UDC 005.8:64

Chernov Sergiy
Doctor of Science (technology), head of project management department
Admiral Makarov national university of shipbuilding, Nikolayev
Gaida Anatoly
PhD (technology), associate professor of management information systems department
Admiral Makarov national university of shipbuilding, Nikolayev
Kharitonov Yuriy
Doctor of Science (technology), dean of maritime infrastructure
Admiral Makarov national university of shipbuilding, Nikolayev
Koshkin Volodymyr
Post graduate student of project management department
Admiral Makarov national university of shipbuilding, Nikolayev

PROJECT MANAGEMENT OF WATER SUPPLY SYSTEMS RECONSTRUCTION WITH DECISION SUPPORT SYSTEM USING

Abstract. *The organization model of decision support system of water supply reconstruction projects is proposed. The methodology of neural networks for the rational project choice is used. Testing the status of the project by means of an artificial neural network was carried out with the help of the module hat is based on a graphical representation of the data distribution works "reliability" of each projection the basis of data on the types of projects, jobs and the necessary technological units.*
The data obtained on the neural network qualifier were transformed to diagrams of distribution of density of estimates of a projects status. In a type of the considerable data volume on operations of projects they aren't given in the real operation. Creation of diagrams was executed in the GnuPlot program.
Implementation of the application was made in the use of API web framework Django, which is open and free software implemented in a high level programming language Python that is wide distributed in development of complex software systems with web-interface.

Key words: water supply system, project of reconstruction, decision support system, neural networks

Problem definition

Currently, one of the major problems that determines the further development of both individual country and the whole of mankind is the problem of the efficient use of water resources. The urgency of this problem is due to increasing scarcity of water involved in the various fields of industrial activity, as well as drinking water consumed [6].

One aspect of this problem is to develop a set of activities related to the provision of drinking water to municipalities. With regard to the conditions of Ukraine, the problem is exacerbated by significant physical and moral deterioration of the basic elements of water supply (WS) systems, non-compliance of technical and technological parameters of the WS system existing in the European Union standards and norms, lack of the necessary resources for the renovation and also developed evidence-based recommendations for the implementation of projects and programs of the WS system reconstruction [7, 8, 10].

The water supply system is a complex technical system, including various technological equipment (pumps, pipes, tanks etc.), appliances for information collection and transmission, actuators and other equipment. Obviously, for the management of such a system it is necessary to consider its structure, organization and architecture.

To provide opportunities for problem solving, in accordance with the objectives, the automated system should include the following basic functionality:

- automated system for water management collects information from the stations of automatic control and building an adequate model of real-time status.
- operator is able to control the process.
- the operator can identify critical situations on the basis of the data collected.
- system allows you to receive information from remote pumping stations.
- is provided by wireless technologies.
- the World Wide Web allows real-time data about the state of the system.
- storage server ensures the integrity and security of data.

In order to provide opportunities for horizontal integration of subsystems designed automated system between themselves and the vertical integration of the information system development project management of technical water supply system of the city,in the draft of the automated system shall be provided to the complexity and characteristics of tasks mechanisms and tools for integration of subsystems of the information system into a single system.

Because of the considerable moral and physical wear and tear of the basic elements of the Ukrainian WS they need to be reconstructed according to the corresponding projects.

There are a significant number of project management systems, portfolio management systems. These systems include both corporate Microsoft Project Serverand Microsoft Project Professional, Oracle Primavera Enterprise Portfolio Management and open system based on SaaS: Basecamp, TeamLab, Teamwork, etc. However, they are more universal in nature and are used eitherseparately or integrated via files or standard communications interface. A cut of their application in problems of project management of the WS systems reconstruction complicated due to the following features of these projects:

- a significant number of simultaneously running projects;
- involved in the project resources;
- variabilityof the environment, defined worn outwater systems.

These features determine the need to develop solutions that limited resources would allow for the effective management of projects of reconstruction of water supply networks.

The organization responsible for WS systems commissioning characterized by the presence of scheduled projects and projects that are in progress.

Planned to carry out projects typically involve reconstruction of and /or the introduction of new facilities and transferred to the execution state as they become expected conditions, income and release the necessary resources to carry them out. In some cases,such projects an be converted into a state of execution ahead of time,for example,as a result of unforeseen deterioration in the monitored parameters of water supply systems, or as a result of equipment failure. In this case,the implementation of such projects may require additional resources.

In turn, projects that are in the running state can be performed with a delayfrom the time schedule,for example,as a result of unforeseen effects in the planning of factors, such as process equipment breakage, deviation of characteristics of the external environment and so forth.In this part of the resources allocated for these projects may be used inefficiently or evenidle.

It is obvious that under the conditions of the external environment priorities of projects may change constantly, including – with the need to "freeze" the ongoing projects or initiate projects that are in the standby state. It is also obvious that the decision to amend the work plans for such projects is a complex management task, which should take into account the projects, the state of the resources, the monitored parameters, requirements and priorities of consumers. By its nature, such problems belong to the class of multiobjective optimization problems.

With this in mind, the ability to make effective management decisions is determined by:

- the presence and the use of appropriate methods for solving optimization problems;
- the presence of mechanisms and opportunities for assessing the status of ongoing projects;
- the presence of opportunities for assessing the effect of the implementation of each project.

For solving optimization problems developed with the nature of problems and mathematical methods of linear and nonlinear optimization (such as the simplex method, the method of penalty functions, branch and bound, and the like). Their application usually provides the possibility of defining a target function, which allows to solve the optimization problem as a problem of finding the maximum or minimum values for some of its higher-dimensional space of feasible solutions.

The difficulty of assessing the status of ongoing projects is that the values of the attributes of the projects are, as a rule, to a large extent not clearly specified, blurred, are qualitative in nature. In addition, the complexity of assessing the impact of the implementation of each of the project is that the values of the attributes of projects have disparate units.

In this context, the problem of determining the current state of the project, in fact, is the task of recognition and classification, composed to include a recognizable image to any known class. The initial data for the solution of classification problems are the limited amount of sample data on the values of the attributes of the elements that describe the classified image or situation. In this case, the classification is to determine the degree of similarity of classified sample precedents – samples for which membership in the class known as a precedent may be considered as a sample. One of the aims of classification is to determine the relationship between the signs and symptoms of the classified object class and study of this connection. To determine the relationship between the features used correlation analysis or artificial neural networks (ANN), and, in this case, the ANN have certain advantages in that the ANN is not programmed and trained.

To solve the problem of estimating the effect of the implementation of each project requires the use of mathematical tools provide some generalized value as

an integral evaluation of the project. It may involve a variety of methods, one of the most simple and effective – weighted sum method, which allows to take into account the values of the individual parameters of the projects, and the contribution of these values to the integral value of assessing the impact of projects.

Thus, it is possible to implement a solution of the above problems through the development of a decision support system (DSS) in the management of the process of reconstruction of the municipal WS [2, 3, 4].

The aim of the article is to develop and to test the DSS of municipal WS reconstruction projects.

Main part

Typical structure of the water supply system is shown in Figure 1. The main structural elements of the system: the water treatment plant and desalination, pumps, water treatment industries and consumers.

Currently on improving the efficiency of theWS municipalities devoted a considerable amount of research [4, 9]. Indifferent systems of municipal water supplies, as small towns and big cities,is widely used by significant developments in the field of IT-technologies. Thus, in [9] considered architecture and main elements of a typical control of the municipal WS system which consists of a central computer, the primary sensors and electromechanical control devices, means for transmitting and receiving signals.

Reflection of the functioning municipalities of the WS systems usually represented mimic, sources of data setsin which, speak a variety of design solution simplemented on the basis of systems SCADA at various stages of processing water.

Based on the description of the system, it can be isolated subsystems: control parameters on intakes; control parameters in wastewater treatment plants; control parameters of reverse supply; control of the parameters of networks and storage systems,water supply systems; control systems for the collection of information, control and tele-control remote signaling; storageof the information system; control access to the subsystems of the system, administration and so on.

In order to provide opportunities for horizontal integration of subsystems designed automated system between themselves and the vertical integration of the information system of project management of technical city water supply system, in the draft of the automated system shall be provided to the complexity and characteristics of tasks mechanisms and tools for integration of subsystems of the information system into a single system.

Providing opportunities for horizontal integration of subsystems with each other should provide such tools implement a system that will simply increase the functionality of the system by expanding the knowledge base of the system and the introduction of new modules into the system.

Vertical integration of the information system of the city should include provision of access to the system for the persons concerned, and should not require significant modification of their information systems. This problem can be solved by providing remote access to the system resources for other clients of the system via a local network or the Internet with the use of common and public communication protocols for data transfer and control between the subsystems.

Local access can be provided through the automated work places installed on client work stations plant personnel.

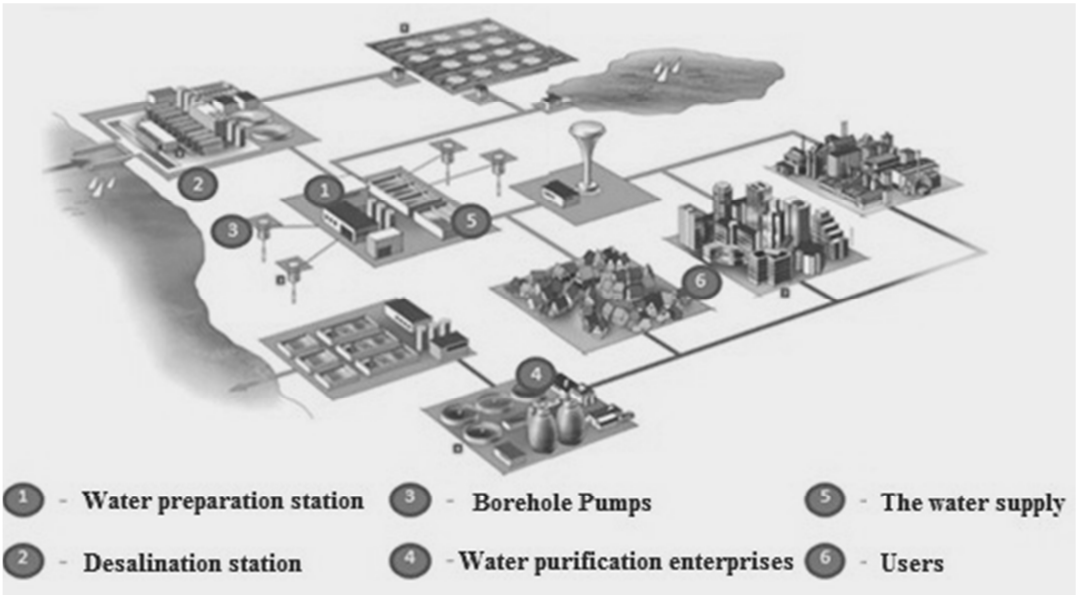

Figure 1 – Typical structure of the water supply system

To do this on the client work stations must be set to the appropriate functions o fcustomer client software, and customers should be given the rights and powers of access to information resources of the server information system in accordance with the functional responsibilities of each client system.

Given that the system will also collect information on the parameters of water supply systems, which can be used independently or in other automated systems of the city, it is necessary to consider mechanisms for access to information resources and systems from other systems. This may use global (remote) access over the Internet, including – using the protocols TCP/IPand HTTP.

As a result of the sesecurity mechanisms for access, access to information system resources can be provided for the following types of users:

-authorized users-enterprise managers, the project management team(the granting of rights and powers ofaccess to information resources of the system should be provided for both local access mode);

-authorized users – employees settlement centers of municipa lwater services (authentication is performed on the basis of the known users of private account information: address, passbook, etc.);

-other users-information is provided without authorization (ads, tables, graphsrepairs, water parameters, etc.).

With this in mind, it may be suggested the following structural model of managerial decision-support project management reconstruction and developmentof water supply systems (Figure 2). In the model presented packets "Parameters of the environment", "Planned to carry out projects", "Ongoing projects", "Resources projects", "Block assessment of the projects", "Block assessing the impact of implementation of the projects", "Power ranking projects", "Projects to implement".

Package "Parameters of the environment" should provide for storage and provide tools for their processing for the measured parameters of the environment on the projects related to the reconstruction projects.

Package "of scheduled projects" stores attribute values, and provides tools for their processing of scheduled projects of reconstruction projects and the need for resources.

Package "Ongoing projects" stores attribute values, and provides the tools to handle them for ongoing projects and needs of these projects in the resources.

Package "ResourcesProjects" stores information and provides tools for its processing resources projects and the organization as a whole.

Package "unit assessment of the projects" must carry out the assessment of the current state of the projects based on the values of attributes of projects and generate value of the evaluation function as a number between 0 and 1, which can be used as Westview Coefficient when calculating the effectiveness of projects.

Package "Block assessing the impact ofi mplementation of the projects" should calculate the value of the objective function efficiency projects based on the values of attributes of projects, and for ongoing projects-given the importance of the project status.

Package "Block ranking projects" should provide a ranking of projects on the weighted effect of their expected realization.

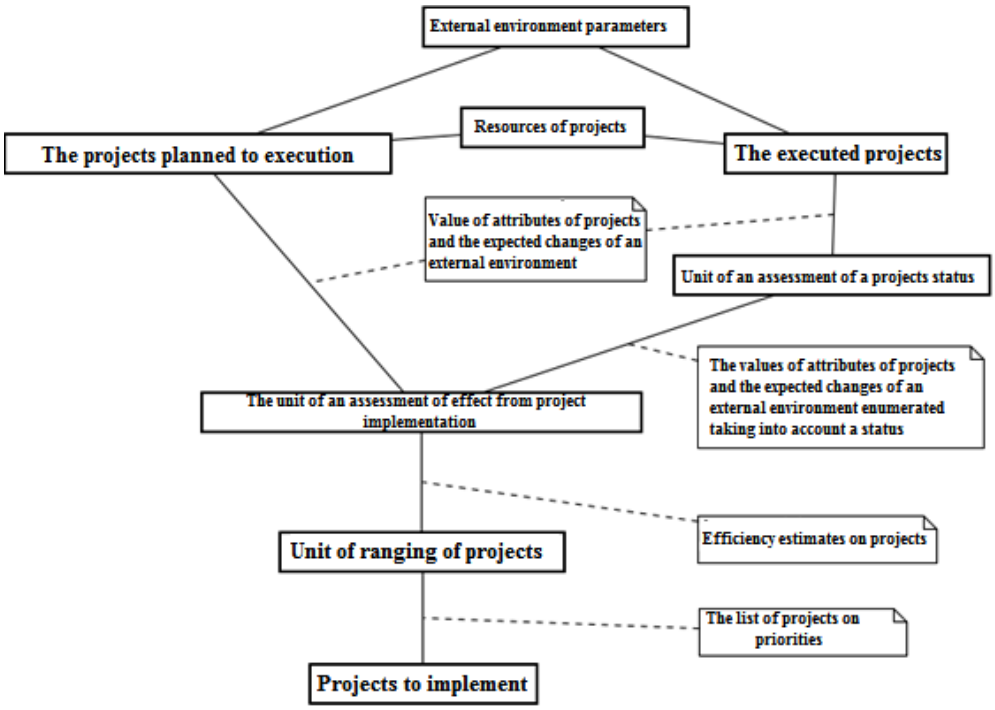

Figure 2 – Structural model of an automated decision support system for ranking of projects

Package "To implement projects" will contain a prioritized list of projects for implementation to start.

Based on the fact that each project for a higher quality of service, there is the possibility of comparing the parameters of the projects in such a way that it will be possible to choose projects that will help achieve the best system performance. To do this, we apply the method of weighted sums. For simplicity, we assume that the weights of the criteria are given by experts and are defined as priorities of projects and types of projects and types of beneficiaries. When this weighted sum may be represented as:

$$Y_i = w_{0i}\left(w_1 \cdot w_2 \cdot \sum_{r=0}^{R} w_3 \cdot p_{ri} + w_4 \cdot \sum_{j=0}^{J} w_5 \cdot u_{ij}\right),$$

where

Y_i - integrated evaluation of the project;

w_0 – weighting assessment of the project;

w_1, w_2, w_3, w_4, w_5 – the weights determines the priority of projects, project declared technological parameters, priority sites and the measured parameters on it, respectively;

p_{ri} - declared value of the process variable project;

u_{ji} - critical value for the recipient of the process variable of the project;

$r \in [0, R]$ – coefficients which are common for a group of parametres;

$j \in [0, J]$ – coefficients which are unique for a group of parametres;

Weighting factor assessment of the project can be calculated as:

$$w_{0i} = \begin{pmatrix} 0, \text{if the project i is not involved} \\ NN.backPropagate(), \text{if the project is involved} \end{pmatrix}.$$

As mentioned above, for projects affected by many factors, notall of which can be taken into account initially, but they can be identified and taken into account in the future -as more is learned about the previously implemented projects.Account factors such methods of correlation analysis would require a revisiono f the corresponding mathematical models, each time the data structure of the system were added to the new characteristics of the projects. It is obvious tha in terms of project management as a continuous activity, ongoing development of mathematical models is hardly advisable. For this reason,it is interesting to use artificial neural networks (ANN) — as to ensure continuity of operational control and flexibility in the choice of a set of characters.

The most widely used and recognized by neural networksare networks with error back propagation ("Back Propagation"), which are used, including, for the solution of problems of classification and pattern recognition [1, 6].

In the simplest case – the single-layernetwork (Figure 3, its output Y can be represented by the vector of input signals x and the vector of coefficients k as:

$$Y = \sum_{i=0}^{n} x_i \cdot k_i.$$

In this case, an important feature of the ANN is that ANN is not programmed and trained (training network is the process of calculating and setting the coefficients k). This means that upon completion of the training phase the ANN will not only be able to replace the experts, but also is able to improve the quality of their own expertise through additional training to current and newly completed projects.

From the standpoint of the problem being solved an important property of neural networks is their ability to learn based on the data of the environment and as a result improve the quality of solutions. Education – an iterative process of adjusting the free parameters of the network (synaptic weights and thresholds) by simulating the environment. The method for adjusting these parameters determines the type of training. The learning process involves a sequence of actions, which consists in the installation of the input signals to the input of the network, and change according to some rule of network parameters. The process is repeated as long as the network is not able to solve the task.

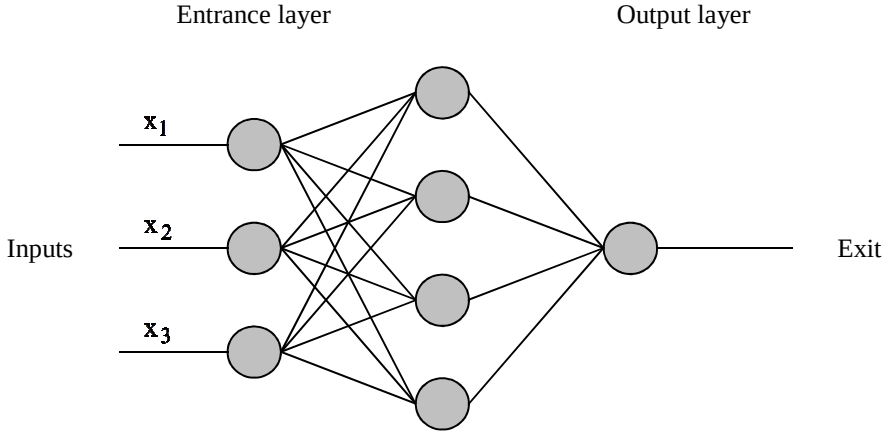

Figure 3 – An example of an artificial neural network for projects status classification

The data obtained on the neural network qualifier were transformed to diagrams of distribution of density of estimates of a projects status (Figure 4 and 5). In a type of the considerable data volume on operations of projects they aren't given in the real operation. Creation of diagrams was executed in the GnuPlot program. The code of the program of creation is given below.

The figures show the distribution of the neural network classifier estimates the project state.

Dots denote estimates that were subjected to inspection during testing of the classifier.

Conclusions

1. The structural model of the municipal WS DSS was proposed and its functionality was tested.

2. In order to improve the effectiveness of managerial decision-making on the projects implemented neural network classifier is developed on the basis of their state of artificial neural networkwithback-propagation errors.

3. The application of the proposed system can reduce project schedules by 15-20% due to the reduction of time for managerial decision-making, reducing the number of errors and increase the efficiency of communication between the participants of reconstruction projects.

4. The testing is state of the project by means of an artificial neural networkbased on the data on the types of projects, jobs and the necessary technological units.

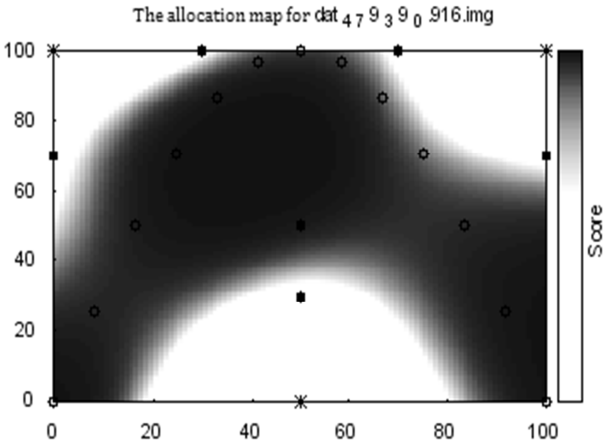

Figure 4 – Graph of the evaluation of density distribution (project 1)

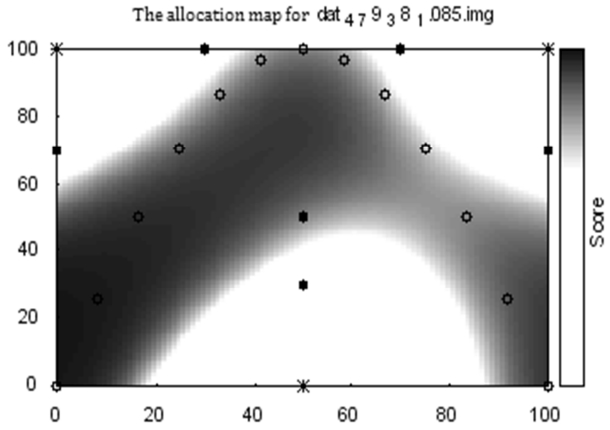

Figure 5 – Graph of the evaluation of density distribution (project 2)

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Стаття надійшла до редколегії 27.03.2015

Рецензент: д-р техн. наук, проф. В.С. Блінцов, Національний університет кораблебудування ім. адмірала Макарова, Миколаїв.

Чернов Сергій Костянтинович
Доктор технічних наук, професор, завідувач кафедри управління проектами
Національний університет кораблебудування імені адмірала Макарова, Миколаїв
Гайда Анатолій Юліанович
Кандидат технічних наук, доцент кафедри інформаційних управляючих систем та технологій
Національний університет кораблебудування імені адмірала Макарова, Миколаїв
Харитонов Юрій Миколайович
Доктор технічних наук, директор інституту морської інфраструктури
Національний університет кораблебудування імені адмірала Макарова, Миколаїв
Кошкін Володимир Костянтинович
Аспірант кафедри управління проектами
Національний університет кораблебудування імені адмірала Макарова, Миколаїв

УПРАВЛІННЯ ПРОЕКТАМИ РЕКОНСТРУКЦІЇ СИСТЕМ ВОДОПОСТАЧАННЯ З ВИКОРИСТАННЯМ СИСТЕМИ ПІДТРИМКИ ПРИЙНЯТТЯ РІШЕНЬ

Анотація. *Запропоновано організаційну структуру системи підтримки прийняття рішень проектів реконструкції систем водопостачання. Для вибору раціонального проекту використано механізм нейронних мереж. Виконано апробацію системи.*

Ключові слова: система водопостачання, проект реконструкції, система прийняття рішень, нейронні мережі

Чернов Сергей Константинович
Доктор технических наук, профессор, заведующий кафедрой управления проектами
Национальный университет кораблестроения имени адмирала Макарова, Николаев
Гайда Анатолий Юлианович
Кандидат технических наук, доцент кафедры информационных управляющих систем и технологий
Национальный университет кораблестроения имени адмирала Макарова, Николаев
Харитонов Юрий Николаевич
Доктор технических наук, директор института морской инфраструктуры
Национальный университет кораблестроения имени адмирала Макарова, Николаев
Кошкин Владимир Константинович
Аспирант кафедры управления проектами
Национальный университет кораблестроения имени адмирала Макарова, Николаев

УПРАВЛЕНИЕ ПРОЕКТАМИ РЕКОНСТРУКЦИИ СИСТЕМ ВОДОСНАБЖЕНИЯ С ИСПОЛЬЗОВАНИЕМ СИСТЕМЫ ПОДДЕРЖКИ ПРИНЯТИЯ РЕШЕНИЙ

Аннотация. *Предложена организационная структура системы поддержки принятия решений проектов реконструкции систем водоснабжения. Для выбора рационального проекта используется механизм нейронных сетей. Проведена апробация системы.*

Ключевые слова: система водоснабжения, проект реконструкции, система принятия решений, нейронные сети

Link to publication

APA *Chernov, S., Gaida, A., Kharitonov, Yu, & Koshkin, V. (2015). Project management of water supply systems reconstruction with decision support system using. Management of Development of Complex Systems, 22 (1), 6 – 12.*

ГОСТ *Чернов С.К. Управління проектами реконструкції систем водопостачання з використанням системи підтримки прийняття рішень [Текст] / С.К. Чернов, А.Ю. Гайда, Ю.М. Харитонов, В.К. Кошкін // Управління розвитком складних систем. – 2015. – № 22 (1). – С. 6 – 12.*