

## Model of the Formation and Development of Intellectual Teams

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**Abstract.** The work is devoted to the task of intellectual team's management, namely the problem of their formation, adaptation and training. The paper presents a mathematical model of the multifactor estimation of intellectual team, allowing to choose the best of its composition from a plurality of possible options. To formalize the problem using utility theory, candidates in the team are assessed for their professional, profile and personality characteristics. The model also takes into account the requirements for the competence of the performers. Various options for the formation of the optimality criteria are considered. The paper also considers the process of motivating the members of the intellectual team for their development, namely, adaptation and training.

**Key words:** theory of utility, attractiveness of the applicant, adaptation, training, motivating the members of the intellectual team.

### 1. Introduction

The increasing pace of technology improvement, the creation of new products, the growing competition create conditions for the use of project management not only in the IT sphere, but also in other kinds of intellectual activity. In the field of information technology, the command form of the organization is the main or the only type of organization of the technological process and performance of works. As an organizational form of professional activity, the teams of performers also operate in other spheres of society: economic, industrial, social, intellectual, cultural.

The system of working with intellectual project teams has its own specifics and consists of interconnected subsystems: team formation, its evaluation, adaptation and team training. The concepts of management and development of the organization's intellectual team are based on the knowledge of the employee's motivational skills, the ability to form and guide them in accordance with the tasks that are necessary for the organization. Intellectual teams can be formed both for a long time, and for a while to solve a specific problem. The longer the team will exist, the higher will be its level of harmony and professionalism, and the more successfully and efficiently it will act. When forming intellectual teams, it is necessary to take into account the level of competence of the team members regarding the requirements for competencies.

### 2. Analysis of Research and Publications

Earlier, in project management in an organization, employees were viewed as an element of a technical system, and the task of managing a team was reduced to the task of managing the company's human resources. In modern conditions, more and more attention is paid to the personality of the employee, and the company's employees are regarded as its intellectual capital, which determines the relevance of project management and directly affects the effectiveness of project management and the success of its implementation, which are impossible without the formation of an effective team. A lot of scientific and practical developments of domestic and foreign authors are devoted to the research of mathematical models and methods of formation and functioning of teams. Recently, in the literature, the competence approach and decision-making methods are increasingly used in the formation and management of teams [1-3]. More and more attention is paid to interpersonal relations in the team [4,5].

The analysis of scientific publications has shown that the existing methods and approaches to the task of managing the teams of performers are not always applicable or effective and cover not a full range of factors that need to be taken into account when in project management. This is due to possible changes in the conditions for the functioning of teams due to political, social or labor conflicts, changes in the timing of the project or a number of other reasons. Unfortunately, most sources give only general recommendations on the choice and use of a particular approach and method.

In general, the problem of formation of the team are considered as assignment tasks that cover a wide class of optimization tasks: the formation of the composition of teams, the distribution of functions (roles) in heterogeneous teams, and the tasks of allocating workloads. Existing approaches to the solution of such problems allow to designate the applicant for one and only one position and do not take into account all possible characteristics of the applicant, therefore they require development and improvement, which determines the relevance of the issue under study.

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### 3. Formulation of the Problem

Teams can be divided into two large classes: homogeneous and heterogeneous. Intellectual teams refer to heterogeneous teams, where its members perform various functions, and each member of the team is generally characterized by certain efficiency of implementing certain functions. Therefore, when forming a heterogeneous team, the main task is the distribution of roles and activities among performers.

Each team member has two roles: functional and command. A functional role is determined by professional competencies that describe the level of knowledge, skills and competences that determine the level of orientation in the environment, understanding of technologies and trends, knowledge of business processes and the specifics of working in a given field of activity. The level of competence of professional and profile characteristics of applicants for different functional roles will be different. Functional roles are defined by job responsibilities [6].

The command roles reflect the way in which the team member performs his work, they are determined by innate and acquired personal qualities, which include the degree of responsibility, the ability to make decisions independently, to work in a team, in tight schedule, in conditions of risks and uncertainties, systemic and strategic thinking, leadership skills, organizational and motivational skills, discipline and organization, analytical approach, ability to communicate effectively (oral and written), creativity. For different team roles, a different level of competence is required for the personal characteristics of applicants [7]. Examples of team roles are "ideas generator", "resource researcher", "coordinator", "organizer" and others.

The role of a particular participant is determined by his contribution to the work of the team and the relationship between the team members, so the team can have several performers with the same role. From the point of view of the competence approach, such an allocation of roles is considered effective, under which the responsibility of each role does not exceed the skills of a member of the team to whom this role was given [1]. In this case, it is necessary to ensure the composition of the team composition to the task for which it is created.

Consider the task of forming an intellectual team in this setting. For the implementation of the project you need a team in which the team members are assigned a number of different functional roles (positions)  $Y = \{y_j\}$ ,  $j = \overline{1, m}$ . The quantitative composition of the team is determined by the scope of work envisaged by the project. We assume that the amount of work shared between functional roles. The project manager for each project determines the role composition of the team and the number of performers of each role. Several specialists can perform one role. But, in turn, one and the same specialist can combine different roles.

There are also known the sets of applicants  $X_j = \{x_i\}$ ,  $i = \overline{1, n}$  for every  $j$ -th role. However, some elements  $x_i$  can be included in several sets of applicants (claiming different roles in the team). Each applicant  $x_i$  from the sets  $X_j$  is described by the set of professional  $K_f(x_i) = \{k_f(x_i)\}$ ,  $f = \overline{1, F}$ , profile  $K_r(x_i) = \{k_r(x_i)\}$ ,  $r = \overline{1, R}$  and personality  $K_l(x_i) = \{k_l(x_i)\}$ ,  $l = \overline{1, L}$  qualities (characteristics). For definiteness, we assume that the values of  $K_f(x_i)$ ,  $K_r(x_i)$  and  $K_l(x_i)$  are known and given in the form of quantitative estimates. These values can be obtained by human resources specialists during interviews using methods accepted in the given subject area, for example, as a result of processing of psychological tests, tests for professional knowledge and skills, etc.

For each role  $y_j$ ,  $j = \overline{1, m}$  in the intellectual team, the value of the criteria from the set of professional  $K_f^*(y_i) = \{k_f^*(y_i)\}$ , profile  $K_r^*(y_i) = \{k_r^*(y_i)\}$  and personality  $K_l^*(y_i) = \{k_l^*(y_i)\}$  competencies are known and can be given by quantitative estimates. Each applicant  $x_i$  for the role  $y_j$  has many characteristics  $K_f(x_i) = \{k_f(x_i)\}$ ,  $f = \overline{1, F}$ ,  $K_r(x_i) = \{k_r(x_i)\}$ ,  $r = \overline{1, R}$  and  $K_l(x_i) = \{k_l(x_i)\}$ ,  $l = \overline{1, L}$ . If the applicant has the required competencies, then  $x_i$  participates in the selection. If at least one of the conditions is not satisfied, then  $x_i$  is excluded from consideration for the execution of this role.

Considering the set of applicants  $X_j$  as a set of alternatives that are characterized by some set of partial criteria  $K(x_i)$ , the task of forming the optimal command can be attributed to the decision making problem. The ultimate goal of the overall decision-making task is to choose the only best solution from the admissible set of solutions  $X_j$ , i.e. extreme of the selected particular criteria. By the optimal performer  $x_j^0$  of the role  $y_j$  we will understand such an applicant  $x_i$  from the set  $X_j$ , which has the best characteristics [3]:

$$x_j^0 = \arg \text{extr}_{x_i \in X_j} \{K_f(x_i), K_r(x_i), K_l(x_i)\}, j = \overline{1, m}. \quad (2)$$

### 4. Development of the Method for Solving the Problem of Forming the Intellectual Team

The problem of multi-criteria optimization (2) is incorrect, since in the general case it does not ensure the determination of a unique optimal solution from  $x_i \in X_j, j = \overline{1, m}$ , therefore it is necessary to transform it into a one-criterion one with a scalar criterion.

The main methods for transforming multi-criteria optimization problems into single-criterion ones are: the selection of the main criterion and the transfer of all other criteria to restrictions; functional and cost analysis; sequential optimization; the formation of a generalized scalar criterion that takes into account all the heterogeneous partial criteria [3].

To form an optimal team, i.e. selection of the best candidates for the team and evaluation of the team's effectiveness we use functional-cost analysis and the formation of a generalized scalar criterion based on the theory of utility. Taking into account the merits and demerits of possible functions of convolution of particular criteria [3], we use the additive function of the form:

$$P(x) = \sum_{i=1}^n a_i p_i(x), \quad (3)$$

where  $a_i$  – the dimensionless weight coefficients of the importance of particular criteria satisfying conditions:

$$\sum_{i=1}^n a_i = 1, \quad 0 \leq a_i \leq 1, \quad (4)$$

and  $p_i(x)$  – normalized, i.e. reduced to a dimensionless form, to the same interval of variation, and to the direction of dominance of particular criteria:

$$p_i(x) = k_j^H(x) = \left( \frac{k_j(x_i) - k_j^{HX}(x_i)}{k_j^{HL}(x_i) - k_j^{HX}(x_i)} \right)^{\alpha_i}, \quad (5)$$

where  $k_j^{HX}(x_i)$ ,  $k_j^{HL}(x_i)$  – respectively, the worst and best values of particular criteria on the entire set of applicants  $X_j$ ,  $\alpha_i$  – the nonlinearity parameter realizing a linear dependence for  $\alpha_i = 1$ , for  $\alpha_i < 1$  – is a convex upward dependence, for  $\alpha_i > 1$  – is a convex-down dependence [7].

In general, in different projects the significance of the qualities of applicants  $k(x_i)$  of the corresponding competencies is different, therefore the attractiveness (usefulness) of the  $i$ -th applicant for the  $j$ -th functional role in professional  $P_j^f(x_i)$ , profile  $P_j^r(x_i)$  and in personality  $P_j^l(x_i)$  characteristics are defined as:

$$P_j^f(x_i) = \sum_{f=1}^F q_f k_f^H(x_i), \quad (6)$$

$$P_j^r(x_i) = \sum_{r=1}^R q_r k_r^H(x_i), \quad (7)$$

$$P_j^l(x_i) = \sum_{l=1}^L q_l k_l^H(x_i), \quad (8)$$

where the weight coefficients  $q_f$ ,  $q_r$ ,  $q_l$  satisfy the requirements (4).

1. *Generalized evaluation of the attractiveness of the  $i$ -th applicant for the  $j$ -th functional role.*

The attractiveness  $P_j(x_i)$  of each applicant  $x_i$  to the  $j$ -th role takes into account the presence and the degree of development of his professional  $K_f(x_i)$ , profile  $K_r(x_i)$  and personality  $K_l(x_i)$  characteristics required for the position in question  $y_i$ , as well as requirements  $K_f^*(y_i)$ ,  $K_r^*(y_i)$  and  $K_l^*(y_i)$  to these characteristics. Then

$$P_j(x_i) = a_f \sum_{f=1}^F q_f k_f^H(x_i) + a_r \sum_{r=1}^R q_r k_r^H(x_i) + a_l \sum_{l=1}^L q_l k_l^H(x_i), \quad (9)$$

where the weight coefficients  $a_f$  for the professional group,  $a_r$  or the profile group and  $a_l$  for the group of personality characteristics, satisfy the conditions of the form (4). And the task of choosing the optimal performers has the form:

$$x_j^0 = \arg \max_{x_i \in X_j} P_j(x_i), \quad j = \overline{1, m}, \quad (10)$$

with restrictions

$$K_f^*(y_i) \leq K_f(x_i), \quad K_r^*(y_i) \leq K_r(x_i), \quad K_l^*(y_i) \leq K_l(x_i). \quad (11)$$

2. *Functional-cost analysis.*

The mathematical model (9) does not take into account the desired salary level  $C(x_i)$  of applicant  $x_i$  for performing the role  $y_i$ . We use the method of functional-value analysis, which allows us to determine the quality-cost ratio. The use of the cost factor in absolute terms in the problem of selecting the performers of the work is incorrect, so we use the relative cost in the form of a value normalized by formula (5). Then the mathematical model for choosing the optimal performers is:

$$G(x_i) = \frac{P_j(x_i)}{C(x_i)} \rightarrow \max_{x_i \in X_{j,j}}, \quad (12)$$

with restrictions (11).

The disadvantage of the method of functional and cost analysis is the possibility of a situation when the team will recruit applicants who do not have sufficient functional characteristics, but have a small value of the desired salary.

### 3. Generalized evaluation attractiveness considering costs.

In the utility function (9) we introduce the value of the particular wage criterion  $C^H(x_i)$ , normalized by formula (5) with the weighting coefficient  $a_s$ . Then the generalized evaluation of the attractiveness of the  $i$ -th applicant to the  $j$ -th functional role of  $P_j^C(x_i)$  taking into account the salary  $C(x_i)$  is defined as:

$$P_j^C(x_i) = a_f \sum_{f=1}^F q_f k_f^H(x_i) + a_r \sum_{r=1}^R q_r k_r^H(x_i) + a_l \sum_{l=1}^L q_l k_l^H(x_i) + a_s C^H(x_i). \quad (13)$$

The method of selection of applicants for the intellectual team is selected by the project manager, depending on the project requirements, organizational capabilities and team characteristics. If the utility of the applicant and the desired salary have the same importance for the organization, then it is expedient to use the method of functional and cost analysis (12). In other cases, it is necessary to apply a generalized method of assessing the applicant's attractiveness to the position (13).

## 5. Development of Intellectual Team through Motivation

After the project is completed, a situation may arise where it is not advisable to dissolve the formed cohesive team, and to recruit a new team for the next project. This will entail unnecessary financial costs and may adversely affect the interpersonal relationships that have developed in the team. At the same time, members of the existing team may not be competent enough in the sphere of the new project or do not have sufficient experience, knowledge and skills to implement it. In this case, it is necessary to pay attention and efforts of the organization to the development of the intellectual team, namely, its adaptation and training.

Adaptation of the intellectual team is the process of adapting the collective to the changing conditions of the external and internal environment of the organization. It has a complex structure and represents a unity of professional, socio-psychological, socially organizational and cultural-domestic adaptation [8]. The successful implementation of the project is an indicator of a successful process of adapting an intellectual team, selecting candidates and their introduction into the post.

The training of an intellectual team is designed to ensure that the professional knowledge and skills of employees correspond to the current level of production and management. In accordance with the urgent needs and perspectives of the organization, the development of an intellectual team is a complex, multifaceted process of training an employee for the performance of new production functions, the employment of new posts, the solution of new tasks [9]. More perspective is the attitude to learning as to the investment of material resources in the intellectual capital of the organization.

The success of the organization's adaptation and training of an intellectual team is based on motivating its members to develop. At the core of the concepts of management and development of the intellectual team lies the increasing role of the employee's personality, the knowledge of his motivational attitudes, the ability to form and guide them in accordance with the tasks facing the organization.

Motivation is the internal process of a person's conscious choice of one or another type of behavior, determined by the complex effect of external (incentives) and internal (motives) factors [9]. For each member of the team, these factors may differ: some may be more focused on the meaningfulness and social significance of labor, others - on salary and status values. As factors of motivation for members of an intellectual team, high salaries, bonuses, career and professional growth, education, development and self-improvement, the ability to travel, a flexible work schedule, life insurance, recognition in the team, etc. Motivating is an external impact on a person's work behavior for achieving personal, group and social goals [9].

But if significant advances have been made in the understanding of motivation and its qualitative nature, there are many theories that provide adequate descriptions of the process of motivating, then with a quantitative tool for managing the process of motivating, there are great difficulties. Since at present very few mathematical methods are known for modeling and predicting the motivation of employees, and especially taking into account the characteristics of intellectual teams.

A feature of motivating intellectual teams is that intangible factors that are difficult to manage come to the fore. Since the motivation of an individual depends on the psychic-moral moments, such as values, attitudes, aspirations, on the basis of which its preferences are formed, the task of developing and adapting the team can be considered as a management task, first, preferences, and secondly the professional qualities of the members intellectual team. Resources are needed to manage them. Therefore, the task of further research is the study of existing theories of motivation and the development of a mathematical model and a method for managing the motivation of members of an intellectual team.

There is content theories of motivation are based on the fact that there are internal motivations (needs) that make a person act and process motivation theories that determine not only the needs but also come from the person's perception and expectations associated with the given situation and the possible consequences chosen type of behavior. Content theories of motivation are based on the identification of those internal needs that cause people to act this way, and not otherwise. This group includes theories of Maslow, Herzberg, McClelland. Process theories of motivation (more modern) are based on models of people's behavior with regard to their perception and cognition (Vroom theory, justice theory and Porter-Lawler motivation model, McGregor theory).

For motivating the members of the intellectual team, it is necessary to go through five stages. The first stage is the assessment of the needs of employees, determining their working behavior, attitude to work and tasks. The second is the definition of those factors that affect the labor motivation of workers, determining their attitude to work, the degree of interest in the results and the willingness to work with full efficiency. The first and second stages relate to the identification problem. The third stage is the development of such measures of influence, the construction of such a motivating working environment,

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which contributes to high interest in the results. At this stage, a model of motivation management is being built. The fourth is the impact on labor motivation, taking into account the individual characteristics of the employee, which is the realization of the task of managing motivation. And the fifth is to evaluate the effectiveness of the selected measures of influence, and to correct them if necessary, i.e. evaluation of management results.

## 6. Conclusion

Based on the analysis of the problem and the existing methods of forming teams, a new model was proposed that allows to form of an intellectual team for the duration of the project, taking into account both professional and economic factors. Also, the process of motivating the members of the intellectual team was considered and the importance and expediency of their adaptation and training was shown, as the development of an effective intellectual team contributes to the creation of a favorable climate in the organization, increases the efficiency and motivation of the employees of the organization: employees become more competitive and receive additional opportunities for professional growth, which is especially important in the current conditions of rapid obsolescence of professional knowledge. This directly affects the effectiveness of the project, and therefore contributes to improving the financial performance of the organization.

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