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CONCEPT OF MANAGEMENT OF IT-ARCHITECTURE OF ORGANIZATION IN CONDITIONS OF DIGITAL TRANSFORMATION

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The issue of managing the IT architecture of an organization in the context of digital transformation is considererd in the paper. Digital transformation is a complex task that is associated with changing the information processes of an organization. In terms of complexity, digital transformation can be compared to continuous system restructuring. When developing a strategic information technology profile of an organization (IT profile), the task arises of assessing the effectiveness of its heterogeneous components and the profile as a whole. Based on the assessment results, the task of choosing the most preferred IT profile option from a variety of alternatives is solved. Due to the complexity of the formalized representation of a holistic model of the effectiveness of a strategic IT profile, it is often impossible to solve this problem using formal mathematical methods based on an accurate and adequate description of heterogeneous objects. To solve the problem under consideration, an approach is proposed using the apparatus of fuzzy sets and fuzzy logic and a system of unified IT profile indicators. The proposed approach makes it possible to carry out quantitative and qualitative assessments of components and to obtain an integrated assessment of the alternatives being formed for the strategic IT profile of the organization and is aimed at reducing the risk of making inefficient project decisions.

Keywords: digital transformation, strategic IT profile, fuzzy sets, fuzzy inference, a new level of consistency

КОНЦЕПЦИЯ УПРАВЛЕНИЯ ИТ-АРХИТЕКТУРОЙ ОРГАНИЗАЦИИ В УСЛОВИЯХ ЦИФРОВОЙ ТРАНСФОРМАЦИИ

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В статье рассматривается вопрос управления ИТ-архитектурой организации в условиях цифровой трансформации. Цифровая трансформация – это сложная задача, которая связана с изменением информационных процессов организации. По сложности цифровую трансформацию можно сравнить с непрерывной системной перестройкой. При разработке стратегического профиля информационных технологий организации (ИТ-профиля) возникает задача оценки эффективности его разнородных компонентов и профиля в целом. По результатам оценки решается задача выбора наиболее предпочтительного варианта ИТ-профиля из множества альтернатив. Вследствие сложности формализованного представления целостной модели эффективности стратегического ИТ-профиля решить данную задачу с помощью формальных математических методов, основанных на точном и адекватном описании разнородных объектов, часто не представляется возможным. Для решения рассматриваемой задачи предлагается подход с применением аппарата нечетких множеств и нечеткой логики и системы унифицированных

показателей ИТ-профиля. Предложенный подход позволяет проводить количественные и качественные оценки компонентов и получить интегральную оценку формируемых альтернатив стратегического ИТ-профиля организации и направлен на снижение риска принятия неэффективных проектных решений.

Ключевые слова: цифровая трансформация, стратегический ИТ-профиль, нечеткие множества, нечеткий вывод, новый уровень системности

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Introduction

At the present, information and communication technologies (ICT) are the point of growth at both the macro and micro levels. They form the basis for the development of the digital economy, in which intellectual capital is becoming increasingly important [1]. The analysis of ICT development trends makes it possible to ensure the timely development and practical application of achievements as they become available. Continuous enhancement of the functioning of the organization based on the achievements of ICT is called digital transformation. In practice, digital transformation is a complex task that never ends, and its size, risks and benefits are constantly increasing. Along with the growth of the advantages of digital transformation, the dependence of the results of the organization's functioning on the reliability of ICT tools increases, the risks of inadequate reactions of the management system to emergency situations increase. Taking into account these factors, digital transformation can be compared with a continuous system restructuring of an organization.

During the transition of information technologies of an organization to a new level of systematicity, a strategic IT profile is being developed on a variety of hardware and software components that provide the implementation of information services in a functional relationship [2]. At the same time, the issues of assessing the effectiveness of heterogeneous components and the IT profile as a whole, choosing from a variety of alternatives the most preferable option arise, taking into account the specified requirements for the information support of production processes. Due to the complexity of the formalized representation of a holistic model of the effectiveness of a strategic IT profile, it is often not possible to solve this problem using formal mathematical methods based on an accurate and adequate description of heterogeneous objects. One of the effective ways to solve a poorly formalized problem is to use the apparatus of fuzzy sets and fuzzy logic.

1. Computational mathematical model for assessing the effectiveness of the strategic IT profile of the organization using the apparatus of fuzzy sets and fuzzy logic

The approach to assessing the effectiveness of an organization's strategic IT profile is based on the construction of a system of unified indicators and a calculated mathematical model that allows evaluating its heterogeneous components by quantitative and qualitative criteria, as well as evaluating the resulting effectiveness of the strategic IT profile variant being formed. In this paper, we consider a computational mathematical model using the apparatus of fuzzy sets and fuzzy logic, which makes it possible to create a holistic model of the effectiveness of a strategic IT profile and make an acceptable description of the task from the point of view of accuracy and compactness. The Mamdani-type algorithm [3] is used as a research method, which provides a minimax composition of fuzzy sets.

In general , the computational mathematical model can be described by a set of the following procedures:

1) introduction of fuzziness – for a given (crisp) value of the argument $x=x_0$, the degrees of truth of the premises of each rule are found

$$a_i = \mu_{Ai}(x_0),$$

where A_i is a set of alternatives to the i-th component of the IT profile, which are subject to multi-criteria analysis;

2) fuzzy inference for each rule – there are "truncated" membership functions for the variable values of the analyzed indicators Z in the form of

$$\mu_{Bi}^{*}(z) = minZ\left[a_{i,}\,\mu_{Bi}(z)\right],$$

where B_i are the values of the criteria for assessing the i-th component of the IT profile;

3) composition – using the MAXIMUM (max) operation, the found truncated functions are combined, which results in a final fuzzy subset for variable values with a function of their belonging of the form

$$\mu_{\Sigma}(z) = \mu_{B}(z) = maxZ\left[\mu_{B1}^{*}(z), \mu_{B2}^{*}(z), \ldots \mu_{Bn}^{*}(z)\right];$$

4) bringing to clarity is finding $z_0=F(x_0)$, which is advisable to carry out by the centroid method, that is, the clear value of the output variable is defined as the center of gravity for the curve $\mu_{\Sigma}(z)$:

$$z_0 = \frac{\int_{\Omega} z \times \mu_{\Sigma}(z)\,dz}{\int_{\Omega} \mu_{\Sigma}(z)\,dz}$$

or in discrete form

$$z_0 = \frac{\sum_i \left(z_i \times \mu(z_i)\right)}{\sum_i \mu(z_i)}.$$

In order to select the most preferred variant of the IT profile, it is necessary to determine a set of heterogeneous components $X^* = (x1^*, x2^*, ..., xn^*)$, which integrally correspond to the specified criteria $K = (k1, k2, ..., km)$. The task of choosing the most preferred component for inclusion in the strategic IT profile is to arrange the elements of the set X^* according to the corresponding criteria of the set K [4].

Fuzzy logical inference according to the Mamdani-type algorithm is made using a fuzzy knowledge base [5], in which the values of input and output variables are given by fuzzy sets:

$$\bigcup_{p=1}^{k_j}\left(\bigcap_{i-1}^{n} x_i = a_{jp}\ with\ weight\ w_{jp}\right) \rightarrow y = d_j, j = \overline{1,m},$$

where $a_{i,jp}$ is the membership function of the considered alternative of the i-th component according to the j-th criterion with the weight w_{jp} of the region of possible values d_j, $w = \{w_{ip}\}$ is the domain of definition $\mu_{\Sigma}(z)$.

The fuzzy set of output values of d_j is defined by the expression

$$d_j = \int_{\underline{y}}^{\overline{y}} \frac{\mu_{jp}(y)}{y}, y \in \left|\overline{y}, \underline{y}\right|,$$

where $\mu\,jp\,(y)$ is the membership function of the output parameters y to a fuzzy set of criteria values;

$y \in \left|\overline{y}, \underline{y}\right|$ – the maximum and minimum values of y available in the sampling.

Using the function of whether input x_i belongs to a fuzzy set of values of the j -th criterion, the following correspondence can be determined:

$$a_{i,jp} = \int_{\underline{x_i}}^{\overline{x_i}} \frac{\mu_{jp}(x_i)}{x_i}, x_i \in \left|\overline{x_i}, \underline{x_i}\right|,$$

where $a_{i,jp}$ is an integral function of whether input x_i belongs to a fuzzy set of values of the j -th criterion;

$x_i \in \left|\overline{x_i}, \underline{x_i}\right|$ are the maximum and minimum values of x available in the sampling.

The membership degrees of the input set of variables X^* variants to a fuzzy set of criteria values, taking into account weights, are calculated by the formula

$$\mu_{dj}(X^*) = \bigvee_{p=\overline{1,k_j}} w_{jp} \bigwedge_{i=\overline{1,n}}\left[\mu_{jp}(x_i^*)\right], j = \overline{1,m},$$

where $\vee(\wedge)$ is a logical operation OR (AND).

It is advisable to use the following options for implementing this operation: for operation OR – finding the maximum; for operation AND – finding the minimum.

As a result, we obtain a fuzzy set $\tilde{y}$ corresponding to the input vector X^*, which characterizes the variant of the IT profile:

$$\tilde{y} = \frac{\mu_{d1}(X^*)}{d_1} + \frac{\mu_{d2}(X^*)}{d_2} + \ldots + \frac{\mu_{dm}(X^*)}{d_m}.$$

The numerical (crisp) value of the output parameter y corresponding to the input vector X^* is determined as a result of defuzzification of the fuzzy set $\tilde{y}$. In this case, it is possible to carry out defuzzification by the method of determining the centroid:

$$y = \frac{\int_{\underline{y}}^{\bar{y}} y \cdot \mu_{\tilde{y}}(y)\, dy}{\int_{\underline{y}}^{\bar{y}} \mu_{\tilde{y}}(y)\, dy}.$$

In order to implement this multi-criteria model, it is required to define a set of criteria, their acceptable values and weights. The definition of criteria and their weight functions depends, first of all, on the technical requirements for the information services of the organization and is a separate issue.

2. System of unified indicators of static and dynamic parts of the strategic IT profile

Any new technology should be integrated into the existing infrastructure with the targeted installation of database and knowledge preservation, which requires additional integration tasks. This paper discusses the issues of assessing the effectiveness of the strategic IT profile of the organization in terms of software and information resources. The strategic IT profile of an organization includes heterogeneous components that are characterized by a certain set of indicators. In order to assess the effectiveness of the IT profile, it is necessary to create a system of unified indicators, which is the basis for creation of a criterion space and implementing computational algorithms. The system of unified indicators is aimed at solving the following tasks: achieving the reliability of the functioning of information systems and the implementation of services for information support of production processes, software compatibility at the level of functional applications and data, the necessary level of conformity of individual components and IT as a whole, the necessary level of protection of information resources of the organization [6].

In order to build a system of unified indicators in the structure of an IT organization, static and dynamic parts are allocated, which determine the reliability of information support for production processes and the directions of IT development respectively. As part of the solution of the task, it is advisable to attribute databases and knowledge to the static part, and software – to the dynamic part. At the stage of the strategic IT profile of the organization forming, the accumulated data and knowledge are considered as an unchangeable part. The software is formed on a variety of means of implementing information services in various combinations and is considered as a changeable part of the strategic IT profile.

An approximate set of unified indicators that determine the properties of databases and knowledge includes [7]:

– type of structure;
– database amount (number of records);
– frequency of data updates;
– the level of reliability requirements;
– number of serviced business processes;
– data privacy level;
– acceptable recovery time in emergency situations;
– classes of solved tasks;
– requirements for the level of standards support.

The elements of the strategic profile corresponding to the static part are selected in order to ensure the integration of databases and knowledge in the new information environment without data loss and distortion.

Software in the IT architecture of an organization has a multi-level functional structure and is classified into the following types within the framework of issues to be solved: system software, database management systems, general-purpose applications, special-purpose applications. These types of software are characterized by a certain set of indicators, which, with common names, have different contents in accordance with the level in the functional structure and the purpose of the software components. The following unified indicators defining the properties of the dynamic part are distinguished [7]:

– functionality as an optional extension;

– reliability of operation (number of failures per unit of time);
– degree of compliance with standards;
– the degree of security;
– license level;
– scalability;
– productivity (number of operations per unit of time);
– portability;
– degree of administration complexity;
– cost category.

The elements of the strategic IT profile corresponding to the dynamic part are selected in order to achieve system-wide criteria and seamless integration of software components at all levels of the information process implementation [8].

Unified indicators that determine the properties of static and dynamic parts are used to build the criteria space of the strategic IT profile, on the basis of which the potentials of the constituent parts and the effectiveness of the studied variants of the strategic IT profile are assessed. The static and dynamic parts are functionally interconnected during the implementation of information processes. As the results of the study display, the greatest efficiency is achieved at the point of mobile equilibrium of their potentials. The set of software components should be necessary and sufficient in terms of their functionality for sustainable and reliable information support of the organization's production processes.

Conclusions

An approach to assessing the effectiveness of an organization's strategic IT profile using fuzzy sets and fuzzy logic and a system of unified IT profile indicators is proposed. A mathematical calculation model representing an integral model of the effectiveness of the strategic IT profile is defined. In order to build a system of unified indicators in the structure of an IT organization, static and dynamic parts are highlighted, which determine the reliability of information support for production processes and the directions of IT development respectively. A mathematical calculation model using fuzzy sets and fuzzy logic allows quantitative and qualitative assessments of heterogeneous components of the strategic IT profile of an organization, as well as to build fuzzy inference rules for evaluating the alternatives being formed according to specified criteria. Assessment of the effectiveness of an organization's strategic IT profile using the proposed approach makes it possible to increase the accuracy of assessing alternatives and reduce the risk of making inefficient project decisions.

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