Formation of Effective Leading Project Teams: A Multi-Objective Approach

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Abstract The formation of project executives is the most important task facing the project manager and a project leader. Indeed, it is possible to formulate goals correctly, set tasks correctly, choose appropriate management methods and mechanisms, but all this may be in vain if not enough attention is paid to personnel selection. The paper considers the existing approaches to the formation of project teams. The task of forming the team of project executives in the general case is to re-group them by project teams on the basis of the existing set of applicants with many different indicators so that the combined interaction between the members of each team would be as effective as possible. It is worth noting that this problem reduces to the NP-hard problem of combinatorial choice. However, along with the assessment of the professional suitability of employees and roles, it is necessary to consider several indicators: psychological compatibility between team members, the degree of interchangeability in the context of the work performed, etc. All these indicators can be measured in points; however, the values of their indicators can belong to different scales. It is said that such situations are modelled under multicriteria conditions. Our paper presents a methodology for the formation of project teams and builds a model using an interdisciplinary approach based on methods of graph theory, socionics, and operational research.

Keywords: leadership, team, multi-objective approach, project management

1 Introduction

Currently, many companies are introducing modern management methods based on the project management approach (Smith 2013). One of the important and complex processes in project management is the human resource management process. The Human Resource Management process is focused on managing employees as the organization's most valuable resources, comparable to the importance of financial, material and information resources. Carefully and correctly conducted team selection can be an important factor in the success of a project. Currently, there are not enough analytical approaches and procedures to support the selection of teams of project executors, which consider many criteria based on which candidates are selected. In the presented article, a technique for the optimal formation of project teams is given, which allows automating the process of support and decision-making in project management systems.

The symbiosis of approaches based on the theory of graphs and socionics is most effective for solving the problems of forming project teams in organizations with many employees in conditions when it is necessary to constantly reallocate employees to project teams. In this case, in addition to assessing professional competencies or roles, it is necessary to consider some indicators: psychological compatibility between team members, the degree of interchangeability in the context of the work performed, and. etc. All these indicators can be measured in points, but their values can refer to different scales (for example, a sixteen-point assessment of socionic personality typing and a ten-point assessment of the level of professional competence are different scales). Situations of this kind are modelled under multicriteria conditions (Emelichev and Perepelitza 1991).

The result of work on any project depends on the coordinated work of the project team, and its correct formation is one of the main factors for the success of the project. The project team is one of the main concepts of project management. This is a group of employees directly working on the implementation of the project and

subordinate to the project manager, which is the main element of its structure since it is the project team that ensures the implementation of its ideas. The project team is created for the period of the project and after its completion is dissolved. Typically, project activities are characterized by functional organizational structures using teams or with matrix organizational structures (Pugh 1990).

Such teams are created "over" existing functional relationships and act as independent organizational units. Fig. 1 that follows shows two teams within an existing functional structure. Dotted and solid lines connect the members of these teams. Each team member is administratively subordinate to its functional department.
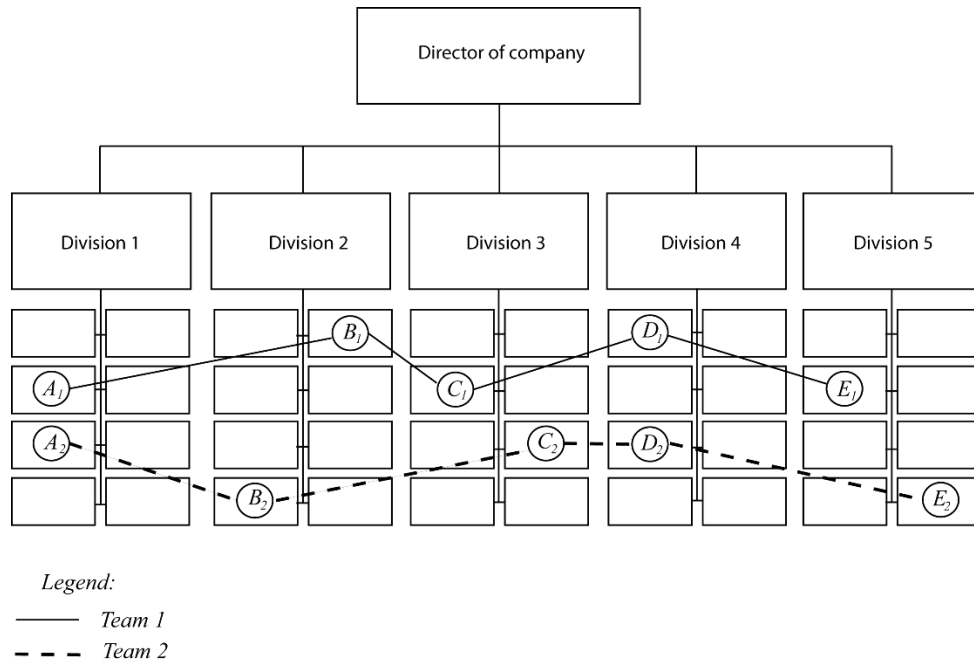

Fig.1. An example of team building in a matrix organizational structure
Source: Own results

At the initial stage, when deciding on the creation of a project team, it is necessary to describe and take into account: the restrictions imposed by the external and internal environment on the choice of members of the project team; restrictions imposed by the external and internal environment on the actions of the head and members of the project team (Polozhentseva et al. 2019). It is necessary to develop a methodology for the formation of a project team, which should: allow selection of candidates for professional competencies; allow the selection of team members by the roles in the team; provide an opportunity to assess the relationship between future members of the project team (see e.g. Takhumova et al. 2018a; Takhumova et al. 2018b). Any projects, regardless of purpose, content, urgency, and design object, can be divided into stages:

1. Formation of the layout of the innovation project.
2. Feasibility study.
3. Creating a team to complete the project.
4. Project development.
5. Decision-making on the feasibility of implementing an innovative project.
6. Material embodiment of the project.

At stages 1, 2, requirements arise for the team: its composition, number and qualifications of its future members. All stages of the project are supervised by the project manager and curator. Leader - a representative of the team who is responsible for the successful implementation of the project, protects design decisions and reports to the customer and the curator. The curator is a senior management representative who provides information support and finances the project. To implement the project, we need a group of performers (working group). Requirements for it are developed at the stages of forming the layout of an innovative project and drawing up a feasibility study. At the stage of creating the project team, a group of performers is formed, which must meet the requirements identified at the previous stages. Regardless of the professional requirements described above (composition, quantity, qualifications), the group of performers should: focus on the general goals and objectives of the project; bear overall responsibility for the final result; carry out a large number of communications between participants; have a limited number of members (from three to nine people).

Recent studies show that group performance begins to decline significantly when team sizes exceed 12 members (Creighton 2006). A survey of 35 companies on the impact of team remuneration on team performance showed that the average size of workgroups was seven people (McClurg 2001). Thus, we can conclude that the number of group members of 5-7 people is optimal for mobilizing the efforts, experience, abilities and creative capabilities of team members.

2. The main approaches and problems of forming a project team

Project teams (PT), like the projects themselves, have their life cycles. The life cycle of a PT consists of several stages: creating a team, developing team relationships or team building, maturity, disbanding. The most problematic stages are those aimed at creating an effective PT - creating a team and forming relationships within this team.

An analysis of the literature (Wysocky et al. 2000; McClurg 2001; or Dyer 2015) on project management shows that there are three approaches to PT formation: i) professional; ii) role; iii) by sociotype of personality. The main criteria for selecting employees will be knowledge and skills in the industry in which the company operates. For the selection of personnel there is a professional approach.

Selection criteria in the PT can be direction or specialty; knowledge gained through training and work experience; skills gained through training and work experience; experience in participating in such projects; PT experience. The problem with using a professional approach is that an employee who is not suitable for working in a PT can meet the above criteria.

The principle of the distribution of roles in the project team may be different. For example, you can use the approach based on team roles in management (Belbin 1981): chairman, designer, idea generator, analyst or critic, performer, support, researcher, finalizer. Another problem when creating a PT is the formation of team relationships. When selecting staff in a PT, personal qualities, skills and abilities of the applicant for a certain position are taken into account. But an ideal employee may not get along with the team at all. The problem is psychological and can be solved by using socionics.

When creating a PT, it is recommended to take into account the personality type (Fisher et al. 2005). Socionics is a concept of personality types and the relationship between them. Socionics purposefully studies the mechanism by which a person perceives and evaluates the information coming to him. This science is based on the typologies of Jung, Kretschmer, and Lichko and the theory of information metabolism by Kempinsky (see Augustinavichute 1995). This is an exact science, showing that the basis of the perception and thinking of man, as well as the basis of the functioning and development of society, are the laws of physics.

When determining a sociotype, special tests are used, the questions of which are aimed at determining character traits. Classical distribution Jung shows that there are only 16 sociotypes (Augustinavichute 1995), contrasted in four pairs of characteristics: i) extraversion - introversion; ii) sensorics - intuition; iii) ethics - logic; iv) rationality - irrationality.

Any sociotype is a combination of four characteristics that correspond to different positions (or roles in the team). When recruiting employees in a PT for certain roles, an additional selection of a candidate can be made according to the corresponding set of sociotype parameters. For example, when choosing a designer in a PT, the considered characteristics include logic and intuition. Logic is the exact perception of the material world. Intuition - the ability to think in abstract images. The designer creates projects of various innovative objects or products, participates in almost all stages of research and development work. The ability to think in abstract images, together with an accurate perception of the material world, provides a person with the benefits of working as a designer.

Companies that do not use the project form of management, implement only a professional approach. In companies that use the process-design form of management, two approaches are often used jointly (as a rule, professional and role). Socionics is not used or rarely used by many employees of HR services since project managers do not favour socionics when forming project teams. Although professionals in the field of psychology argue that socionics gives accurate results and allows you to form an effective team. The results of the relationship can conditionally be divided into three groups: i) a good relationship; ii) neutral relations; and iii) bad relationships.

Having a bad relationship in a PT will lead to interpersonal conflicts that worsen communication. The formation of good and neutral relations in the PT with limited recruitment of employees (only company employees) and the need to take into account the professional and role qualities of employees (applicants in the PT) is possible using the PT formation mechanism.

The main idea here is to use three approaches at the same time: according to professional criteria, by roles (required for a project), as well as by sociotypes and the nature of relationships within the team.

3. The mechanism for the formation of the project team

Depending on the distribution of relationships between employees with different sociotypes, it is possible to build effective and conflict-free relationships between members of the project team. Each personality type is a set of qualities with certain characteristics. Identification of the qualities of each team member allows you to identify the strengths and weaknesses of the employee. Grouping by the personality type criterion of all team members shows the types of relationships between them. Based on the received data on relationships, the project management decides on the approval or replacement of some members of the PT.

Based on the characteristics of Jung can be selected for each member of the team four sociotypes (see Table 1). Of course, professional testing will be required here.

Table 1. Sociotypes for team members

Position	PT leader	Executor
Main characteristics	Irrationality Extroversion	Logics Intuition
Option 1	Intuitive logical extrovert	Logical and intuitive introvert
Option 2	Sensory logical extrovert	Logical and intuitive extrovert
Option 3	Sensory-ethical extrovert	Intuitive logical introvert
Option 4	Intuitive ethical extrovert	Intuitive logical extrovert

Source: Own results

Using the options for selecting sociotypes of the personality of team members in the PT (Table 1), you can build a matrix of relationships between applicants. An example is presented in table 2, it can be seen that good interaction is provided by people who have the same or similar sociotypes. Neutral relations are established between sociotypes that have common features. Common features ensure the presence of similar views and reactions to certain situations or a set of character traits, thanks to which mutual understanding is better established. Poor relationships show the risk of conflicts due to different points of view, characters and characteristics that opponents do not accept.

Table 2. The relationship between different sociotypes of team members on the example of the head of the PT and the performer

		PT leader			
		Intuitive-logical extravert	Sensory-logical extravert	Sensory-ethical extravert	Intuitive-ethical extravert
Executor	Logical and intuitive introvert	Bad	Bad	Bad	Bad
	Logical and intuitive extrovert	Neutral	Bad	Good	Bad
	Intuitive logical introvert	Neutral	Neutral	Good	Neutral
	Intuitive logical extrovert	Good	Neutral	Neutral	Neutral

Source: Own results

- Good relationships mean non-conflict employee relationships that lead to an effective team;
- Neutral relationships mean non-conflict relationships that do not ensure the effective work of the team;
- Bad relationships are not considered due to the high risk of conflict.

When forming relationships between PT members (more than two), a separate relationship matrix is built for each pair. The totality of the results for all matrices makes it possible to form a conflict-free relationship in the PT.

4. Methodology for the formation of the project team

We use the following hypothesis: with a multiplicity of factors affecting the PT, there is a limited number of factors that must be considered when forming an effective PT.

The main factors affecting the formation of the PT: external factors, such as professional requirements for team members and the role of the composition, determined at the stage of the innovative layout of the project; internal factors, such as sociotypes of personalities of applicants to the PT from a limited number of company employees, which determine the relationship between the members of the PT.

At each stage of the project, the requirements for the composition of the PT (to the role distribution within the PT) are identified. Each member of the PT performs its work in accordance with professional knowledge and skills and plays its role in accordance with the distribution (official or unofficial) of authority in the project.

Based on the hypothesis put forward, we can describe the methodology by which the formation of the project team is possible:

- Determination of the initial composition of the project team (description of professional requirements and roles) at the stages of the formation of an innovative project and a feasibility study. Selection of candidates for professional qualities and skills;
- The distribution of candidates by roles in accordance with the initial composition of the team defined in the first paragraph;
- Building a matrix of relationships between all members of the PT based on the developed mechanism of relationships;
- Checking the compliance of the selected candidates by the criterion of good/neutral relationships to the role composition of the team through the relationship matrix.

5. Graph-theoretic statement of the problem

We make a reservation in advance that the missing terms and definitions of graph theory can be found in (Harary 1969; or Emelichev and Perepelitza 1991). Let an ordinary graph $G = (V, E)$ be given, in which each vertex $\{v_i\} \in V$, $i = 1,2,\ldots,n$, corresponds to a certain applicant from the total number of employees from which candidates are selected for the formation of projects. The edge $\{e_{ij}\} \in E$, $i, j = 1,2,\ldots,n$ connecting the vertices i and j correspond to the revealed relationship between the pair of applicants. Each vertex $v_i \in V$, $i = 1,2,\ldots,n$, corresponds to some numbers $w_{r'}(v_i)$, $r' = 1,2,\ldots,N$ called the weight of the vertex, which evaluate some characteristic: socionic type, competence, the functional responsibility of the employee, etc. (estimated in points). Each edge $\{e_{ij}\} \in E$, $i, j = 1,2,\ldots,n$ is associated with some numbers $w_{r''}(e_{ij})$, $r'' = 1,2,\ldots,N$ corresponding to estimates of the quality of communication between the *i*-th and *j*-th candidate, also scored. In the present work, it is proposed to use socionic typing methods to determine the psychological types of specialists working in this collective as the main measure of the relationship between employees.

With the graph G, a set of admissible typical subgraphs $H = \{H_1, H_2, \ldots, H_t\}$ is defined. Typical subgraph H reflects the organizational structure (subordination relationships) within project teams. So, for example, for teams working under permanently extreme conditions, a full type subgraph $H = (U, \psi)$ is characteristic. In this typical subgraph, the vertices $u \in E$ one-to-one represent the members of the formed PT, where each has certain functional responsibilities. These responsibilities determine the information connections and subordination relationships within the PT. In a typical subgraph H, the pair $u', u'' \in U$ is connected by $\psi = (u', u'')$ if for the team members in the process of achieving the main goal of the group they are significant and there is a production information connection, as well as subordination relations.

Based on the existing set of applicants, it is required to regroup them according to project teams in such a way that the joint interaction between the members of each team would be as effective as possible. Each applicant from a set of employees should be included in only one project team.

A feasible solution x of a problem is a spanning subgraph $G = (V, E_x)$, $E_x \subseteq E$, in which each connected component is isomorphic to one of the typical subgraphs of H.

For a given G and H, the set of feasible solutions (MDS) is denoted by $X = \{x\}$.

On the MDS $X = \{x\}$, we define the vector-objective function (VTsF):

$$F(x) = (F_1(x), F_2(x), \ldots, F_N(x)) \qquad (1)$$

MINSUM view criterion

$$F_r(x) = \sum_{e \in E_x} w_r(e) \to max \qquad (2)$$

or a criterion of the form MAXMIN:

$$F_r(x) = max_{e \in E_x} w_r(e) \to max \qquad (3)$$

We use the following assessments of the quality of business cooperation of a pair of applicants:

$w_r(v_i) = w_r(v_j)$, if r characteristics of the respective applicants coincide;

$w_r(v_i) = 1 - w_r(v_j)$, if r characteristics of the respective applicants are complementary;

$w_r(v_i) = -w_r(v_j)$, if r the characteristics of the respective applicants are conflicting;

otherwise $w_r(v_i) \neq w_r(v_j)$.

Then
$$w_r(e_{ij}) = \begin{cases} 1, w_r(v_i) = 1 - w_r(v_j) \\ 0, w_r(v_i) \neq w_r(v_j) \\ -1, w_r(v_i) = -w_r(v_j) \end{cases} \qquad (4)$$

VTsF (1) defines in the MDS X the Pareto set (PS) $\tilde{X}$ (Emelichev and Perepelitza 1991). Considering the PS $\tilde{X}$ and choosing one representative from each subset of the PS, we get the Pareto set of alternatives (PSA) X^0. The solution to any individual task of forming project teams is PMA X^0.

6. The algorithm for solving the problem

Perepelica and Tambieva (2009) investigated the problem of covering a graph with k-vertex cliques (or k-cliques). A clique is a complete subgraph contained in the original graph. The solution scheme of this algorithm can be applied to the problem of covering a graph with typical subgraphs. The problem of covering a graph with k-cliques is NP-hard (see Garey and Johnson 1979). The proposed algorithm is justified as an exact algorithm for solving the NP-hard problem of covering the (unweighted) *n*-vertex graph $G = (V, E)$ by *k*-cliques. The algorithm is a method of guaranteed finding any feasible solution $x \in X$ of the problem of *k*-clicks.

The algorithm for solving this problem is iterative and consists of 2 stages: preparatory and basic. The main idea of the preparatory stage is to partition the set of all vertices into possible *k*-combinations, which are feasible solutions to the problem under study.

The main idea of the main stage is that all *k*-combinations that are not suitable for the general solution are iteratively excluded from consideration.

7. Conclusion

All in all, in the process of forming a project team, it is advisable to supplement professional and role approaches with an approach related to the description of personality types. Based on the constructed approaches, a mathematical model is constructed for an adequate decision support system for the problem of effective human resource management.

Our results confirm that an interdisciplinary approach using graph theory and socionic typing is most effective for solving the problem. The algorithm proposed in our work. This approach is guaranteed to build an acceptable leading solution taking into account the recommended average number of team members.

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