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Methodology Development for Evaluating the Effectiveness of Implemented Regional Government Information Systems

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***Abstract*—The work is dedicated to the analysis of criteria used to assess the effectiveness of public information systems to meet the demands of citizens for government services in the digital form. This work presents a methodology for assessing the priority of projects to create, maintain and upgrade government information systems. The groups of criteria based on qualitative and quantitative indicators are proposed, as well as a methodology that allows comparing information systems in order to identify unclaimed and ineffective government information systems. Qualitative criteria are determined by experts or as a result of surveys and quantitative criteria are statistical data. This paper proposes the use of machine learning methods to identify the relationship between qualitative indicators and metrics of information systems.**

Keywords— efficiency of information systems, state information systems, machine learning, efficiency criterions

I. INTRODUCTION

Currently, a large number of state information systems have been developed and implemented in the regions of the Russian Federation, which to a large extent duplicate information collection and processing procedures, either have isolated data that is not available for use in other systems, or do not ensure uninterrupted and reliable functioning, or not configured to scale with a large increase in the number of users or the volume of operations performed.

There is also a major problem in the choice of systems under development, due to the diversity of technologies, as well as the lack of uniform standards for the decision to implement. In this connection, approaches of business organizations that focus on compliance with technical requirements and economic indicators such as cost reduction, profit, return on investment are used [1]. Despite the importance of the above indicators, they are not suitable for use in government systems, as they are not aimed at achieving strategic goals of government agencies and objectives of socio-economic development [2,3].

Having carried out a literature review on foreign existing methods of evaluating information systems and the demand for government systems [4-10], the most significant works have been identified:

- Richard Heeks [4] in his article "Information Systems and Developing Countries: Failure, Success, and Local Improvisations" considers the method of systems evaluation based only on quantitative indicators.
- Based on the analysis of results by Miltiadis D. Lytras and Anna Visvizi [6] can conclude that even the most knowledgeable and skillful citizens have very serious concerns about the availability and effectiveness of services received.
- The methodology of DeLone and McLean [7] using criteria of impact on an individual (direct and indirect users of the system) and, as a consequence, on organizations. Other quality assessment criteria include the quality of incoming, outgoing and stored information and the direct satisfaction of system users.
- The assessment methodology of Hallikaien P, Chen L. [9], describes the approach to evaluating the effectiveness of information systems by comparing strategic product values with similar systems used in world practice.

The models analyzed have both advantages and a number of disadvantages:

- the principles for evaluating systems in the absence of feedback from users are not described;
- approaches to transforming qualitative indicators into quantitative ones are not presented;
- legal features of the creation of the state information systems in the Russian Federation are not considered.

This problem is relevant due to the fact that there is no single unified methodology for assessing the effectiveness of information systems [2].

The main goal of this study is to solve the problem of assessing the demand for information systems developed by the state, which are not taken into account when using traditional approaches to analyzing the effectiveness of information systems, and to create a model for evaluating the criteria developed and supported by information systems.

II. METHODOLOGICAL ISSUES OF PRIORITIZATION OF INFORMATION SYSTEMS FUNCTIONING

In connection with the centralization of the information systems infrastructure of the Khanty-Mansiysk Autonomous Okrug - Ugra was developed the methodology that established the procedure for determining the priority of projects for creation, operation, and development of information systems operated by the executive bodies of state power of the autonomous okrug and subordinate institutions.

The results of evaluating the effectiveness of functioning information systems has been obtained in accordance with this methodology can be used to:

- determine the feasibility and effectiveness of the creation, functioning and development of information systems;
- monitor the effectiveness of functioning information systems.

Guided by the regulatory legal acts of the Khanty-Mansiysk Autonomous Okrug - Ugra [11–13] and the Interstate Standard (GOST) for project management [14,15], a procedure was developed for determining the priority of projects, which includes:

- evaluation of the project according to six criteria characterizing the information system;
- calculation of the value for an integrated indicator to prioritize systems;
- formation of the list of information systems, sorted in descending order of the corresponding integrated indicator values.

The methodology contains the following criteria:

- publisher of a regulatory act (NLA). The weight of this criterion is 5. For the criterion, there are three classification features and their corresponding estimates;
- project cost. The weight of this criterion is 1. For the criterion, there are five classification features and their corresponding estimates;
- scale of the project. The weight of this criterion is 1. For the criterion, there are three classification features and their corresponding estimates;
- project implementation period. The weight of this criterion is 1. For the criterion there are four classification features and their corresponding estimates
- type of project. The weight of this criterion is 10. For the criterion there are three classification features and their corresponding estimates;
- achievement of performance targets. This criterion is used for projects aimed at supporting or developing an information system. The weight of this criterion is 5. For the criterion, there are three classification features and their corresponding estimates.Integrated indicator of project priority is calculated by summing the estimates of all the criteria, taking into account the weight of each criterion according to the following formula:

$$R = \sum_{i=1}^{6} k_i * v_i, \quad (1)$$

R - integrated indicator of the priority of the project, k - evaluation of the criterion, v - weight of the criterion, i is the ordinal number of the criterion.

This methodology was approved and introduced by the Department of Information Technologies and Digital Development of the Khanty-Mansiysk Autonomous Okrug - Ugra in 2018 [16].

However, during the testing of the methodology, the following disadvantages were identified:

- methodology does not take into account feedback from users of the system;
- methodology is based on formal criteria and does not take into account statistical data on the use of the information system by users.

Based on the identified shortcomings in the methods [4, 6, 8, 9, 17–20], it is necessary to consolidate key criteria and supplement the assessment system with new criteria, both quantitative and qualitative.

III. Selection and classification of criteria

This paper proposes an approach to assessing state information systems by calculating and visualizing the values of groups of criteria and their combined assessment.

The final value for the group of criteria is determined by the formula (2).

$$P = \frac{\sum_{i=1}^{n} Cr_i}{n}, \quad (2)$$

P - group of criteria of the system, Cr - value of the criterion (group of criteria), n -number of criteria (group of criteria).

The proposed approach is based on 5 groups of criteria by which expert councils will evaluate state information systems:

- financial– this is a group showing all the costs of the implementation, maintenance, modernization of the system;
- personal– this is a group that exerts influence on a person as an individual person when using information systems;
- legal– this is a group showing the impact of the legal framework on the development and maintenance of the state information system;
- social– this is a group showing the impact exerted on the society and the company of developers when creating and maintaining the state information system;
- technological– this is a group that shows the effectiveness of solving technological problems, technical capabilities and limitations of the system.

For each group of criteria, unique criteria were selected that have quantitative and qualitative indicators.

Approach supposed to interpret quantitative criteria in the work according to the principle of the scale of intervals. It is used to display the differences between the properties of objects, allowing you to determine how much one object is superior to another. This scale can have arbitrary reference points and scale [21]. Quantitative indicators are applied to the financial group of criteria.

The financial group of criteria consists of:

1. Development costs. Possible values of the indicator:

- 0 points — costs exceeding 50,000,000 (rubles);
- 1 point — costs from 10,000,000 (rubles) to 50,000,000 (rubles);
- 2 points — costs less than 10,000,000 (rubles).

2. Cost of maintaining the system for the planned period of operation of the system. Possible values of the indicator:

- 0 points — costs exceeding 5,000,000 (rubles);

- 1 point — costs from 1,000,000 (rubles) to 5,000,000 (rubles);
- 2 points — costs less than 1,000,000 (rubles).

This indicator is calculated by the formula 3:

$$C_{mt} = C * t\ , \tag{3}$$

Cmt - cost of maintaining the system, C - amount of allocated funds per year, t is the planned number of years of operation).

3. Cost of modernization. Possible indicator values:

- 0 points— costs over 25,000,000 (rubles);
- 1 point— costs from 5,000,000 (rubles) to 25,000,000 (rubles);
- 2 points— costs less than 5,000,000 (rubles).

For qualitative indicators, it is proposed to use an ordinal scale (rank) assessment. It represents a qualitative assessment expressed in a natural language. The numbers on this scale determine only the order of objects according to their preference, but does not allow us to state to what extent one object is preferable to another [21].

To calculate quality indicators, a survey of system users could be used or collect key statistical parameters that are most likely to correlate with the results of the survey.

Personality group of criteria consists of:

1. Customer support - a quality indicator, is carried out using a dedicated group of employees responding to requests for technical user support. Possible values:

- 0—dissatisfied with the support;
- 1— neutral attitude;
- 2— completely satisfied with the support.

Statistical Parameters:

- the number of calls to the technical support of the system;
- operator response time;
- Average time spent on the site.

2. User satisfaction is a subjective criterion in which the user reflects the level of satisfaction with the information system. Possible values:

- 0— urgent need to take action
- 1— the system is satisfactory
- 2— citizens are satisfied with the system

Statistical Parameters:

- engagement rate;
- returning visitors;
- churn rate;
- time spent on site;
- total visits.

3. Changes in the interaction of users with the system over time - a qualitative indicator, determined by the troubleshooting of the system, the duration of use of the system. Possible values:

- 0— problems are not resolved;
- 1— malfunctions are partially eliminated;
- 2 — all problems are resolved.

Statistical Parameters:

- quantity of requests for system upgrade;
- the time of processing the application;
- quantity of completed applications.

Legal group of criteria consists of:

1. Strategic value of the system is a criterion that demonstrates the achievement of target indicators for the implementation of the main directions of the Government of the region and the socio-economic development of the region. Possible values:

- 0— not achieved;
- 1— partially achieved;
- 2— achieved in full.

Statistical Parameters:

- level of achievement of target indicators from state statistics.

2. Level of penetration of the information system is a criterion showing the use of information systems at all levels of government. Possible values:

- 0— the system is used by up to 30% of government bodies and municipalities;
- 1—system is used by 30% to 80% of state authorities and municipalities;
- 2—system is used by 80% of government bodies and the municipality.

Statistical Parameters:

- The number of public authorities and the municipality (OGV and MO) using the information system;
- The number of public authorities and municipalities (OGV and MO) in the region.

3. Publisher of a normative legal act (NLA) is a criterion showing the level of a publisher of a normative legal act. Possible values:

- 1— legal acts of the autonomous region;
- 2 — NLA of the Russian Federation, NLA of the Government of the Autonomous Okrug.

Statistical Parameters:

- register of publishers of regulatory legal acts;
- grounds for creating an information system (NLA).

Social group of criteria consists of:

1. The need for a specific information system is a criterion showing the need for an information system according to requests and necessary criteria. Possible values:

- 0—system does not meet the needs of society;
- 1—system partially meets the needs of society;
- 2—system meets the needs of society.

Statistical Parameters:

- frequency of visits to the information system;
- quantity of proposals received;
- quantity of goals achieved in the system;
- quantity of services received in an alternative way.

2. Evaluation of effectiveness - a criterion that shows how effectively the system copes with assigned tasks. The methodology for developing performance criteria is presented in order [16]. Possible values:

- 0— up to 50%;
- 1— from 50% to 80%;
- 2— from 80% to 100%.

Statistical Parameters:

- quantity of system indicators achieved (information from the information system).Technological group of criteria consists of:

1. Security is a quality criterion that defines: confidentiality of the information system. Possible values:

- 0— the system is unsafe;
- 2— the system is reliably protected.

Statistical Parameters:

- the amount of unauthorized entry into the system;
- quantity of hacking attempts;
- quantity of successful attacks.

2. Reliability is a quality criterion that determines the level of fulfillment of specified functions in the system for a certain time under specified operating conditions: redundancy of technical means, use of standard protocols for operating IP devices, use of specialized technological means of information protection. Possible values:

- 0— low reliability system;
- 1— system of an average level of reliability;
- 2— system of a high level of reliability.

Statistical Parameters:

- Amount of system downtime;
- % of successful logins;
- The number of critical system errors.

It is assumed that criteria that cannot be unambiguously assessed without the help of expert opinion may be causally related to other statistical criteria. In this regard, the approach of an indirect method for evaluating such criteria, expressed through the representation of the collected statistical parameters from various systems, is proposed.

IV. Business process of creating a system for estimating the efficiency of state information systems

To determine the dependence of the selected correlation quantitative indicators, it is proposed to use the following business process:

- Conduct a survey of users of state information systems to obtain estimates according to criteria for the study period;
- Collect statistical information of all the calculated features for each group of criteria for the study period;
- Process the obtained statistics, find correlation variables;
- Normaliz data to an interval from 0 to 1;Build a rating system for information systems developed by the state, based on the data obtained using machine learning methods. In the course of the work, the coefficients are added to each criterion attribute, the correlation variables are checked, and the criteria are classified and selected.

To achieve a more efficient grading system, it is proposed to build several models using various machine learning algorithms:

- SVM algorithm [22] was chosen on the principle that it is one of the most advanced classification methods [23]. It should be noted that SVM can be represented as a two-layer neural network, where the number of neurons of the hidden layer is determined automatically (it is equal to the number of reference vectors) [22-23].
- Decision Tree Regression algorithm was chosen according to the principle of easy interpretation of this in the form of a clear tree structure and the absence of the need to explicitly set the relationship between the response and predictors, when working with data on the properties of which little is known [24].

V. Conclusion

As a result of the study, an approach was proposed for assessing state information systems to effectively solve the problems of demand for developed systems, scaling an information solution, integrating interaction with related systems, and reliable and safe functioning. At the same time, the needs for technological compliance with the goals of departmental systems and the tasks of socio-economic development were taken into account.

During the analysis of domestic methods, no integrated solutions were found for assessing state information systems. In foreign methods for evaluating information systems, critical shortcomings were identified that does not allow the use of one of the methods as a tool for evaluating departmental systems. However this allowed to create a list of key criteria that affect the development, modernization and maintenance of systems.

Based on the methods studied, a comprehensive system for assessing state information systems was proposed, which takes into account multilevel quantitative and qualitative indicators.

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