THE DEVELOPMENT OF OPTIMIZATION MODEL AND ALGORITHM FOR SUPPORT OF RESOURCES MANAGEMENT IN ORGANIZATIONAL SYSTEM

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Abstract: In the paper the sequence of actions for the formation of an optimization model and an algorithm for the intellectual support of the process of rating management of the distribution of resource support in the organizational system are discussed. We can see a set of features in the structure of the rating management system. On the base of features it is possible to establish a sequence of particular management tasks that form a single decision-making cycle. Extreme and boundary requirements can be formed on the base of optimization model. We can do it when the interests of the management center of the system and the administration of the objects included in it in the distribution of resource support are corresponding. It will improve the position of the object in the rating. The intellectual support algorithm is based on a game approach to solving the block linear programming problem.

Key words: optimization, organizational system, resource, management.

1. INTRODUCTION

In the context of intensification of the digital transformation process in all social spheres the prerequisites have been created for the use of various forms of rating evaluation of their performance in the management of organizational systems [1].

During working with ratings of organizational systems it is proposed to manage not only performance in calendar periods $t = \overline{1, T}$ monitoring and rating of organizations, but also in subsequent periods $t_1 = \overline{T+1, T_1}$ its development with reaching higher positions in ratings [2]. Let us consider an organizational system in which under the administrative direction of the Management Center the same objects (education, health care, banking sector, etc.) are combined. The Management Center defines the objectives of effective operation for periods

$t = \overline{1,T}$ and future development $t_1 = \overline{T+1,T_1}$ objects and regulates distribution of resource support between them. Recently, their ratings have been a common assessment of the performance of facility $sr_i, i = \overline{1,I}$ [3].

By rating management of the *i*-th object in the organizational system we mean the decision-making process by Managing Center and the object administration, which allows ensuring the efficiency of functioning and determining development conditions based on the analysis of the results obtained within the framework of a certain rating system with the additional use of monitoring data [4, 5].

2. THE STRUCTURE OF THE RATING MANAGEMENT SYSTEM

The implementation of rating management processes depends on a number of classification characteristics of rating and management systems, which affect the capabilities of intellectual support for management decision-making [6].

The rating system is characterized by the following set of features.

1. Rating organizer: Management Center, external organization (rating agency). Direction accounting (numbering set $l = \overline{1,L}$) Functioning and development of rating objects: global rating r_i, thematic ratings (r_{il}).

2. Mechanism of formation of rating sequence of objects: it is following by maximum value of integral evaluation, taking into account weight of each detailed indicator, proportionality of detailed indicators when comparing objects, is calculates with use expert priorities, deviations of basic values. For the rating management system we will take into account the following classification characteristics: 1.The form of implementation of the management decision-making process: administrative, with elements of intellectual support [7, 8]. 2. Nature of resource provision: main activity, development. 3. Type of control effect on performance indicators are following: distribution of resources among main activity and development regimes, distribution of resources between actions to change development conditions [9]. 4. Number of rating systems used for efficiency evaluation can be: mono rating, multi-rating.

Source of information support: rating $(r_i),(r_{il})$, monitoring rating ($y_{i,ji,} j_l = \overline{1,J_l}$ is numbering set of detailed indicators in the *l*-th direction).

Number of rating periods in information support generation can be: multi-period, with limited number of periods. The determination of the sequence of private management problems forming a single decision-making process in rating management is carried out in accordance with the successive identification of dominant characteristics or some combinations of characteristics. The first dominating sign is the sign 4 leading to two tasks: management of resource providing, management of development conditions. Taking into account feature 3, the first task is divided into: management of resource support of the main activity

$\left(V_i^0\right)$ and resources for development $\left(V_i^p\right)$. Taking into account characteristic 2, the second task is divided into: management of development conditions on the basis of global rating, management of development conditions on the basis of thematic rating estimates $\left(V_{il}^p\right)$. The remaining features define additional features of the listed control tasks.

The management decision-making process [10, 11] is carried out directly either on the basis of expert assessments of the management centre administration and organizational system objects, or on the basis of a combination of expert assessments and formalized assessments of intellectual support [12]. It is proposed to use information technologies of modeling and optimization as the main methods of ensuring intellectual support of administrative management decisions [13, 14].

3. INTELLIGENT SUPPORT OPTIMIZATION MODEL

Let 's look at the formation of an optimization model of intelligent support for management of resource allocation of Management Center *V* between operation and development modes $i = \overline{1, I}$ objects that are part of the organizational system At the same time, the purpose of management for the system will be to minimize the total costs of implementation $n = \overline{1, N}$ substantive activities with a voluminous description of the results of these activities for $i-$ th object $-$ $x_{in} \geq 0$ and the cost of each such result $-c_{in}$:

$$\sum_{i=1}^{I} \sum_{n=1}^{N} c_{in} x_{in} \rightarrow \min \quad (1)$$

The achievement of this goal should primarily meet the boundary requirements of resource support at the system level in the nth direction of activity. The management center plans that to the resource support $V_n, n = \overline{1, N}$. Received in the allocation of the preliminary integrated resource *V*, it is possible to attract additional funds for development programs [15]. Therefore sets organizational system objects the right to exceed the level $V_n, n = \overline{1, N}$.

Then, in the formalized form, the constraint is written

$$\sum_{i=1}^{I} v_{in}, x_{in} \geq V_n, n = \overline{1, N}, \quad (2)$$

where v_{in} is recalculating coefficient of expenditure *i* with the object *n*-th resource per unit of *i*-th activity result. Also, each *i*-th entity assesses the need for a resource $\hat{V}_i$ and strive to create conditions for saving its consumption in the implementation $n = \overline{1, N}$ activities. In formalized form, this means that the following constraint must be executed

$$\sum_{n=1}^{N} v_{in}, x_{in} \leq \hat{V}_n, i = \overline{1, I}. \tag{3}$$

Combining criterion (1) and constraints (2), (3), we obtain optimization model of block linear programming [6]

$$\begin{gathered} \sum_{i=1}^{I}\sum_{n=1}^{N} c_{in}, x_{in} \leq \rightarrow \min, \\ \sum_{i=1}^{I} v_{in}, x_{in} \leq V_n, n = \overline{1, N}, \\ \sum_{n=1}^{N} v_{in}, x_{in} \leq \hat{V}_n, i = \overline{1, I}. \end{gathered} \tag{4}$$

After receiving the block programming solution (4) [6] $x_{in}^{*}, i = \overline{1, I}, n = \overline{1, N}$ the Management Center determines the resource support for the implementation of the main activity and development for each *i*-th object

$$V_i^0 = \sum_{n=1}^{N} c_{in}, x_{in}^{*}, i = \overline{1, I}. \tag{5}$$

$$V_i^p = \left(\hat{V}_i - \sum_{n=1}^{N} v_{in}, x_{in}^{*} \right) + V_i^q, \tag{6}$$

where V_i^q additional resource allocated by the Management Center to the *i*-th object in case of its participation in the system development program.

4. GAME-BASED ORGANIZATIONAL SYSTEM CHANGE MANAGEMENT

In the information database of the educational and game model, constants are initially placed: production associations, departments, work directions, employee collectives, employees, and their relations are defined. Such information can be considered as fairly static. Changes or additions in it are carried out quite rarely: introduction into the enterprise of new subdivisions, implementation of movements of employees between subdivisions [16], consolidation of subdivisions or directions of work, introduction of other industries and, as a result, new facilities in production, etc.

There is information that cannot be initially generated and defined as a constant - information defining the game process. Therefore, proposals are made on the model of optimization of the main components [17] of the game process:

1. Create a production object for a team of employees. 2. Define production types for a team of employees. 3. Specifies the sequence of object components within the view. 4. Determine the price of the object component in production. 5. Assignment of estimates for the production type. 6. Determine when object components are created. 7. Forecast output for your organization.

We will demonstrate the structure of these models.

1) Generate a manufacturing object for a team of employees.

A manufacturing object (*O*) consists of multiple categories (C). Initially, you put as many categories as possible in the object. The number must be greater than or equal to the number of employees (*St*) within the team (*G*).

$$O \subset C_j,\ j = 1,2...,n; \quad (7)$$

$$G \subset St_j,\ j = 1,2...,n; \quad (8)$$

$$\sum_{j=1}^{n} C_j \geq \sum_{j=1}^{n} St_j,\ j = 1,2...n; \quad (9)$$

$$O \subset C_j,\ j = 1,2...,\sum_{i=1}^{n} St_i \quad (10)$$

Condition (7) means that the object consists of a specific set of categories. Condition (8) indicates that the employee team consists of individual employees. Condition (9) provides each employee with a production category within the object. Condition (10) defines the final set of categories for the employee team object [18]. Thus, the set of categories within an object is directly determined by the number of employees in the team.

2) Define the production types for the employee team.

Based on the above condition (7), the categories of the object with respect to the students will be distributed as indicated in (11).

$$Se_o \subset C_i, i, j = 1, 2...,\sum_{k=1}^{n} St_k \quad (11)$$

3) Specifies the sequence of object components within the view.

Suppose *n* is the number of components that make up the category. It is necessary to sequence their interaction in order to obtain the final product.

In order to structure the components relative to each other, it is necessary to draw up a matrix of their sequential distance on a scale from 1 to *m*, where *m* is the number of components in the category. Table 1 shows an example of such a matrix. Columns - number of components. Cells indicate the distance of each component to the rest.

Table 1. Component Occurrence Sequence Matrix for Final Product

-	27	43	16	30	26
7	-	16	1	30	25
20	13	-	36	5	0
21	16	25	-	18	18
12	46	27	48	-	5
23	5	5	9	5	-

The main condition is that within one cycle of the category assembly, the required component can be involved once.

$$F(x) = \sum_{i=1}^{n}\sum_{j=1}^{n} t_{ij} x_{ij} \to \min; \quad (12)$$

$$\sum_{i=1}^{n} x_{ij} = 1, \ j = 1,2,...,n; \quad (13)$$

$$\sum_{j=1}^{n} x_{ij} = 1, i = 1,2,...,n; \quad (14)$$

$$u_i - u_j + nx_{ij} \le n - 1, \quad i, j = 1,2...,n, \quad i \ne j; \quad (15)$$

$$x_{i,j} = 0 \ \ or \ \ 1, \quad i, j = 1, 2...,n, \quad i \ne j; \quad (16)$$

Condition (12) is a function where t_{ij} – logical distance between components $(i, j = 1,2,...,n, i \ne j)$, and it is in general $t_{ij} \ne t_{ji}$; (13) means that during the cycle the component is withdrawn only once; (14) - that the input to the component is performed only once; (15) ensures route closure and absence of loops, where u_i and u_j – some material values $(i, j = 1,2,...,n, i \ne j)$; (16) – there is a variable x_{ij}, taking value 1 if you are moving from component i to component j $(i, j = 1,2,...,n, i \ne j)$ and 0 otherwise.

4) Determine the price of the object component in production.

The object is produced by the employee team over a period of time. The cost of all category components per employee will be determined according to the production plan and valuation types. The maximum possible price that an employee can earn within a given time can be calculated as follows:

$$\sum_{i=1}^{n} Tp_i = (A_i \cdot B_i) \cdot K_i, i = 1, 2, ..., n; \quad (17)$$

It is necessary to take into account the fact that not every employee can earn the maximum price; therefore it is logical to enter a reduction factor, which can be specified separately, for both the employee and the team of employees:

$$\sum_{i=1}^{n} Tp_i = ((A_i \cdot B_i) \cdot K_i) - L, i = 1, 2, ..., n, \quad (18)$$

where L is the reduction factor. $Tp_i > L > 0$.

Next, we determine the total (*Sm*) price that can be earned for all types of production:

$$Sm = \sum_{i=1, j=1}^{n} F_i Tp_j = ((A_i \cdot B_i) \cdot K_i) - L, \quad i, j = 1, 2, ..., n \quad (19)$$

We will now calculate the cost of each component in the production object category. The cost of the components will increase in arithmetic progression in order of their sequence [19]. We calculate the cost of the first component, D_0:

$$D_0 = \left(\frac{Sm}{P} \right) \cdot 0{,}1 \quad (20)$$

Here P is the number of components in the category.

Then we calculate the cost of the last component, D_n:

$$D_n = \left(\frac{Sm \cdot 2}{P} \right) - D_0 \tag{21}$$

After we calculate the value by which each subsequent component will be more expensive than the previous one, *U*:

$$U = \frac{D_0 + D_n}{P} \tag{22}$$

5) Assignment of estimates for the production type.

In order for the components to be available for production, the employee must master the appropriate technology. Determine the number of estimates in a given time period for each direction [20], as shown in Table 2.

Table 2. Structure of Subject Training Testing

Direction, *F*	**Number of estimates in the specified period, pcs, *Q***
Direction 1	5
Direction 2	3
Direction 3	7
. . . .	. . . .
Final result, I	15

Now calculate the number of components (N) attached to each direction:

$$N_{Fi} = \frac{q_i \cdot P}{I}; \tag{23}$$

$$P \geq I; \tag{24}$$

The components are attached to the directions in the following order. Next, you map the components selected for the direction to the estimates available for it. The components are attached to the estimates within the direction, in the same order:

$$Q_{ij} \subset N_{Fik}, i, j, k = 1,2,...,n, \tag{25}$$

where

j – Rating sequence number in the direction,

k – The sequence number of the component attached to the direction,

if *k* > *j*, then $j = 0$.

6) Specifies the time when the object components were created.

The production time of each component within the category is strictly defined. If the employee is unable to complete the component for some reason, he or she falls into the category of weak links.

The production time of the component is limited by the date of the last evaluation assigned to it by the direction. Table 3 shows an example of the conformity of assessments and their timing [21] relative to a certain direction.

Table 3. Schedule of testing

Direction 1	**Date, Dt**
Assessment 1	01.10.19
Assessment 2 …	05.11.19

Calculate the time limit (*Td*) for each component in the production object category:

$$Td_{N_{Fik}} \le Dt_{Q_{ij}}, \quad i,k = 1,2,...,n, \quad j = n; \tag{26}$$

3. ALGORITHM OF RATING CONTROL PROCESS INTELLIGENT SUPPORT

It is proposed to implement intelligent support of the rating control process using the game algorithm of solving the block problem of linear programming (4) [6]. We will form a game equivalent to the optimization problem (4) based on the method of bringing a pair of straight and dual linear programming tasks together to a zero-sum two-person game. Proceed to the vector-matrix form of the optimization problem record with objective function (1) and constraints (2), (3) at non-negative values of the vector of optimizable variables of direct (x) and dual (y) tasks

$$x = \begin{pmatrix} x_{11} \\ . \\ x_{1N} \\ . \\ x_{i1} \\ . \\ x_{iN} \\ . \\ x_{I1} \\ . \\ x_{IN} \end{pmatrix}, y = \begin{pmatrix} y_1 \\ . \\ y_i \\ . \\ y_I \end{pmatrix}.$$

Direct problem

$$c^T x \to \max, v_x \le V, x \ge 0, \tag{27}$$

dual problem

$$V^T y \to \min, v^T y \ge c, y \ge 0, \tag{28}$$

where v matrix whose elements are coefficients v_{in},

V constraint vector with coordinates V_l, V_i;

$c^T, V^T, v^T -$ Transposed vectors and matrix.

Let 's set additional constraints on multiple valid problem solutions (27)

$$X = \{x_{in} | 0 \le x_{in} \le h'_{in}\}, \tag{29}$$

tasks (28)

$$Y = \{y_i | 0 \le y_{in} \le h''_{in}\} \tag{30}$$

where h'_{in}, h''_{in} sufficiently large vector components *x* and *y*.

Consider the solutions to tasks (7), (8) as a solution to the game with payment function (Lagrange function) [5])

$$L(x, y) = c^T x + V^T y - yvx \tag{31}$$

and we have multiple *X* and *Y* strategies.

Transform function (11) by dividing matrix *v* and vector *V* according to constraints (2), (3) into two parts:

$$v = \begin{pmatrix} v_1 \\ v_2 \end{pmatrix}, V = \begin{pmatrix} V_1 \\ V_2 \end{pmatrix}. \tag{32}$$

The payment function of the equivalent game is

$$L(x, y) = c^T x + V_1^T y - yv_1 x \tag{33}$$

and set of strategy

$$X = \{x_{in} | 0 \le x_{in} \le h'_{in}, v_2 x \le V_2\} \tag{34}$$

$$Y = \{y_i | 0 \le y_i \le h''_i\} \tag{35}$$

As area $v_2 x \le V_2$ is limited, multiple strategies of the first player exactly correspond to (12).

To solve the game (12) - (14) we use the iterative procedure of finding the saddle point of the Lagrange function x^*, y^* with number of steps $k = 1,2,...$[5]

$$x^{k+1} = (1 - \lambda^{k+1}) x^{k+1} + \lambda^{k+1} \bar{x}(y), \tag{36}$$

$$\lim_{k \to \infty} \lambda^k \to 0, \sum_{k=1}^{\infty} \lambda^k = \infty, 0 \le \lambda^k \le 1, \tag{37}$$

where conditions (16) for value selection λ^k corresponds to a harmonic numerical series, i.e. $\lambda^k \approx \frac{1}{k}$: component $\overline{x_n}, n = \overline{1, N}$. Optimal responses of the first player $\bar{x}(y)$ are calculated by the formula

$$\bar{x}_n(y) = \begin{cases} x_n : \max\left[(yv_1 - c)x | v_2 x \le V_2\right] when (yv_1 - c)_n > 0, \\ 0 \qquad when (yv_1 - c)_n \le 0 \end{cases} \tag{38}$$

where $n = \overline{1,N}$; component $\overline{y}_i, i = \overline{1,I}$. Optimal response of the second player is calculated by formula

$$\overline{y}_n(x) = \begin{cases} h_i'': & (V_1 - v_1 x)_i > 0 \\ 0 : (V_1 - v_1 x)_i \le 0 \end{cases} \quad (39)$$

5. CONCLUSION

Taking into account classification characteristics of rating management of organizational system objects allows to highlight in the management structure a number of problems related to distribution of resource support, which require intellectual support of decision-making on the basis of optimization approach is calculated. As an optimization model, adequate problem setting, presentation in the form of a block problem of linear programming is considered. Such a model allows for one optimization criterion to provide intelligent support for harmonization decisions by limiting the interests of the Management Center and organizational system objects. An effective algorithm for determining the optimal solution is the iterative procedure of finding the saddle point of the Lagrange function, which is considered as a payment function of the game equivalent to the generated model.

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