

Intelligent Information Technology for Providing Human Resources to Projects in a Multi-Project Environment

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Abstract

The implementation of projects in a multi-project environment imposes additional restrictions on human resource management processes. In order to monitor the provision of human resources to projects in a multi-project environment, a method for analyzing the involvement of human resources in a portfolio of projects is proposed, which is based on the use of a logical-combinatorial approach. The use of positional diagrams allows you to analyze the distribution of resources between portfolio projects and determine the degree of involvement of performers in the project.

Metrics that are used in the analysis of a project portfolio have been determined. They are involvement of stakeholders in the project portfolio; involvement of stakeholders in the project; interest of stakeholders in project management; interest of stakeholders in human resource management of the project; stakeholder loyalty indicator. Since various stakeholders are involved in the implementation of a portfolio of projects, when ensuring the redistribution of resources in the portfolio, it is necessary to take into account the level of involvement of resources in the projects of certain stakeholders. A method for the analysis of stakeholder-oriented resource redistribution is proposed, which allows taking into account the interests of stakeholders and identifying a potential conflict in the redistribution of project portfolio resources.

Keywords

Project, stakeholders, engagement analysis, resource reallocation, multi-project environment.

1. Introduction

Developing sustainable human capabilities for project team members during the COVID-19 crisis increases team resilience and facilitates the adaptation of technical skills to dynamic economic changes [1]. In a crisis, the company's management faces the task of improving human resource management in order to optimize them. In some cases, it is impossible to do without staff cuts. Reduction of personnel, aggressive influence of the external environment, increased mobility of team members lead to an increase in project risks associated with the influence of the human factor.

To increase the viability of projects and the company's competitiveness, it is necessary to apply modern approaches to human resource management in project-oriented companies.

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The development of effective methods for managing human resources of a multi-project is an urgent task, since for the implementation of a multi-project it is necessary to synthesize the resources of individual projects within the existing constraints. Multi-project management leads to the need to analyze the distribution of resources between portfolio projects [2-4].

2. Related works

Product development organizations are faced with a growing number of fast and small development projects to meet market and customer needs. By multi-project management we mean the management of a group of projects, programs, project portfolios carried out by one or more organizations in the industry in a certain period of time to achieve the strategic goals of the industry or a certain circle of stakeholders.

The characteristic features of human resource management in a multi-project environment are:

- the presence of a certain circle of stakeholders;
- the need to ensure the management of critical competencies;
- specific requirements for resource management;
- involvement of performers in several projects.

In order to ensure rapid product development, it is proposed to allocate competent developers for quick projects, joint placement of a development team, effective personal communication and the implementation of a specific but flexible process for rapid product development [5]. Jin Guangying; Sperandio Severine; Girard Philippe consider the formation of the project team taking into account the possibility of collaboration, the level of expectations of the participants from the project, using the values of AWTEL [6].

Application of a multi-agent approach to the allocation of human resources [7-9] is aimed at solving problems when planning several projects with limited resources in conditions of uncertainty [10].

When solving the decentralized problem of finding a compromise between time and costs in multi-project time-cost tradeoff problem, project planning and resource allocation are performed in a distributed manner by autonomous project managers to optimize local goals, taking into account global requirements [11].

When planning a project in a multi-project environment, there are:

- Resource Constrained Project Scheduling Problem (RCPSP) [11];
- Resource Constrained Project Scheduling Problem with Bounded Multitasking (RCPSPB) [12];
- Multi-mode resource-constrained project scheduling [13];
- Robust Resource-Constrained Multi-Project Scheduling Problem (RRCMPSP) [14];
- Project Scheduling with Dynamic Resource Allocation in a Multi-project Environment [15];
- The task of planning a portfolio of projects in the context of restrictions on the available labor resources of various specializations and fuzzy estimates of labor costs for performing work [16].

The use of multicriteria optimization based on the modified TOPSIS method in solving the human resource management problem allows ranking alternative solutions for human resource management, further analysis and selection of the final solution [17].

A targeted search is used to provide the company with employees with critical competence. Its effectiveness is determined by the formalization of requirements for the candidate, determined by the requirements for the project and the interests of the stakeholders.

When managing a project portfolio, the stakeholders are [18]:

- the supreme governing body of the company, which makes strategic decisions on the development of the company's portfolio;
- portfolio management group;
- portfolio director;
- portfolio management committee (portfolio board);
- managers (leaders) of programs;
- managers (leaders) of projects;
- program / project office;
- teams of programs / projects;

- clients;
- suppliers and partners.

The methods of attracting employees to the project team are determined by the availability of resources in the company, their availability at a certain point in time, and the consent to take part in the project [19]. The application of the competence-based approach is considered in the works of Bushuev S.D., Bushueva N.S. [20].

In order to increase the efficiency of project management, it is proposed to consider the integration of stakeholder management and project human resources management. The relationship between human resource management processes in a multi-project environment and critical competence management processes is discussed in [21].

A method of project-oriented management of the provision of human resources for projects in a multi-project environment is proposed, based on the analysis of stakeholders' interest in human resource management processes, taking into account the loyalty of stakeholders, which, unlike the existing ones, takes into account the consistency of certain resource constraints, which will provide project teams with the necessary resources for given restrictions [22].

Among the main tasks that arise during changes in a multi-project environment, the most urgent is the redistribution of resources between projects while ensuring existing restrictions. The current direction is the creation of an adaptive team - a team that reacts to changes in the currently available business requirements and technical requirements for the project and its product, by redistributing functions with the same team composition. The need to take into account changes to the requirements of the project and the project product, to adapt the team to the changed requirements, the ability to reserve and ensure donor-acceptor interaction leads to the need to develop methods for redistributing resources in a multi-project environment.

3. Proposed methods and model

Implementation of projects in a multi-project environment with a limited pool of resources, staff reduction during a crisis leads to the involvement of performers in several projects at the same time. On the one hand, this approach reduces the amount of resources involved, but it can also lead to a decrease in the efficiency of project implementation due to the switching of performers' attention between projects and the need to focus on the completed projects.

At the stage of resource planning in a multi-project environment (project portfolio or program), it is proposed to determine the maximum possible degree of involvement of an employee with a certain qualification, at which he can perform work with a given quality.

The degree of overlap of projects by the parameter human resources shows the number of performers simultaneously involved in the implementation of a given combination of projects. Excessive involvement of employees (especially middle management) in various projects leads to a decrease in the efficiency of functioning, an increase in the influence of the subjective factor, and a decrease in the quality of decisions made.

The maximum possible degree of involvement of the i -th performer in the project is the number of projects carried out by the i -th employee in a certain period of time with the given quality indicators.

The maximum allowable load for the whole organization reflects the percentage of resource utilization. For example, in budgetary institutions, the maximum allowable workload is 150% (1 rate of a full-time employee and 0.5 of a part-time rate). Using overlapping positions and allowances can increase the maximum allowable workload. The maximum load on the j -th project at a certain time interval is determined by the amount of involvement of the i -th performer in the j -th project (hours, or % rate).

For the purpose of analyzing the involvement of human resources in the project portfolio, methodological support has been developed.

A method for analyzing the involvement of human resources in a portfolio of projects.

Stage 1. Formation of maximum permissible engagement metrics for each job position:

- determining the maximum possible degree of involvement in the project;
- determination of the maximum allowable load in the whole organization;
- determination of the maximum load in one project at a certain time interval.

Stage 2. Determination of prohibited combinations of involved performers.

At the stage of determining the prohibited combinations of the involved performers, a check is performed:

- prohibited combination of roles by one performer within the i-th project:

$$ZS^1 = \{ZS^1_1, \dots, ZS^1_i, \dots, ZS^1_n\}; \quad (1)$$

- prohibited combination of work performance by one performer in different projects of the project portfolio:

$$ZS^2 = \{ZS^2_1, \dots, ZS^2_i, \dots, ZS^2_n\}; \quad (2)$$

- overlapping prohibited by the conflicts of interests of stakeholders: analysis of resource requirements of stakeholders; stakeholder loyalty analysis:

$$ZS^3 = \{ZS^3_1, \dots, ZS^3_i, \dots, ZS^3_n\}. \quad (3)$$

After analysis for consistency, a set of prohibited alignments ZS is generated, which displays all prohibited alignments in the project portfolio.

Stage 3. Building a positional diagram for a portfolio of projects.

Stage 4. Analysis of the involvement of human resources in portfolio projects using positional diagrams:

- audit of a portfolio of projects by the criterion of prohibited combinations;
- audit of the project portfolio by the criterion of the engagement metric;
- audit of projects by the criterion of prohibited combinations;
- audit of projects by the criterion of engagement metrics.

Stage 5. Determination of inconsistency.

Stage 6. Development and implementation of corrective measures.

To formalize resource management in the project, a model of the process of analyzing the involvement of human resources in the project portfolio is proposed (Fig. 1).

Engagement metrics can be:

- involvement of stakeholders in the project portfolio (characterizes the number of projects in which a stakeholder is involved);
- involvement of stakeholders in the project (characterizes the level of involvement of stakeholders in the project);
- interest of stakeholders in project management;
- interest of stakeholders in human resource management of the project;
- stakeholder loyalty indicator.

In the absence of the possibility of attracting resources from the pool to the project that are not involved in the implementation of other projects, when reallocating resources in a multi-project environment, it is necessary to take into account the interest of stakeholders and their loyalty. In order to reduce the risk of conflict situations, redistribution in projects is carried out among projects in which a minimum number of stakeholders are involved:

- Up – many performers of projects of a project-oriented company, having a specific list of considered stakeholders;
- Up0 – many performers of projects in which certain stakeholders are not involved;
- Upi – many project executors, in which only the i-th stakeholder is involved;
- Up1,2 – a lot of project executors, in which the 1st and 2nd stakeholders are involved;
- Up1, ..., |ST| – many project executors in which all stakeholders are involved.

The use of a logical-combinatorial approach will allow analyzing the distribution of human resources between projects in a project portfolio.

The use of positional diagrams [23] visualizes the analysis of the degree of involvement of performers in the project. If the executor is involved in the execution of the project, then he is displayed in the corresponding elements of the positional diagram.

The diagram of overlapping projects by the parameters of performers, stakeholders is shown in Fig. 2.

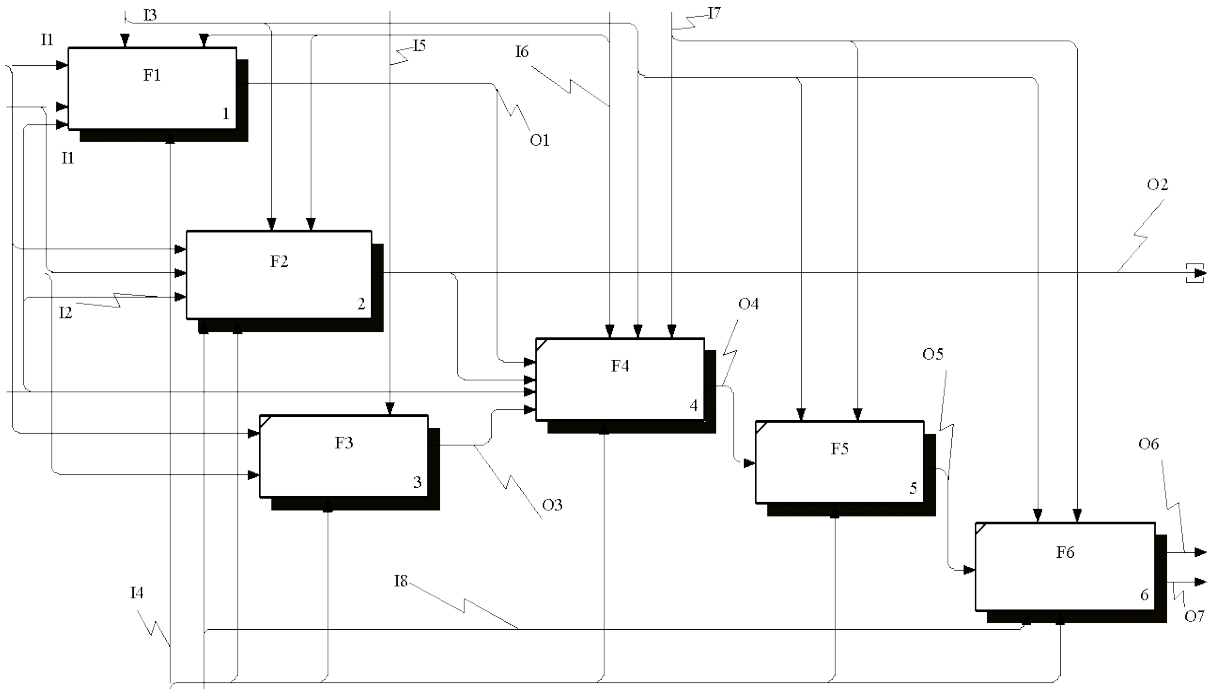


Figure 1: Model of the process of analyzing the involvement of human resources in a project portfolio (Processes: F1 – formation of engagement metrics; F2 – determination of prohibited combinations of involved performers; F3 – construction of positional diagrams for a project portfolio; F4 – analysis of human resources involvement; F5 – determination of inconsistency; F6 – development and implementation of corrective actions Inputs: I1 – a group of i inputs ($i = 1, \dots, n$), displaying information about the i -th project; I2 – resource requirements of stakeholders; I3 – corporate standards; I4 – HR service; I5 – method for constructing positional diagrams; I6 – job descriptions; I7 – analysis method; I8 – stakeholders Outputs: O1 – boundary permissible engagement metrics; O2 – prohibited alignments; O3 – positional diagrams of a project portfolio; O4 – analysis results; O5 – verification results; O6 – corrective actions; O7 – report)

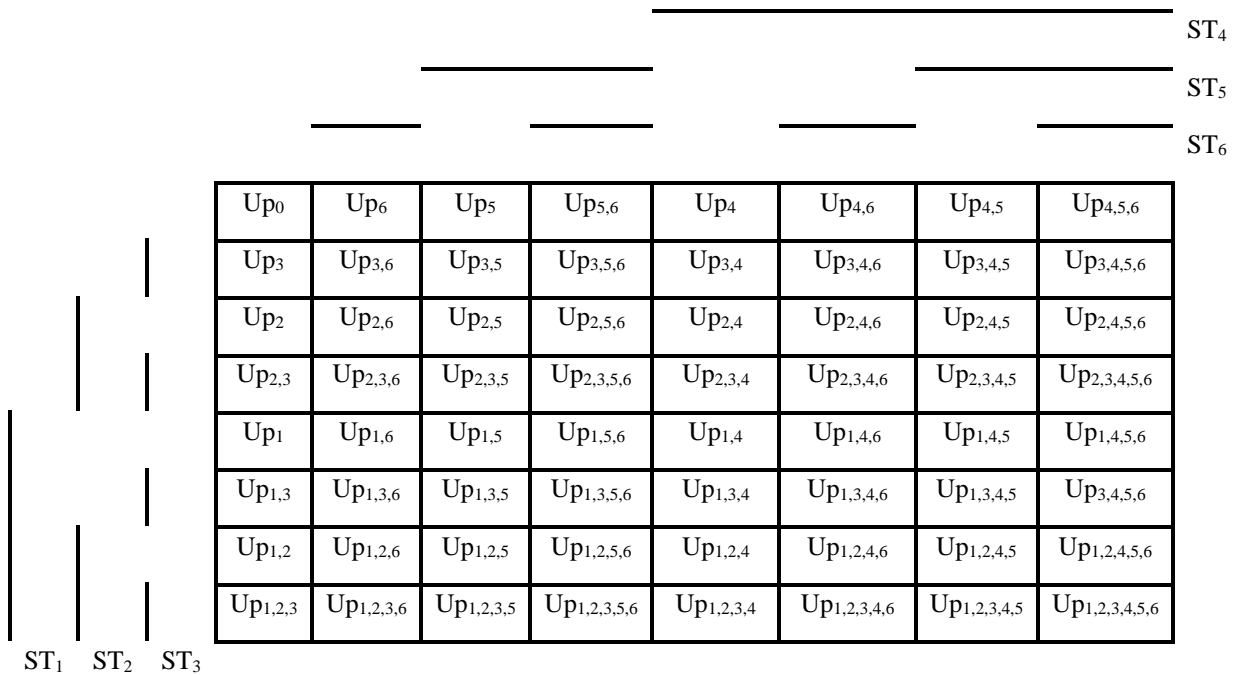


Figure 2: Diagram of project overlap by parameters performers, stakeholders $|ST|=6$

The distribution of human resource management processes in time depends on the stage of project implementation. Since the resources in the project are involved in a certain time interval, then after the work is completed, the resources are released, which can later be used in other projects.

Donor-acceptor resource interaction in a multi-project environment is due to the presence of a single pool of organizational resources, within which resources are redistributed between the work of donor projects and acceptor projects.

If it is necessary to attract additional resources to the project, an assessment is made of the possibility of redistributing resources (availability of resources, their availability, cost and duration of redistribution).

Method for analysis of stakeholder-oriented resource reallocation:

Stage 1. Determination of the matrix of changes in multi-project environment projects.

Stage 2. Determining the involvement of stakeholders in projects of a multi-project environment.

Stage 3. Building a responsibility matrix for projects in a multi-project environment.

Stage 4. Determination of indicators of involvement of performers in stakeholder projects.

Stage 5. Determination of the stakeholder loyalty matrix.

Stage 6. Determination of the overlap of projects by the parameter human resources.

Stage 7. Analysis of project overlap in terms of human resources and stakeholder loyalty.

Stage 8. Constructing options for redistribution taking into account the loyalty of stakeholders using positional diagrams.

Application of the developed method makes it possible to take into account the level of loyalty of the stakeholders of human resource management processes when reallocating resources in a multi-project environment.

4. Results

Let's consider the application of the proposed method.

Let the stakeholders who are involved in project management be identified:

$ST = \{ST_1, ST_2, ST_3, ST_4, ST_5, ST_6\}$.

$ST_1 = \{P_1, P_2, P_4, P_6, P_8, P_{10}\}$;

$ST_2 = \{P_3, P_4, P_5\}$;

$ST_3 = \{P_1, P_4, P_7, P_9\}$;

$ST_4 = \{P_2, P_6, P_8, P_{10}\}$;

$ST_5 = \{P_3, P_4, P_{10}\}$;

$ST_6 = \{P_5, P_8\}$.

Projects implemented by stakeholders are shown in Table 1.

Table 1
Stakeholder Projects Matrix

ST/P	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀
ST ₁	1	1	0	1	0	1	0	1	0	1
ST ₂	0	0	1	1	1	0	0	0	0	0
ST ₃	1	0	0	1	0	0	1	0	1	0
ST ₄	0	1	0	0	0	1	0	1	0	1
ST ₅	0	0	1	1	0	0	0	0	0	1
ST ₆	0	0	0	0	1	0	0	1	0	0

ST-equivalence of projects – projects have the same combination of stakeholders involved.

In the considered example of a portfolio of projects, ST-equivalent projects P₂ and P₆.

The matrix of overlapping projects by the parameters of projects, stakeholders is shown in Fig. 3.

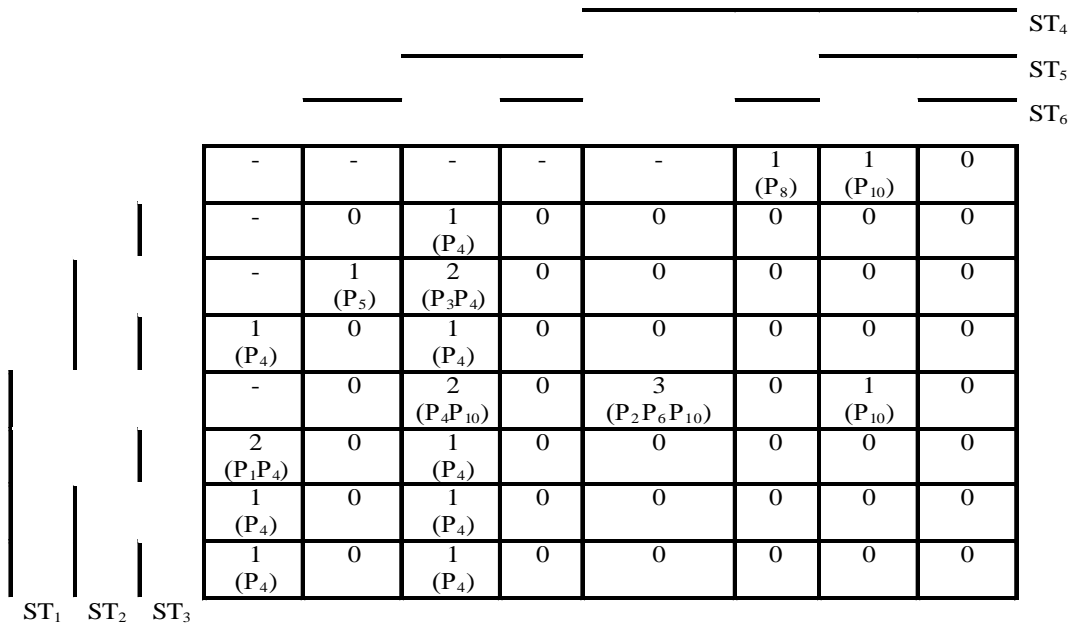


Figure 3: Diagram of project overlap by parameters projects, stakeholders

A set of project teams implemented in a multi-project environment (Table 2):

$P_1 = \{q_1, q_5, q_7, q_{11}, q_{14}, q_{16}, q_{18}, q_{20}\};$

$P_2 = \{q_2, q_4, q_6, q_8, q_9, q_{12}, q_{14}, q_{15}, q_{17}, q_{19}\};$

$P_3 = \{q_1, q_2, q_4, q_7, q_{10}, q_{13}, q_{17}, q_{19}\};$

$P_4 = \{q_1, q_5, q_7, q_9, q_{11}, q_{13}, q_{15}, q_{18}, q_{20}\};$

$P_5 = \{q_2, q_5, q_6, q_8, q_{10}, q_{12}, q_{15}, q_{17}, q_{19}\};$

$P_6 = \{q_6, q_{13}, q_{16}\};$

$P_7 = \{q_2, q_3, q_7, q_{10}, q_{18}\};$

$P_8 = \{q_4, q_8, q_{13}, q_{16}, q_{18}\};$

$P_9 = \{q_1, q_3, q_6, q_{11}, q_{15}, q_{20}\};$

$P_{10} = \{q_2, q_5, q_9, q_{17}\}.$

Table 2

Matrix of performers who can participate in the redistribution

Q/P	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀	Q/P	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀
q ₁	1	0	1	1	0	0	0	0	1	0	q ₁₁	1	0	0	1	0	0	0	0	1	0
q ₂	0	1	1	0	1	0	1	0	0	1	q ₁₂	0	1	0	0	1	0	0	0	0	0
q ₃	0	0	0	0	0	0	1	0	1	0	q ₁₃	0	0	1	1	0	1	0	1	0	0
q ₄	0	1	1	0	0	0	0	1	0	0	q ₁₄	1	1	0	0	0	0	0	0	0	0
q ₅	1	0	0	1	1	0	0	0	0	1	q ₁₅	0	1	0	1	1	0	0	0	1	0
q ₆	0	1	0	0	1	1	0	0	1	0	q ₁₆	1	0	0	0	0	1	0	1	0	0
q ₇	1	0	1	1	0	0	1	0	0	0	q ₁₇	0	1	1	0	1	0	0	0	0	1
q ₈	0	1	0	0	1	0	0	1	0	0	q ₁₈	1	0	0	1	0	0	1	1	0	0
q ₉	0	1	0	1	0	0	0	0	0	1	q ₁₉	0	1	1	0	1	0	0	0	0	0
q ₁₀	0	0	1	0	1	0	1	0	0	0	q ₂₀	1	0	0	1	0	1	0	0	1	0

Based on the analysis of project teams implemented in a multi-project environment, we determine the indicators of the involvement of performers in the projects of stakeholders (Tables 3, 4).

Table 3

A quantitative indicator of the involvement of performers in the projects of the stakeholders

Q/ ST	ST1	ST2	ST3	ST4	ST5	ST6	Q/ ST	ST1	ST2	ST3	ST4	ST5	ST6
q1	2	2	3	0	2	0	q11	2	1	3	0	1	0
q2	2	2	1	2	2	1	q12	1	1	0	1	0	1
q3	0	0	2	0	0	0	q13	3	2	1	2	2	1
q4	2	1	0	2	1	1	q14	2	0	1	1	0	0
q5	3	2	2	1	2	1	q15	2	2	2	1	1	1
q6	2	1	1	2	0	1	q16	3	0	1	2	0	1
q7	2	2	3	0	2	0	q17	2	2	0	2	2	1
q8	2	1	0	2	0	2	q18	3	1	3	1	1	1
q9	3	1	1	2	2	0	q19	1	2	0	1	1	1
q10	0	2	1	0	1	1	q20	3	1	3	1	1	0

Table 4

Involvement of performers in stakeholder projects

Q/ ST	ST ₁	ST ₂	ST ₃	ST ₄	ST ₅	ST ₆
q1	P ₁ , P ₄	P ₃ , P ₄	P ₁ , P ₄ , P ₉	0	P ₃ , P ₄	0
q2	P ₂ , P ₁₀	P ₃ , P ₅	P ₇	P ₂ , P ₁₀	P ₃ , P ₁₀	P ₅
q3	0	0	P ₇ , P ₉	0	0	0
q4	P ₂ , P ₈	P ₃	0	P ₂ , P ₈	P ₃	P ₈
q5	P ₁ , P ₄ , P ₁₀	P ₄ , P ₅	P ₁ , P ₄	P ₁₀	P ₄ , P ₁₀	P ₅
q6	P ₂ , P ₆	P ₅	P ₉	P ₂ , P ₆	0	P ₅
q7	P ₁ , P ₄	P ₃ , P ₄	P ₁ , P ₄ , P ₇	0	P ₃ , P ₄	0
q8	P ₂ , P ₈	P ₅	0	P ₂ , P ₈	0	P ₅ , P ₈
q9	P ₂ , P ₄ , P ₁₀	P ₄	P ₄	P ₂ , P ₁₀	P ₄ , P ₁₀	0
q10	0	P ₃ , P ₅	P ₇	0	P ₃	P ₅
q11	P ₁ , P ₄	P ₄	P ₁ , P ₄ , P ₉	0	P ₄	0
q12	P ₂	P ₅	0	P ₂	0	P ₅
q13	P ₄ , P ₆ , P ₈	P ₃ , P ₄	P ₄	P ₆ , P ₈	P ₃ , P ₄	P ₈
q14	P ₁ , P ₂	0	P ₁	P ₂	0	0
q15	P ₂ , P ₄	P ₄ , P ₅	P ₄ , P ₉	P ₂	P ₄	P ₅
q16	P ₁ , P ₆ , P ₈	0	P ₁	P ₆ , P ₈	0	P ₈
q17	P ₂ , P ₁₀	P ₃ , P ₅	0	P ₂ , P ₁₀	P ₃ , P ₁₀	P ₅
q18	P ₁ , P ₄ , P ₈	P ₄	P ₁ , P ₄ , P ₇	P ₈	P ₄	P ₈
q19	P ₂	P ₃ , P ₅	0	P ₂	P ₃	P ₅
q20	P ₁ , P ₄ , P ₆	P ₄	P ₁ , P ₄ , P ₉	P ₆	P ₄	0

Table 3 shows that q_3 participates only in the projects of the third stakeholder, which will ensure the transfer between projects without additional approval.

For the given example, a diagram of the overlap of projects by the parameters of performers, stakeholders is built.

For the considered case, when several stakeholders are involved in the implementation of the project, we adjust the positional diagram, exclude the corresponding combinations of stakeholders from consideration:

$\{0,0,0,0,0,0\};$
 $\{1,0,0,0,0,0\};$
 $\{0,1,0,0,0,0\};$
 $\{0,0,1,0,0,0\};$
 $\{0,0,0,1,0,0\};$
 $\{0,0,0,0,1,0\};$
 $\{0,0,0,0,0,1\}.$

To take into account the interests of stakeholders and identify a potential conflict in the redistribution of project portfolio resources, it is proposed to use a loyalty matrix, which reflects the relationship between stakeholders.

The loyalty matrix element reflects the assessment by the i -th stakeholder of the attitude towards the j -th stakeholder. The score is measured in points:

- - 3 – extreme degree of dislike;
- - 2 – are in a state of conflict at the moment;
- - 1 – there were conflict situations earlier;
- 0 – neutral attitude;
- 1 – has a positive experience of working together;
- 2 – ready for cooperation;
- 3 – complete trust.

An example of a loyalty matrix is given in Table 5.

Table 5
Stakeholder Loyalty Matrix

ST	ST ₁	ST ₂	ST ₃	ST ₄	ST ₅	ST ₆
ST ₁	-	0	1	0	2	-3
ST ₂	0	-	1	-2	0	1
ST ₃	1	1	-	1	1	2
ST ₄	0	-2	1	-	1	1
ST ₅	2	0	1	1	-	1
ST ₆	-3	1	2	1	1	-

Based on the analysis of the stakeholder loyalty matrix in the positional diagram, we determine the projects, during the implementation of which there may be a risk of project failure due to a conflict of interests of stakeholders.

It was determined that the portfolio involved the first and sixth stakeholders who have an extreme degree of hostility (-3, according to the loyalty matrix), then when analyzing the diagram, we identify problem cells (Fig. 4): $Up_{1,6}$, $Up_{1,5,6}$, $Up_{1,4,6}$, $Up_{1,4,5,6}$, $Up_{1,3,6}$, $Up_{1,3,5,6}$, $Up_{1,3,4,6}$, $Up_{3,4,5,6}$, $Up_{1,2,6}$, $Up_{1,2,5,6}$, $Up_{1,2,4,6}$, $Up_{1,2,4,5,6}$, $Up_{1,2,3,6}$, $Up_{1,2,3,5,6}$, $Up_{1,2,3,4,6}$, $Up_{1,2,3,4,5,6}$.

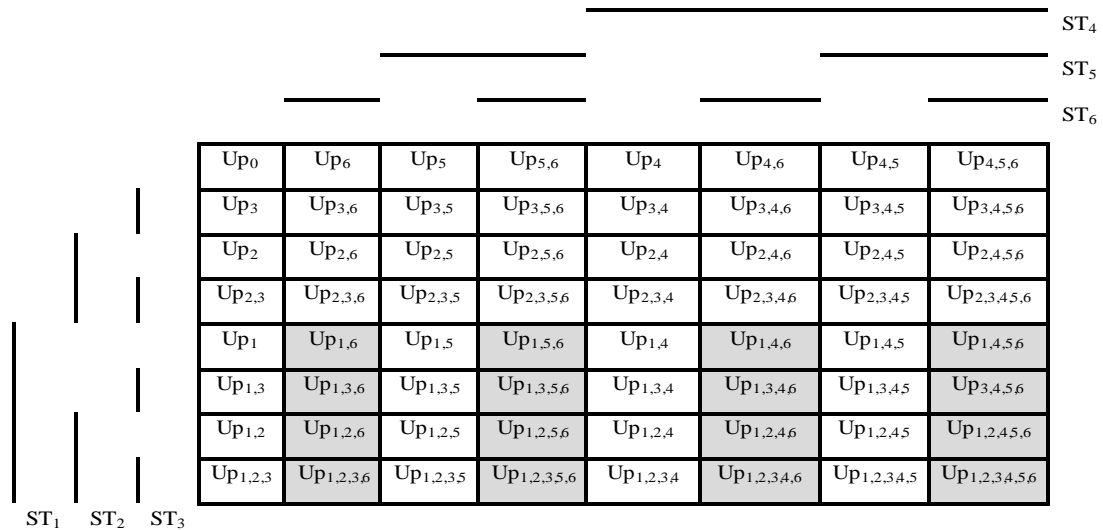


Figure 4: Overlap diagram (problem cells)

Fig. 5 shows a diagram of overlapping projects by parameters performers, stakeholders (numbers of performers are indicated).

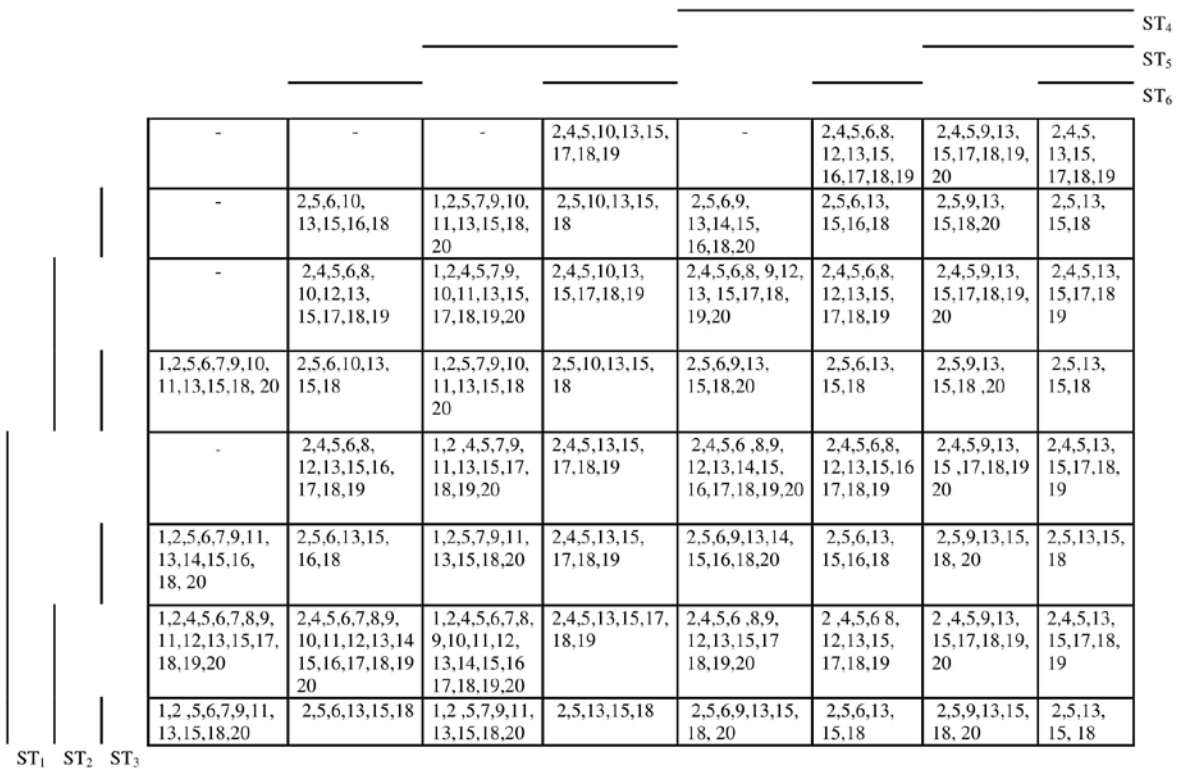


Figure 5: Diagram of project overlap by parameters performers, stakeholders

The analysis of the positional diagram reveals a conflict over the involvement of performers in projects. When redistributing resources corresponding to the configuration of the positional diagram cells: $ST_1 = 1$, $ST_6 = 1$, it is necessary to take into account the interest of stakeholders in a specific resource and to carry out the redistribution only upon agreement with the stakeholders (Table 6). If other stakeholders are involved in the redistribution, it is possible to smooth out the conflict, since they, having a positive level of loyalty towards ST_1 and ST_6 , can positively influence the position of the first and sixth stakeholders.

Table 6Performer of works at $ST_1=1, ST_6=1$

Stakeholder configuration	Performers
{1, 0, 0, 0, 0, 1}	Q ₂ Q ₄ Q ₅ Q ₆ Q ₈ Q ₁₂ Q ₁₃ Q ₁₅ Q ₁₆ Q ₁₇ Q ₁₈ Q ₁₉
{1, 0, 0, 0, 1, 1}	Q ₂ Q ₄ Q ₅ Q ₁₃ Q ₁₅ Q ₁₇ Q ₁₈ Q ₁₉
{1, 0, 0, 1,0, 1}	Q ₂ Q ₄ Q ₅ Q ₆ Q ₈ Q ₁₂ Q ₁₃ Q ₁₅ Q ₁₆ Q ₁₇ Q ₁₈ Q ₁₉
{1, 0, 0, 1, 1, 1}	Q ₂ Q ₄ Q ₅ Q ₁₃ Q ₁₅ Q ₁₇ Q ₁₈ Q ₁₉
{1, 0, 1, 0, 0, 1}	Q ₂ Q ₅ Q ₆ Q ₁₃ Q ₁₅ Q ₁₆ Q ₁₈
{1, 0, 1, 0, 1, 1}	Q ₂ Q ₄ Q ₅ Q ₁₃ Q ₁₅ Q ₁₇ Q ₁₈ Q ₁₉
{1, 0, 1, 1, 0, 1}	Q ₂ Q ₅ Q ₆ Q ₁₃ Q ₁₅ Q ₁₆ Q ₁₈
{1, 0, 1, 1, 1, 1}	Q ₂ Q ₅ Q ₁₃ Q ₁₅ Q ₁₈
{1, 1, 0, 0, 0, 1}	Q ₂ Q ₄ Q ₅ Q ₆ Q ₇ Q ₈ Q ₉ Q ₁₀ Q ₁₁ Q ₁₂ Q ₁₃ Q ₁₄ Q ₁₅ Q ₁₆ Q ₁₇ Q ₁₈ Q ₁₉ Q ₂₀
{1, 1, 0, 0, 1, 1}	Q ₂ Q ₄ Q ₅ Q ₁₃ Q ₁₅ Q ₁₇ Q ₁₈ Q ₁₉
{1, 1, 0, 1, 0, 1}	Q ₂ Q ₄ Q ₅ Q ₆ Q ₈ Q ₁₂ Q ₁₃ Q ₁₅ Q ₁₇ Q ₁₈ Q ₁₉
{1, 1, 0, 1, 1, 1}	Q ₂ Q ₄ Q ₅ Q ₁₃ Q ₁₅ Q ₁₇ Q ₁₈ Q ₁₉
{1, 1, 1, 0, 0, 1}	Q ₂ Q ₅ Q ₆ Q ₁₃ Q ₁₅ Q ₁₈
{1, 1, 1, 0, 1, 1}	Q ₂ Q ₅ Q ₁₃ Q ₁₅ Q ₁₈
{1, 1, 1, 1, 0, 1}	Q ₂ Q ₅ Q ₆ Q ₁₃ Q ₁₅ Q ₁₈
{1, 1, 1, 1, 1, 1}	Q ₂ Q ₅ Q ₁₃ Q ₁₅ Q ₁₈

The most critical is the redistribution of resources for the configuration $ST = \{1, 0, 0, 0, 0, 1\}$, executors $q_2, q_4, q_5, q_6, q_8, q_{12}, q_{13}, q_{15}, q_{16}, q_{17}, q_{18}, q_{19}$, since this configuration of stakeholders does not include the involvement of other stakeholders. For the second and fourth stakeholders, conflicts do not arise, since there is no overlap of projects in which these stakeholders are involved. Thus, it is advisable to redistribute resources into the project, taking into account the results of the analysis of the involvement of human resources in the project portfolio.

5. Conclusion

The problems of planning a project with limited resources and planning a project with limited resources and limited multitasking are urgent problems that require the development of modern methods and approaches. At the same time, the dynamic change in customer requirements, the impact of the project environment, aggressive competition for key resources, the impact of social trends and the consequences of the COVID-19 pandemic lead to the need to constantly monitor the allocation of resources in a multi-project environment and ensure flexible reallocation of resources between projects throughout the entire life cycle. portfolio of projects.

Methods for analyzing the attraction of human resources to a project portfolio are proposed, based on the use of logical-combinatorial and stakeholder-oriented approaches in managing teams of a multi-project organization, which, in contrast to the existing ones, carries out resource analysis of projects, which makes it possible to increase the efficiency of using human resources in the project portfolio. A promising direction is software for automating the analysis of the provision of human resources to projects in a multi-project environment.

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