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MODELING THE OPERATION OF MULTI-SCENARIO SYSTEMS

Yevhen Artamonov[1]
Iurii Golovach
Halyna Rosinska
Svitlana Stanko
Daniil Krant

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A B S T R A C T

The relevance of the declared subject of this research work is determined by the need to develop and implement software for users of various skill levels, as well as to create effective multi-scenario systems for describing processes occurring in multiple environments. The primary purpose of this scientific research is to study the principles of modeling the functioning of multi-scenario systems. The basis of the methodological approach in this scientific study is a combination of methods of system analysis of the principles of creating models for the functioning of multi-scenario systems with an analytical study of the prospects for building monolithic architectures of online learning systems. In the course of this scientific research, results were obtained that describe the principles of modeling a multi-scenario online learning system, as well as illustrating the features of the interaction of individual subsystems within a single multi-scenario system, taking into account the effectiveness of each of the subsystems performing the functions assigned to it within a single multi-scenario system. The results obtained reflect the fundamental principles of building the operation of multi-scenario systems in the conditions of the need to process a large amount of data, taking into account the difference in user characteristics, their levels of preparedness, as well as the variety of user requests that have a significant impact on the process of creating a multi-scenario system model and its functioning in constantly changing environments. External conditions. The practical significance of the results obtained in this scientific study, as well as the conclusions formulated on their basis, lies in the possibility of their application in the development of information presentation systems, the operation of which is based on the principle of multi-scenario, in order to provide the option of choosing modes of use and their automatic adjustment.

1. INTRODUCTION

The problem with this scientific research is that today there is a tendency to transfer many areas of activity online, which necessitates the search for adequate opportunities for the mass use of modern computer systems and the creation of maximum ease of use. In this context, the provision of convenience in choosing the modes of using computer systems and improving the quality of their settings are the fundamental factors for

[1] Corresponding author: Yevhen Artamonov
Email: yevhen.artamonov@hotmail.com

the success of modeling multi-scenario systems.The problem of modeling the quality of modern information systems was considered in a scientific study by Monakhov and Mager (2020). In the course of the joint research, the scientists concluded that each type of scenario for the system's functioning is characterized by specific steps necessary to determine these scenarios, as well as calculate their reliability and implementation time. According to the researchers, such systems scale well, while their accuracy does not deteriorate when the base scenarios change and the base set of components increases.

The topic is developed by a group of authors represented by Gribova et al. (2022), who considered several problematic aspects of the development in a joint scientific study and implementation of adaptive user interfaces. Scientists concluded that today the expansion of interfaces for knowledge base editors is an urgent task in knowledge engineering. According to scientists, taking into account the difference in the level of training of experts in the field of modern information technologies, the convenience of an adaptive user interface is a fundamental aspect in assessing the quality of their development while providing prospects for including experts in the process of developing knowledge bases. For its part, the team of researchers represented by Zubkova et al. (2019), considered in a joint scientific study the problems of prototyping adaptive user interfaces of application programs using artificial intelligence methods. Scientists note that the development of automated information systems allows you to select a user interface, taking into account the characteristics and conditions of a particular technical specialist. According to the researchers, the practical application of artificial intelligence methods for selecting a user interface when designing application programs will make it possible to consider the specific properties of a particular user audience as much as possible.

In a joint scientific study, Verlan et al. (2014) raised the problem of organizing an adaptive user interface in automated systems. The scientists concluded that taking into account the cognitive characteristics of the user of a multi-scenario system and the specifics of work processes determines that the user interface adaptation system has the property of flexibility, which allows it to be effectively used in various fields of activity, in particular, in decision-making systems, in the development of learning processes, and also in automated control systems for workflows occurring in a wide variety of fields of activity. Building dynamic adaptive interfaces using artificial intelligence technologies is considered in the scientific study by I.M. Ismagilova and S.S. Valeyev(2018). The result of the research conducted was the conclusion of the authors that the practical use of the developed algorithms for adapting the user interface system by redistributing tasks between operators, taking into account their personal characteristics, can improve the efficiency of solving control problems. Researchers point to the fact that it is the quality of the interface of user systems that determines the effectiveness of the interaction between system data operators and the systems themselves at all stages of their management.

The main goal of this research work is to study the fundamental principles of modeling the operation of multi-scenario systems used in various branches of modern science and technology and the field of education and training.

2. MATERIALS AND METHODS

The methodological approach in this scientific study combines system analysis methods of the fundamental principles of modeling multi-scenario systems with an analytical study of the prospects for building monolithic architectures of online learning systems. The main research is preceded by the creation of a theoretical base, which includes an analysis of the results of research by several researchers on the problems of modeling multi-scenario systems and their practical application in various fields of science, technology, and the construction of an education system. A systematic analysis of the main aspects of creating models of multi-scenario systems made it possible to identify the main directions of their practical application, as well as to determine the real prospects for creating an effective software model of online learning for its subsequent use in various areas where there is a need to ensure high-quality interaction between users online. In addition, the analysis of a software multi-scenario system includes several aspects that determine the parameters of study within the system itself. At the same time, a systematic analysis of the sequence of operations for creating a model of a multi-scenario system includes an analysis of this system's critical functional requirements and modes of operation.

An analytical study of the real prospects for building monolithic architectures of online learning systems made it possible to analyze the features of user behavior in direct interaction with a multi-scenario system. At the same time, they were diagnosing the potential possibilities of building monolithic architectures that mainly affected non-specific and specific symptoms, individually and in their direct combination, within the framework of interaction in a single multi-scenario system. The selected combination of scientific research methods determined the presence of specific stages of the work.

At the first stage of this scientific research, the fundamental principles of constructing a software multi-scenario learning model were considered. In the future can be used as a base for developing similar types of models of multi-scenario systems. The fundamental principles of creating a model of a multi-scenario system of this type are presented based on its subsequent functioning, as well as the interaction of an individual user and groups of users with the system itself. The main problems of interaction of this kind and ways to overcome them are considered.

In the second stage of this scientific research, a multi-scenario distance learning system model was presented and considered, indicating the main subsystems and assessing the features of functioning, both subsystems and the entire system as a whole. Graphic displays of the entire system and its individual structural elements are presented in the corresponding diagrams. The principles of the interconnection of particular aspects of the system were also shown in the context of their functions within a single multi-scenario learning system.

At the final stage of this scientific study, an analytical comparison of the results obtained during it with the results and conclusions of several researchers involved in the scientific development of issues of creating models of multi-scenario systems for their subsequent practical application in various industries was carried out. This made it possible to clarify the results of this scientific study and formulate, on their basis, final conclusions that act as their logical reflection and sum up the entire range of scientific research in the field of studying the principles of modeling multi-scenario systems.

3. RESULTS

Today, due to the spread of the COVID-19 coronavirus pandemic, as well as several threats of a different nature, the problem of implementing the monolithic structure of the online learning system, as well as several other data exchange processes and online differences, is relevant. At present, the issues of increasing the efficiency of data exchange, the development of computer training, and the introduction of methods of collective and individual training are the most relevant in the activities of educational centers in many countries of the world. In this context, developing a software learning model for its subsequent use in organizing online learning in various educational institutions, as well as in other structures where there is a need to ensure high-quality interaction between users online, is highly relevant. This scientific study proposes considering the program learning model, which can be used as a basic model for developing various types of multi-scenario systems in the future. When creating the interface, differences in the level of user training were considered, which led to the maximum adaptation of the model to various types of user characteristics. The basic concept of developing the proposed model of a multi-scenario system was based on the following principles:

1. The system's maximum possible and permissible adaptation to users' needs.
2. Accounting for differences in personal and psychophysical differences in the state of users, as well as differences in the level of technical training and health status at the time of using the system.
3. Adjustments to the model's functionality del each time users log into the system.
4. Possibility of upgrading the user's skills as his interaction with the system develops.

Adaptation of the system to the needs of users was implemented by setting the system services for specific user requests. In contrast, the user model is created directly when he first accesses the system, after which the necessary adjustments are made to it. At the same time, the system services are configured by placing certain information, tips on them, and a significant amount of additional information stored in particular databases. Taking into account the level of training of users and their personal differences implies an emphasis on differences in the level of their information competence, which is expressed in the difference in skills in handling computer equipment. In addition, a system of tests for determining user competence is provided, which involves determining differences in the training of users in the field of knowledge of hardware and software computer software (Mistrik et al., 2017).The need to adjust the model's functionality at each user login to the system is determined based on information obtained by clarifying the level of information competence of a particular user, the basis for which is the analysis of the actions performed by him when entering the system. Similarly, there is a test assessment of his psychophysical characteristics at a particular time.

Improving the user's skills in the development of his interaction with the system, including its direct adaptation to various aspects of system software management, is achieved through the introduction of a system of assessment tests, training events, and a system for explaining complex aspects of using information stored in the system's knowledge bases. Analysis of the results of passing tests by users is the basis for making decisions on changing the structure of user access to the system, as well as supplementing and expanding, if necessary, the information array contained in the knowledge base of the multi-scenario system (Dong & Nguang, 2020).Ensuring many options for user access to the architecture of a multi-scenario system is implemented by constantly monitoring user access levels, with the provision of rights to a specific system user that provides access to information arrays of various levels (Boucher & Yalcin, 2006). In this case, the level of user access is determined depending on the level of his general training in computer skills and the level of mastery of the software disciplines included in the online learning system. All changes in the level of user competence are tracked within the system. As the user's competence increases, the level of his user access to individual nodes and elements of the system increases. Figure 1 shows a schematic representation of a multi-scenario e-learning system model allowing distance learning programs to be implemented.

In order to provide a multi-level system of access to a multi-scenario distance learning system and to adapt the system itself to the requests and needs of users, this model provided:

- subsystem for choosing widely used and most frequently used concepts and terms;
- content selection subsystem.

These elements are presented in Figure 2, which shows the interconnection diagram of the central nodes of the multi-scenario distance learning system.

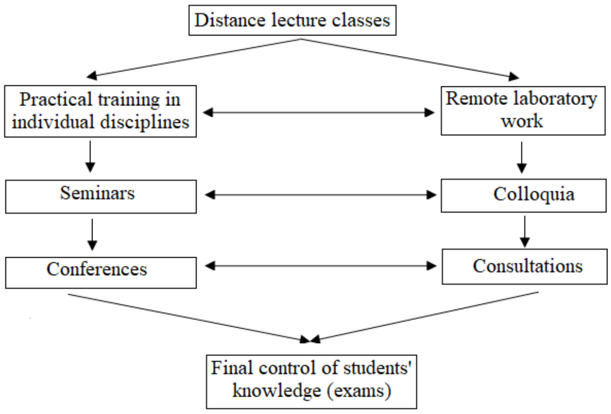

Figure 1. Model of a multi-scenario system of distance e-learning

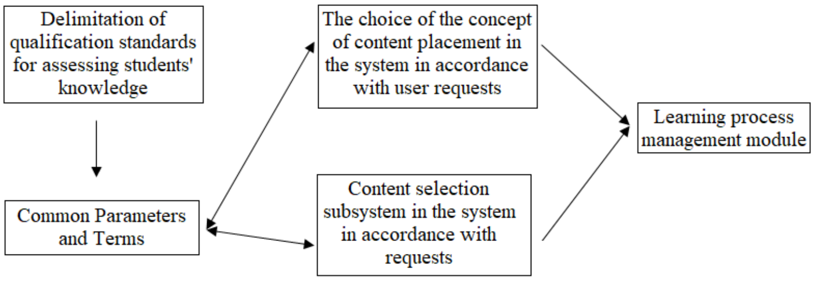

Figure2. The central nodes of the multi-scenario distance learning system

The module for distinguishing qualification standards for assessing students' knowledge is designed to determine differences in the level of computer training of users and create the necessary basis for the subsequent assessment of the level of their knowledge after completing a training program within the system itself. In this module, systems of tests are formed to test students' knowledge of the material presented and the main directions and volumes of providing advisory information to improve system users' skills.

The module of the most widely used terms and concepts includes the placement of the most frequently encountered user queries to create conditions for a quick search for information on given queries. This simplifies the process of searching for information and reduces the time it takes to provide it, which positively affects the organization of the learning process as a whole, increasing its final efficiency.

The module for selecting the concept of content placement by user requests is designed to speed up the search for the necessary information. It acts as a link between the content selection subsystem and the subsystem for matching between user requests. The concept of content placement may undergo changes depending on the change in the frequency and nature of search queries.

The content selection module, by the most common search queries, provides the selection of information that is most relevant to user queries. The choice of content occurs automatically, to the need of users for information of one kind or another.

The learning process management module is responsible for coordinating the interaction of all subsystems in a single distance learning system. The functions of this module include receiving information on changes like user requests, making decisions regarding changes in the structure of the distribution of information related to the educational process and the supply of educational materials, as well as making managerial decisions regarding other aspects of building the educational process.

Modeling the operation of a multi-scenario system implies the need to break it down into several separate services that perform specific functions within the framework of the functioning of a single system. The system management function is assigned to a particular module that performs coordinating functions (Li et al., 2021). In case of problems in the functioning of one of the modules, measures should be taken to ensure the reliability of the functioning of the entire system as a whole and to resolve the situation.

Creating a multi-scenario system model implies the development of an interface that is maximally adapted to the qualifications of various categories of users. The maximum possible adaptation of the interface to the different qualifications of users allows you to solve several issues effectively:

- achieving ease of system management by users of different levels of preparedness;
- provide access to the system to users with low qualifications in the field of handling computer equipment and software;
- ensuring the choice of the display scenario when changing the system parameters;
- the possibility of improving the skills of users, as well as studying the capabilities of the system by directly entering it;
- the possibility of increasing the options for system management scenarios by adding new functionality.

Changing a multi-scenario system's operation is possible at any stage of its functioning, depending on changes in the external environment's parameters that directly affect the system and its functioning. For this reason, a multi-scenario system’s component must be ableto handle all possible failure scenarios correctly. At the same time, they should be able to ensure long-term waiting for orders on system management issues, as well as be able to return to regular operation promptly as a result of the restoration of the counterparty in the case of limited centralization of functionality (with a large number of databases, an excessive number of contexts, which implies the impossibility of achieving synchronous interaction of several micro services) (Rouwet, 2022). Problems of this kind can be solved by abandoning the constant data consistency, where probable errors are either handled by more complex system architecture or by using data obtained from monitoring the current state of the multi-scenario system. The functioning of a multi-scenario distance learning system implies the presence of three main blocks of the system around which all its work is built:

1. Lecture presentation of training material.
2. Independent work of students.
3. Final check of the level of knowledge and assessment of students’ competence (qualification).

At the same time, providing the possibility of multiple access to the system implies the presence of a large number of interfaces for users of various categories: students, teachers, and system administrators. To implement this kind of capabilities, various micro services are used, in particular:

- personal account of the system user;
- online training courses in specific disciplines or areas of knowledge;
- systems of tests and verification of knowledge in certain sections.

Each of these micro services has its own features of providing information and providing users with access to them, depending on the level of access. For each of these micro services, a separately located virtual server is programmatically provided, for which a particular resource is allocated, the volume of which is maintained in strict accordance with the fundamental principles of distributing the load on the system as a whole and its individual nodes in particular, as well as maintaining the necessary systems of tests and verification of knowledge in certain sections of the load balance in the system (Somerville, 2015). At the same time, the adjustment of the module for maintaining the balance of the allowable load is carried out at the server core level and involves the practical use of software decision-making algorithms based on the received data describing the system’s current state. The category of data of this kind should include the following: the type of protocols used, the total amount of system memory and the average parameter of the used RAM, the average server response time, the average response time of the information database, and the average page load time.

The solution of possible problems of the micro service architecture of a multi-scenario system is achieved by synchronizing the functioning of individual nodes of the system, as well as by a consistent transition from monolithic system architecture to a distributed micro service architecture, the functioning of which is based on more minor constituent elements consisting in continuous structural interaction. Eliminating problematic situations that arise in operating individual elements of a multi-scenario system contributes to its efficient functioning for a long time and the highest quality satisfaction of user requests.

4. DISCUSSION

The topic of modeling the operation of multi-scenario systems is discussed in the scientific study by V.R. Barinov (2016) on using use case programs to develop modern software use cases. The scientist notes that a use case should be understood as a particular approach to describing the interaction of a system with the external environment. According to the scientist, in the practical application of a multi-scenario system, the parameter of the frequency of its use is of crucial importance from the point of view of the prospects for subsequent improvement in the quality of the final result of the entire project. The researcher’s conclusions correlate with this scientific study’s results in evaluating the use case concept. In contrast, the conclusion regarding the frequency of use of the model seems controversial since the final results of the entire project depending on several other parameters besides the specified one.

In turn, A. Garces (2021), in his scientific study of modeling, operation, and analysis of DC networks, touches upon the issues of modeling the operation of multi-scenario systems. The scientist concluded that effective management of a multi-scenario system is possible under the condition of effective and coordinated functioning of all elements included in the system. The author notes that testing of the software used has shown that the introduction of hardware and software in the process of creating a model of a multi-scenario system implies the need to monitor at each stage the accuracy of the execution of commands by the elements of the system, which ultimately results in the achievement of the high final quality of the functioning of the entire system. In general. The researcher's conclusions directly correlate with the results obtained in this scientific work, expanding them in the context of software testing issues. This opens up prospects for further scientific research in this direction.

The topic was developed by a team of authors represented by Bansal et al. (2022) in a collaborative scientific study of modeling and dynamics control features in renewable energy microgrid systems. The team of scientists draws attention to the fact that the use of the multi-scenario approach allows for generalizing and clarifying the results obtained during the diagnostics of microgrid systems through the use of the logical input method. According to the authors, the practical application of fuzzy logic methods makes it possible to form certain systems for assessing the actual state of the microgrid system with renewable energy sources and build a system of cause-and-effect relationships based solely on data obtained during diagnostic measures. The conclusions of the research team are controversial because the assessment of the actual state of the microgrid system is possible only when using a sufficiently large amount of initial data that is not always available.

Noergaard (2012), in a scientific study of the fundamental principles of creating an embedded systems architecture, touches upon the problems of building multi-scenario systems and monitoring the quality of their functioning. The scientist concluded that using many options for the placement of embedded equipment, in particular, in e-learning systems, increases the variability of using the system and obtains a significant number of results that are not directly related to each other. The scientist draws attention to the fact that the coordination of the distribution of the load on all elements of the e-learning system can significantly improve the quality of its functioning while greatly complicating the whole process. The researcher’s conclusions do not directly contradict the results of this scientific work. At the same time, the assertion that load coordination improves the system’s quality requires additional verification in natural conditions.

At the same time, a team of researchers represented by A. Puder, K. Romer, F. Pihofer (2005), in joint research work, considered several problematic aspects of building an architecture of distributed systems. According to scientists, the development and implementation of middleware allow you to effectively connect distributed applications with hardware-type platforms, operating systems, and network data distribution technologies. Scientists note that the operation of multi-scenario systems provides the ability to manage large amounts of data and use them to solve the problems of developing data distribution systems with many access options. The scientists’ conclusions coincide with this scientific study’s results in using multi-scenario systems to manage large amounts of information. In contrast, the conclusion regarding the combination of different software types seems controversial since the realities of each specific situation determine this.

A similar topic is considered in the scientific work of the research team J. Wang, C. Wang, M. Xin, Z. Ding, J. Shan (2020), devoted to studying the principles of joint control of multi-agent systems. In the course of the scientific research, the authors concluded that the functioning of systems formed by ensuring the effective interaction of several intelligent agents should be organized with a wide variability of decisions made. This will allow serving a significantly more significant number of users in a given unit of time, as well as achieving higher rates of satisfaction of user requests. The opinion of the researchers does not fundamentally conflict with the results obtained in this scientific work.
S. Batley (2007) conducted an independent scientific study of the fundamental principles of data architecture for information professionals. The scientist concluded that the design of modern information systems must necessarily include the creation of adaptive interfaces that are intuitive to users, as well as maintaining the performance of relevant information tasks at the proper level that meets the most common user requests. According to the researcher, this can be fully implemented through the creation of effective models of the functioning of multi-scenario systems, including large amounts of data and tools for their recognition and timely practical application for a qualitative solution of the entire range of tasks assigned to systems at the stage of their design and development. . The conclusions of the researcher supplement and expand the results of this scientific work, while attention should be paid to the issues of using a large amount of data in the development of multi-scenario systems, as fundamental in this context.

A team of authors represented by Mistrik et al. (2014) conducted a joint scientific study of the basic principles of software architecture for cloud use of big data. Scientists note that the effective functioning of multi-scenario system models can effectively solve the issues of cloud storage of large amounts of data and increase the speed of operations performed. The authors concluded that rethinking specific software architectural solutions can speed up the data processing process and increase the volume of operations performed, which will satisfy several functional and non-functional requirements for the system directly related to the amount of data and the speed of their processing. The researchers' conclusions correlate with this scientific study's results in resolving data storage issues using multi-scenario systems. In contrast, the problems of accelerating data processing require additional study.

The issues of system architecture modeling were considered in a scientific study by P. Roques (2020). In the course of research work, the author concluded that a simple and understandable user interface provides ease of use of computer programs and is extremely important in ensuring that information is communicated to users with varying degrees of training. According to the researcher, intuitive model editing and significantly increased user interface browsing capabilities improve modeling quality and productivity, enabling system engineers to focus on designing improvements to the system and its architectural solutions. The researcher's conclusions are entirely consistent with the results obtained during this research work.

5. CONCLUSIONS

The process of building a model of a multi-scenario system implies the need to consider several factors that affect the efficiency of the functioning of individual subsystems, individually and within a single system, in the context of searching and processing information, as well as satisfying key user requests. In addition, the functioning of subsystems within a single multi-scenario system involves control in the system of processes for distinguishing qualification standards for assessing the knowledge of students using this system, accounting and saving terms and parameters that are important in terms of system speed as a whole and the level of satisfaction of user requests, and also the choice of the concept of content placement in the system by user requests and its provision. Modeling a multi-scenario system allows one to substantiate the choice of the main scenarios of its behavior under changing external conditions. These conditions include a change in the user's qualifications in the case of a multi-scenario online learning system, as well as changes in the volume of information entering the system and processing by the system. In addition, the change in the frequency and nature of user requests is essential, which, in turn, implies the need to adjust the information stored in the databases.

The effective functioning of a multi-scenario system is facilitated by developing a software interface that is maximally adapted to users of various levels of training. Such an interface ensures the efficiency of use, allowing users with different skill levels to access the necessary information. The use of the principle of multi-scenario in the development of the system proves its practical effectiveness in developing software systems and multi-interface systems intended for the broadest user audience. In particular, the model of a multi-scenario learning system can be applied in practice when developing learning systems with many possible scenarios for learning in a wide variety of areas. In contrast, the principle of interaction and information exchange between the individual modules of the system remains unchanged. However, the aspect of verification of data entered into the system needs additional research.

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Yevhen Artamonov
Department of Computerized Control System
National Aviation University
03058, 1 LiubomyrHuzar Ave., Kyiv, Ukraine
yevhen.artamonov@hotmail.com
ORCID 0000-0002-9875-7372

Iurii Golovach
Department of Delivery Company "Squad"
01033, 3 Korolenkivska Str., Kyiv, Ukraine
iuriigolovach@yahoo.com
ORCID 0000-0001-9872-8144

Halyna Rosinska
Department of Computerized Control System
National Aviation University
03058, 1 LiubomyrHuzar Ave., Kyiv, Ukraine
hal.rosinska@outlook.com
ORCID 0000-0002-6348-9419

Svitlana Stanko
GlobalLogic Ukraine
03038, 2/1 M. Grinchenko Str., Kyiv, Ukraine
stankosvit12@gmail.com
ORCID 0000-0001-9859-0261

Daniil Krant
Department of Computerized Control System
National Aviation University
03058, 1 LiubomyrHuzar Ave., Kyiv, Ukraine
dan_krant@outlook.com
ORCID 0000-0003-4601-2827