# MODELING OF OPTIMIZATION PROCESSES OF PERSONNEL ADAPTATION TO DIGITAL MANAGEMENT IN ORGANIZATIONAL SYSTEMS

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**Abstract:** The paper discusses the possibilities of developing problem-oriented means of digital management of the process of adaptation of personnel to innovative activities. The introduction of the aggregation-balance direction of optimization modelling can be considered as an effective approach for coordinating the transition from personnel adaptation in the conditions of single-channel control to adaptation in the conditions of omnichannel control. In this case, it is possible to agree on the significance of the impact of personnel training for single-channel control when additional thematic modules are used. This occurs due to the aggregation of the components of the adaptation level with the simultaneous solution of the problem of balancing at the level of labour intensity of the educational program. Optimization modelling of the personnel adaptation process to single channel digital control is demonstrated. Optimization modelling of the personnel adaptation process to omnichannel digital control is shown. Block diagram of integration in the process of personnel adaptation during the transition from single-channel to omnichannel digital control is demonstrated. The results of the paper can be useful in the management of a wide class of socio-economic systems.

**Key words:** simulation, digital control, organizational system, management decision-making, personnel.

## 1. INTRODUCTION

It is necessary to develop problem-oriented means of digital control of the process of adaptation of personnel to innovative activities. For this, it is necessary to structure the optimization modeling process. To support this structuring, you need to use a number of characteristics. They characterize the features of the influence of the

level of personnel training on the efficiency of the transition to digital management [1]. Since one of the main features is the number of control channels introduced in stages during the transition, it is advisable to start the formation of the optimization model from the situation when at the initial stage single-channel control is implemented. Taking into account other features directly related to the description of the personnel adaptation process, the entire process of optimization modeling is represented by three directions of management decision-making tasks: reduction, balance and resource. The initial information for building models are: a lot of thematic skills and abilities of personnel with single-channel digital control, labor intensity and resource support for the implementation of the educational program. The result of their application is balanced management decisions. The paper is associated with the need to aggregate both primary and additional knowledge, skills, and abilities within the educational program. At the same time, management decisions are based on the aggregation balance optimization of the educational resource of training personnel for activities in the conditions of multichannel digital control.

## 2. OPTIMIZATION MODELING OF THE PERSONNEL ADAPTATION PROCESS TO SINGLE CHANNEL DIGITAL CONTROL

For optimization modeling [2] of the adaptation process, we detail the description in the form of numbering sets. They are related to the main components that will determine the educational resources of personnel adaptation in relation to digital management:

- for competencies we will have

$$\alpha_1,...,\alpha_{i,}...,\alpha_I \quad (1)$$

In this sequence $i=\overline{1,I}$ is the set of competencies related to innovation is considered in the form of a numbering;

- for thematic modules we will have

$$\mu_1,...,\mu_{m,}...,\mu_M \quad (2)$$

In this sequence, $m=\overline{1,M}$ is considered in the form of a numbering set of thematic modules. They are included in the structure of the disciplines of the educational program, which is associated with the adaptation of personnel [3]. On their basis, opportunities arise to ensure the formation of knowledge, skills and abilities in relation to $\alpha_i, i=\overline{1,I}$ competencies.

- for labor functions we will have

$$\tau_1,...,\tau_{j,}...,\tau_J \quad (3)$$

In this sequence, $j=\overline{1,J}$ is considered in the form of a numbering set of labor functions. They are related to the actions of personnel;

- for thematic modules we will have

$$\mu_1,...,\mu_{n,}...,\mu_N . \quad (4)$$

In the specified sequence, $n=\overline{1,N}$ is considered in the form of a numbering set of thematic models. They are included in the structure of the discipline of the educational program. On their basis, there are opportunities to ensure the formation of knowledge, skills and abilities when performing $\tau_j$, $j=\overline{1,J}$ labor functions

$$g_1,...,g_{r,}...,g_R \quad (5)$$

In this sequence, $r=\overline{1,R}$ is considered in the form of a numbering set of alternative forms of technology for the implementation of thematic modules.

Optimization of digital management [4] of the functioning of the organizational system can be achieved through the sequential adoption of the following decisions [5]. At the same time, the level of personnel's knowledge, skills and abilities increases, taking into account the required competencies within the framework of the educational program.

Task 1 (Reduction). It considers the provision of the potential for the implementation of personnel adaptation processes, taking into account the planned labor intensity [6]. In this case, there is a reduction over the original sets (thematic modules (2), (4)) to the set $\mu_s$, $s=\overline{1,S}$. It corresponds to the minimum coverage of a set of competencies (1) and a set of labor functions (3).

Task 2 (Balance sheet). In it, a lot of thematic modules $\mu_v$, $v=\overline{1,V}$ are finally formed, taking into account their importance in the formation of knowledge, abilities and skills [7]. They are associated with the requirements of innovation, and ensuring a balance in relation to the planned labor intensity in the training of personnel [8].

Task 3 (Resource). It manages the technologies for the implementation of thematic modules $\mu_v$, $v=\overline{1,V}$ within the personnel adaptation system due to the fact that each of the modules will be assigned a form of implementation (5). This takes into account limited resources.

When the meaningful setting of tasks will be transformed into optimization models, then it is necessary to go through the following stages:

1) alternative variables are introduced. They take values 1 or 0. They characterize the mechanism for choosing the optimal solution;

2) the extreme requirement is determined in the form of a function. It depends on what the values of the alternative variables are. It characterizes the goal of choosing the optimal solution;

3) boundary requirements are determined in the form of functions. They depend on alternative variables. They characterize many constraints when choosing the optimal solution [9];

4) the introduced requirements are combined into a single extremal problem.

To formalize the mechanism for choosing the optimal solution in Problem 1, we use the following alternative variables:

$$x_m = \begin{cases} 1, \textit{if theme module } \mu_m \textit{ is included in reduction set of modules } \mu_s,\ s=\overline{1,S}, \\ 0, \textit{otherwise},\ m=\overline{1,M}; \end{cases} \quad (6)$$

$$x_n = \begin{cases} 1, \textit{if theme module } \mu_n \textit{ is included in reduction set of modules } \mu_s,\ s=\overline{1,S}, \\ 0, \textit{otherwise},\ n=\overline{1,N}. \end{cases} \quad (7)$$

To formalize the mechanism for choosing the optimal solution in Task 1, we use the following alternative variables $\mu_s,\ s=\overline{1,S}$

$$\sum_{m=1}^{M} x_m + \sum_{n=1}^{N} x_n \to min \quad (8)$$

To form a set of constraints, it is necessary to preliminary conduct an expert assessment when determining the Boolean coefficients:

$$c_{mi} = \begin{cases} 1, \textit{if theme module } \mu_m \textit{ is support the formation of competention } \alpha_i, \\ 0, \textit{otherwise},\ m=\overline{1,M},\ i=\overline{1,I}; \end{cases} \quad (9)$$

$$c_{ni} = \begin{cases} 1, \textit{if theme module } \mu_n \textit{ is support the formation of competention } \tau_j, \\ 0, \textit{otherwise},\ n=\overline{1,N},\ j=\overline{1,J}. \end{cases} \quad (10)$$

Then the restrictions will determine the inclusion of thematic modules in the minimum coverage. At the same time, at least one element will correspond to each competence and labor function

$$\begin{aligned} &\sum_{m=1}^{M} c_{mi} x_m \geq 1,\ i=\overline{1,I}, \\ &\sum_{n=1}^{N} c_{ni} x_n \geq 1,\ j=\overline{1,J}. \end{aligned} \quad (11)$$

By combining the extreme requirement (8), functional constraints (9), and the requirements for the alternativeness of variables (6), (7), we obtain an optimization model. It refers to the problem of Boolean programming [10] about the minimum coverage:

$$\begin{aligned} &\sum_{m=1}^{M} x_m + \sum_{n=1}^{N} x_n \to min \\ &\sum_{m=1}^{M} c_{mi} x_m \geq 1,\ i=\overline{1,I}, \\ &\sum_{n=1}^{N} c_{ni} x_n \geq 1,\ j=\overline{1,J}. \\ &x_m = \begin{cases} 1, \\ 0 \end{cases}, m=\overline{1,M}, \end{aligned} \quad (11)$$

In task 2, alternative variables characterize the mechanism for transforming the reduced set $\mu_s,\ s=\overline{1,S}$ into a set of modules of the educational program for

personnel adaptation $\mu_v, v=\overline{1,V}$, balanced within the framework of the labor intensity of training

$$x_S=\begin{cases}1, if\ mod ule\ \mu_m\ is\ included\ in\ set\ \mu_v, v=\overline{1,V},\\ 0, otherwise, s=\overline{1,S};\end{cases} \quad (13)$$

In order to formalize the extreme requirement, we will preliminary conduct an expert assessment of the significance of thematic modules $\mu_s, s=\overline{1,S}$. At volume there will be adaptation of personnel based on the method of a priori ranking [11] in the form of coefficients $\alpha_s, s=\overline{1,S}, 0\le\alpha_s\le 1$. In this case, the objective function has the form

$$\sum_{s=1}^{S}\alpha_s x_s\to max \quad (14)$$

The limitation [11] is associated with the temporary resource that is set in order to implement the educational program

$$\sum_{s=1}^{S}t_s x_s\le T \quad (15)$$

In the specified expression $t_s$ is the complexity of studying the thematic module, $T$ is considered in the form of the complexity of the educational program.

Due to the fact that we carry out the union within the framework of the optimization model (13)-(15), we come to the problem of Boolean programming about the knapsack:

$$\begin{gathered}\sum_{s=1}^{S}\alpha_s x_s\to max,\\ \sum_{s=1}^{S}t_s x_s\le T,\\ x_S=\begin{cases}1,\\ 0,\end{cases} s=\overline{1,S}.\end{gathered} \quad (16)$$

For the purpose of mathematical description of Task 3, we introduce the following alternative variables

$$x_{vr}=\begin{cases}1, if\ \ for\ realization\ of\ \ mod ule\ \mu_v\ in\ system\ we\ choose\\ g_r-techno log y\ of\ \ realization\ of\ \ theme\ mod ules,\\ 0, otherwise, v=\overline{1,V}, r=\overline{1,R}\end{cases} \quad (17)$$

In order to implement the technologies of the $g_r$ thematic modules [12], it is necessary to attract the appropriate costs for the staffing and logistical support of the thematic module $\mu_v - z_{vr}$. Then we will have such an objective function

$$\sum_{v=1}^{V}\sum_{r=1}^{R}z_{vr}x_{vr}\to min \quad (18)$$

in the fact that in this case only a limitation is imposed, which is due to the fact that each thematic module $\mu_v$ will be implemented using a certain technology:

$$\sum_{r=1}^{R} x_{vr} = 1, v = \overline{1,V} \quad . \tag{19}$$

The optimization model includes an extreme requirement (18), a constraint (19), and a requirement for alternative variables (17):

$$\begin{gathered} \sum_{v=1}^{V} \sum_{r=1}^{R} z_{vr} x_{vr} \to min \\ \sum_{r=1}^{R} x_{vr} = 1, v = \overline{1,V}, \\ x_{vr} = \begin{cases} 1, \\ 0 \end{cases}, v = \overline{1,V}, r = \overline{1,R} . \end{gathered} \tag{20}$$

Based on the totality of the listed optimization problems, it is possible to determine the mathematical one, it is possible to determine a multi-alternative model [13] of competence optimization through the formation of an educational resource for training personnel of organizational systems when adapting to innovative activities in order to increase the efficiency and reliability of their functioning.

## 3. OPTIMIZATION MODELING OF THE PERSONNEL ADAPTATION PROCESS TO OMNICHANNEL DIGITAL CONTROL

The tasks given in the previous paragraph are typical both for single-channel control and for omnichannel control, when the process of adaptation of personnel to perform additional labor functions for digital control conditions takes place.

To detail such a transition, we introduce the following numbering sets, related to additional competencies: $\alpha_1,...,\alpha_{i_1},...,\alpha_{I_1}$, above $i_1 = \overline{1,I_1}$ is a numbering set of complementary competencies. There are additional labor functions $\tau_1,...,\tau_{j_1},...,\tau_{J_1}$. The above $j_1 = \overline{1,J_1}$ is considered in the form of a numbering set of additional labor functions. There are additional thematic modules $\mu_1,...,\mu_{n_1},...,\mu_{N_1}$. In the specified expression, $n_1 = \overline{1,N_1}$ is considered as a numbering set of additional thematic modules.

We can achieve optimization [14] of the process of adaptation of personnel to innovative activities for the conditions of digital transformation of the OS due to the fact that an educational training resource is formed. At the same time, optimization problems 1 - 3 are solved in a sequential manner [15]. In order to form an educational resource for additional training, which forms a single educational program with the resource of basic training, we propose to introduce aggregation-balance optimization

[16] (below is a description of the problem). It will be integrated into the adaptation process using the structural diagram shown in Figure 1.

Task (Aggregation-balance optimization). An optimal choice is made in a joint way of sets of thematic and additional modules. At the same time, there will be adaptation of personnel in the context of the transition from single-channel to omnichannel management $\mu_v, v=\overline{1,V}$, $\mu_{v_1}, v_1=\overline{1,V_1} \in \mu_{s_1}, s_1=\overline{1,S_1}$. The importance of mutual influence is taken into account in the formation of knowledge of skills and abilities and balance according to the established labor intensity of the two components of personnel training.

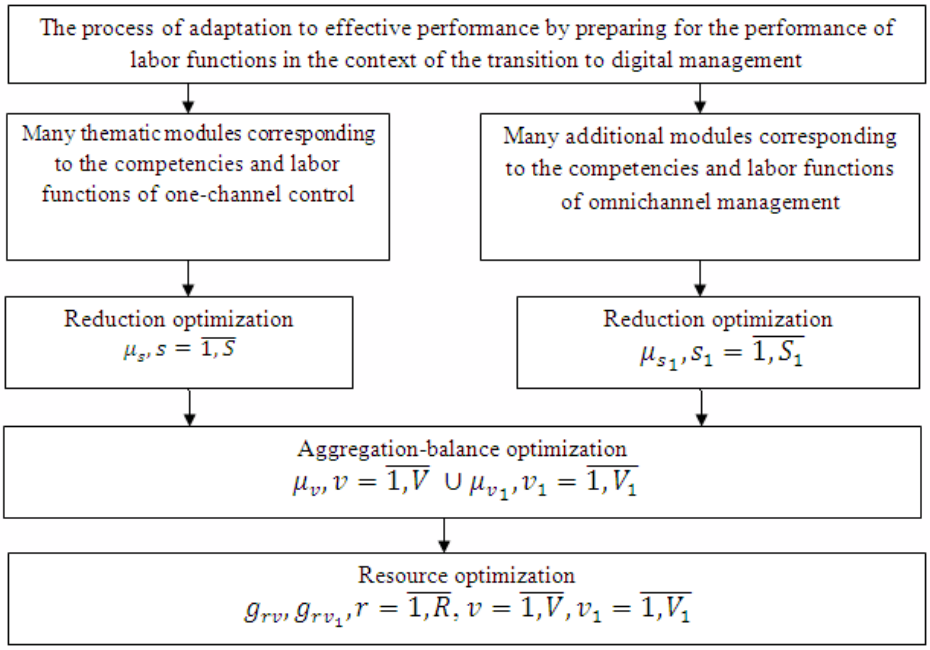


*Fig. 1. Block diagram of integration in the process of personnel adaptation during the transition from single-channel to omnichannel digital control*

At the same time, there will be adaptation of personnel in the context of the transition from single-channel to omnichannel management $\mu_v, v=\overline{1,V}$, $\mu_{v_1}, v_1=\overline{1,V_1} \in \mu_{s_1}, s_1=\overline{1,S_1}$. The importance of mutual influence is taken into account in the formation of knowledge of skills and abilities and balance according to the established labor intensity of the two components of personnel training [17].

For the purpose of a formalized statement of the aggregation-balance optimization problem, we introduce, by analogy with problems (12), (16), (20), the following Boolean variables. In order to formalize the extreme requirement, we will preliminary carry out an expert assessment of the significance in the formation of

knowledge, skills and abilities of effective personnel activity in the context of digital management. The assessment will be in two directions:

1) the degree of change in the volume of content by thematic modules $\mu_s, s=\overline{1,S}$ due to the fact that the content of additional thematic modules of practice-oriented training is taken into account.

2) the degree of influence of additional training modules on the adaptation of personnel to effective activities.

We will associate the first direction in expert assessment with linguistic assessment [18]. At the same time, it is permissible to change the amount of content in thematic modules that are associated with additional modules $\mu_{s_1}$.

Let's represent the introduced linguistic variable using two terms. They have such gradations

$$T_1=\left\{\begin{matrix} increase \\ decrease \\ indifferently \end{matrix}\right\},\ T_2=\left\{\begin{matrix} strong \\ substantially \\ some \\ little \\ few \end{matrix}\right\}. \qquad (21)$$

To carry out a quantitative characterization of the gradation of a term $T_2$, we will consider a certain continuous scale [0, A]. After the expert evaluates the gradation of the term $T_2$ [19], he is asked to indicate the corresponding point on the scale [0, A]. Suppose that this point corresponds to an absolute value or a relative $\hat{A}=\frac{A'}{A}$.

We carry out a quantitative assessment of expert opinions on the basis of calculating the value of the membership function [20]:

$$\begin{gathered} T_1=<increase> \\ \lambda_1=\begin{cases} 1, if\ \hat{A}\le c, \\ \dfrac{1}{1+[a(\hat{A}-c)]}, if\ \hat{A}>c, \end{cases} \\ T_1=<decrease> \\ \lambda_2=\begin{cases} 1, if\ \hat{A}\le c, \\ 1-\dfrac{1}{[a(\hat{A}-c)]^b}, if\ \hat{A}>c, \end{cases} \\ T_1=<indifferently> \\ \lambda_1=\begin{cases} u, if\ \hat{A}<b, \\ 1, if\ b<\hat{A}\le c, \\ a, if\ \hat{A}>c, \end{cases} \end{gathered} \qquad (22)$$

Module significance coefficient is $\mu_s$. Then $\alpha_s = \lambda$, $\alpha_s = \prod_{s_1=1}^{S_1} \lambda_{ss_1}$. In this expression, $\lambda_{ss_1}$ is considered in the form of values of the membership function, which corresponds to the expert's assessment of the influence of the content of additional modules $s_1 = \overline{1,S_1}$ on the volume of the content of thematic modules $s_1 = \overline{1,S}$. The degree of influence of additional thematic modules of practice-oriented training is determined by collective expertise using the method of a priori ranking [11]. As a result, each module $\mu_{s_1}$ has a rank $\hat{s}_1$ that is equal to 1 for the most significant module and $S_1$- for the least significant. The coefficient of significance of the module is calculated as $\alpha_{s_1} = 1 - \frac{\hat{s}_1}{\sum_{s_1=1}^{S_1} \hat{s}_1}$. Using the coefficients of significance $\alpha_s$, $s = \overline{1,S}$, $\alpha_{s_1}$, $s_1 = \overline{1,S_1}$ and variables (21), (22), the criterion for the maximum significance of thematic modules included in the sets $\mu_v$, $v = \overline{1,V} \cup \mu_{v_1}$, $v_1 = \overline{1,V_1}$ will be written as follows

$$\sum_{s=1}^{S} \alpha_s x_s + \sum_{s_1=1}^{S_1} \alpha_{s_1} x_{s_1} \to max \tag{23}$$

The limitation, which is associated with the time resource set for the training of personnel in the process of adaptation and effective activities under digital control, is written in this way

$$\sum_{s=1}^{S} t_s x_s + \sum_{s_1=1}^{S_1} t_{s_1} x_{s_1} \le T \tag{24}$$

where $t_s$, $t_{s_1}$ - respectively, the labor intensity of personnel training within the modules $\mu_s$ and $\mu_{s_1}$; $T$ is the established labor intensity of personnel training.

The combination of the optimization criterion (23), the limitations of personnel training (24) and the variables (21), (22), makes it possible to form the problem of multi-alternative aggregation-balance optimization:

$$\begin{gathered} \sum_{s=1}^{S} \alpha_s x_s + \sum_{s_1=1}^{S_1} \alpha_{s_1} x_{s_1} \to max, \\ \sum_{s=1}^{S} t_s x_s + \sum_{s_1=1}^{S_1} t_{s_1} x_{s_1} \le T, \\ x_s = \begin{cases} 1, \\ 0 \end{cases}, s = \overline{1,S}; \; x_{s_1} = \begin{cases} 1, \\ 0 \end{cases}, s_1 = \overline{1,S_1} \quad . \end{gathered} \tag{25}$$

Combining the optimization models (12), (16), (20) with the aggregation-balance optimization model (25) within the framework of the structural diagram shown in Figure 1, we turn to the algorithms for making managerial decisions when adapting personnel to digital management in the organizational system.

## 4. CONCLUSION

Taking into account the gradual transition to digital control in economic organizational systems, it is acceptable to form optimization models in the case of single-channel control. Such models reflect three directions of optimization: reduction, balance and resource. The first of them makes it possible to single out many of the most significant thematic modules, the second - to balance the labor intensity of their development with the planned labor intensity of the educational program, and the third - to distribute the educational resources necessary for the adaptation of personnel to innovative activities.

An effective mechanism for coordinating the transition from personnel adaptation in the context of single-channel management to adaptation in the context of omnichannel management is the introduction of the aggregation-balance direction of optimization modeling. In this case, it is possible to reconcile the significance of the influence of personnel training for single-channel control when using additional thematic modules by aggregating the components of the adaptation level while simultaneously solving the problem of balancing at the level of labor intensity of the educational program.

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**Manuscript received on 03 September 2021**