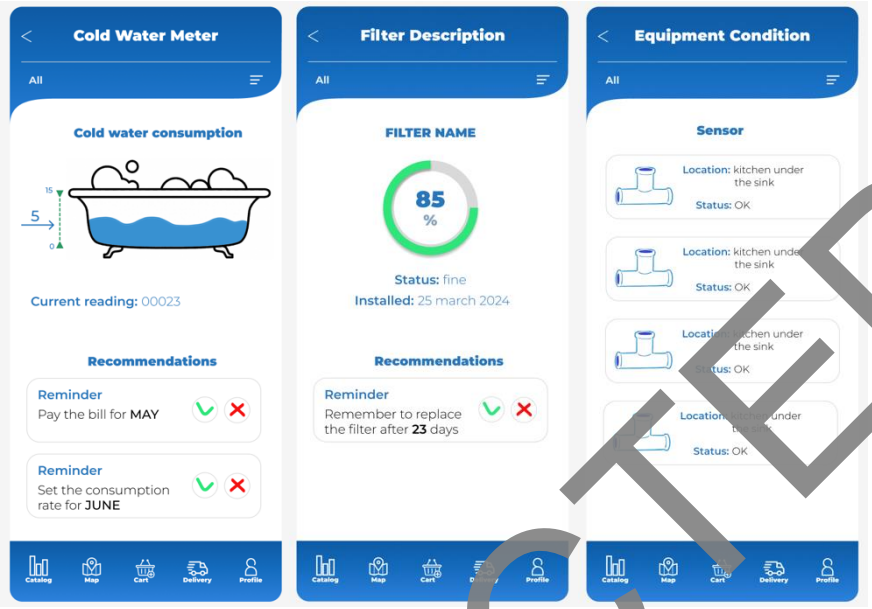

Fig. 2. Basic functionality screens of a prototype mobile application for water conservation

Additionally, the information system can be integrated with the function of ordering and delivery of bottled water, a map with locations of drinking water vending machines or recycling of consumables, etc.

4 Discussion

The results obtained correspond to the problem area and reflect its main characteristics. This is confirmed by the correct use of the stated research methods. The analysis of research results, which formulate tasks similar to the works in progress, has shown that they have developed formal models describing qualitative and quantitative indicators of the problem domain objects and processes affecting the change of their states [8, 9]. Such models are used to create complex information systems that organize, manage [14] or support processes related to agriculture [6, 12], ecology [7, 15, 16], transport [10, 17], construction [18], and so on.

5 Conclusions

It could be said that constant monitoring and use of software and hardware tools for process control are an integral part of modern human life. It would be fair to say that there is no activity (domestic, industrial, etc.) that does not utilize software products to some extent. With the help of these tools, it is possible to effectively manage processes in order to reduce the use of resources, such as economic, time, labor, or consumables.

Water is a valuable resource that plays an important role in connecting society with the environment, sustainable development, food production, and the health of ecosystems. The modern concept of rational use of water resources aims to improve the efficiency of water use and water supply, with the goal of meeting basic human needs. The development of specialized software tools that monitor water consumption has the potential to provide a list of appropriate recommendations for a careful attitude to water in a sufficiently accurate and personalized manner.

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