Models of Harmonization of Interests and Conflict Resolution of Project Stakeholders

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Abstract. The subject of the study is the stakeholder management processes of the project. The purpose of the work is to develop models for making optimal decisions regarding the composition of the stakeholders, supporting the project goals and choosing behavioral strategies for other stakeholders. The article deals with the essence of stakeholder management processes in the project. The main factors that determine the stakeholder management processes are systematized. On the basis of matrix projections, a system cube of interaction of goals and interests at the stages of the project life cycle was formed. Mathematical optimization models have been formulated to solve the problems of forming multiple stakeholders, which harmonize with the project goals and maximize their involvement in communication actions. The use of game theory to make decisions about possible stakeholder conflicts is justified. The game optimization problem of setting a compromise price for resources with multiple suppliers is formulated.

Keywords: project management, stakeholders, harmonization of interests, matrix models, game theory

1 Introduction

Over time, a value-oriented approach to project management is becoming more widespread [1]. It is important to balance the interests of stakeholders (stakeholders) and to align them with the goals of the project over its lifecycle [2].

Some projects, due to their complexity and industry specificity (e.g. transport, infrastructure), require the active involvement and involvement of several stakeholder groups of the project [3]. Often, information is exchanged between the customer, user (public) and the developer as part of a collaborative process that enables greater involvement and stakeholder satisfaction. Regular interaction of the project team with stakeholders reduces the risk of the project, contributes to the early life cycle changes, reducing time consuming and increasing the likelihood of its successful implementation [4, 5].

2 Setting Objectives

A standardized methodology for managing P2M innovation projects and programs focuses on strategic aspects of project management, which in turn create, refine and accumulate values [4]. The use of modern information technology project management enables [6 - 8]:

- to increase stakeholder value networks and balance the profitability of projects,
- to increase stakeholder satisfaction with project results,
- to ensure reliability and reduce the risks of related business processes.

The application of flexible methodologies enables project management to be managed more efficiently, depending on their resources and volume, providing the required level of quality and satisfaction for the stakeholders. [9].

The Project Management Body of Knowledge (PMBOK® Guide) pays much attention to stakeholder management [10]. For example, with regard to internal stakeholders, the notion of "organizational groups" is introduced - internal stakeholders who interact with the project team. As a result, there is a significant degree of interaction between the various business elements of the organizations and the project team as they work together to achieve the goals of the project.

Among the methods that allow the formation and analysis of the characteristics of stakeholder groups, one can distinguish between the matrix of power, interest, and influence characteristics. Stakeholders are grouped based on their level of authority, interest in project results, ability to influence the outcome, and ability to cause changes in the planning or implementation of project work. This method is well proven for small projects or projects with a complex stakeholder relationship with the project team [11, 12].

Another method that is used for complex project relationships is the stakeholder analysis method that involves building a feature model (Mitchell model) [13]. This model describes stakeholder groups based on an assessment of their level of authority - level of authority or ability to influence the end result of a project, urgency - need for rapid communication, and legitimacy - need and degree of involvement. Based on this model, you can also prioritize (determine relative importance) stakeholders.

In recent years, the value of game theory has increased significantly in many fields of science, including in project management practice [14, 15]. But the apparatus of game theory-based stakeholder decision-making is still underdeveloped. Therefore, the purpose of the work is to develop models for making optimal decisions regarding the composition of stakeholders that support the project objectives and the choice of behavior strategies for other stakeholders (which are not always loyal to changes in the project).

Tasks solved in the work:

- analysis of stakeholder management processes,
- developing stakeholder interests harmonization models with project goals,
- choice of stakeholder conflict resolution game models.

3 Analysis of Project Stakeholder Management Processes

Stakeholders, in other words, interested parties, are the parties that are directly involved in the implementation of the project at different or all stages of the life cycle and directly affect it. Stakeholders can include the public, civil servants, owners, managers, investors and all other actors directly influencing and participating in the life cycle of the project.

The community and the interests of the inhabitants of the region have a significant impact on the project, from the design phase and throughout the time of exploitation to the stage of project closure. Some studies and organizations even believe that a proper assessment of the role of society and determining the main characteristics of a society as a stakeholder can play a key role in the implementation of a transport project. Significant public participation in project management also requires significant transparency of project processes and documentation to be disseminated to public resources.

Politicians who embody the side of the state also play a significant role at all stages of the project. In addition to financial issues, civil servants can also resolve public-conflict issues as well as control information channels about the project's progress to the general public. The state may also be responsible for obtaining different types of permits. Obtaining permits is one of the most likely risks of a transport project, which is why the role of state bodies in this matter is difficult to overestimate. And political will can significantly reduce political and some economic risks, which greatly accelerates the process of project implementation.

In the world classification it is used to allocate the project owner as a separate stakeholder.

Stakeholders may also include different supervisory authorities that are related both to the investor or the contractor, that is, those who control the quality of the work, as well as various organizations at the request of the state that control environmental norms and norms of law.

Also, an investor, a project team leader, a contractor with their own subcontractors and a supplier participate in the implementation of the project.

Project stakeholder management processes include [10]:

- identification of project stakeholders;
- involvement of project team members in engaging with stakeholder communications;
- stakeholder adjustments to the risks of the project;
- communication with stakeholders;
- use of value (both positive and negative) involvement and communication stakeholder interest.

Positive value can be based on the benefits of stakeholder support that have a significant impact on certain stages of the project life cycle. Negative value can be obtained by measuring the real costs (losses) of non-productive stakeholder engagement.

Information that can be attributed to stakeholders in a particular group with a common interest is: basic requirements, expectations, opportunities to influence the project deliverables, phase of the project lifecycle, when the stakeholder has the greatest impact [16].

Following the identification of stakeholders and their analysis, a baseline stakeholder engagement plan is developed and updated at project life cycle stages to reflect emerging changes. The following information should be taken into account when drawing up (and adjusting) the plan [10]:

- the culture, political environment and leadership model of the organization (stakeholders);
- administration policies;
- stakeholder propensity to take risks;
- established communication channels;
- global, regional or local practices or practices;
- geographical distribution of objects and resources.

The stakeholder engagement plan identifies the management strategies and actions required to effectively engage and secure stakeholder communications. Implementation of this plan is possible in the absence of conflicts of interest or in the quick reaching of compromise solutions.

Stakeholder identification and engagement processes are iterative. Stakeholder interests and priorities may change at different stages of the life cycle. This is due to the fact that one stakeholder ends up participating in some of the project's work, and new stakeholders fill up the stakeholder groups.

Agreed stakeholder communication strategies are taken into account when drawing up a project communication management plan [17]. The distribution of roles and areas of responsibility of stakeholders is also taken into account in the project's resource management plan. In stakeholder management processes, it is necessary to make optimal decisions when negotiating with different organizations and influencing them on the part of the project team.

Based on the above, it is possible to make a matrix of factors that influence the stakeholder management processes (Table 1).

Table 1. Key factors that determine stakeholder management processes

Stages of stakeholder management	Project's aspects			
	Subjective factors (internal stakeholder environment)	Objective factors (external environment of the project)	Stakeholder communication	Project risks
Stakeholder identification	- requirements - expectations	impact on project results	phases of the life cycle	harmonization of goals
Initial stakeholder engagement plan	- culture, - organization leadership model, - administration policies	- political environment, - global, regional or local practices	communication channels	attitude to risk
Stakeholder management plan	- role distribution, - resource management	change of conditions of realization of works	coordination of strategies	areas of responsibility

The interests of these groups may be contradictory and may not be consistent with the objectives of the project at all stages of the life cycle. Therefore, the task of bal-

ancing the interests of different groups and harmonizing interests with the goals of the project arises.

In the IT sphere, a special recruiting procedure is used to select the project contractors that best meet its objectives. For example, headhunting is a method of selecting rare, key and highly professional specialists with unique competencies (and interests). The application of such technology provides accurate consideration of the project needs and is carried out through direct contact with a potential employee or through networking. It is worth noting that networking is used when the project manager knows which people are irrationally attracted to a specific workplace and at what workplace these people work, but believes that they will not be able to hold effective negotiations with these candidates, so the recruiting agency engages and finds the right candidate.

The main difference between headhunting and standard recruitment technology is that headhunting provides the client with a range of additional consulting and information services. However, the guarantee of a high likelihood of matching a specialist to the project's goals is associated with high financial, time and labor costs. Another modern technology of selecting specialists is recruitment, which involves recruitment taking into account the real features of the workplace and the business, personal qualities of the candidate, and is carried out with the help of an existing pool of candidates.

4 Stakeholder Interests' Harmonization Model

The process of aligning (harmonizing) the interests of stakeholders with project goals include the following steps [13]:

- identifying stakeholder interests of different groups at different stages of the project life cycle;
- determining the importance of each stakeholder in terms of external, internal factors of the project and in view of the project objectives;
- determining the degree of stakeholder influence in terms of their own characteristics (power, legality and urgency);
- calculating the overall balance of stakeholder interests based on the compliance matrix;
- determining that the project objectives are in line with the interests of stakeholders;
- identifying stakeholder loyalty groups to maximize involvement through active communications.

For the formalized presentation of the last two steps, we apply a systematic approach and mathematical optimization models.

The following notations are introduced:

$S = \{s_i\}, i = \overline{1,n}$ - the total set of project stakeholders;

$C = \{c_j\}, \ j = \overline{1,p}$ - set of partial goals of the project;

$G = \{g_k\}, k = \overline{1,m}$ - set of stages of the project lifecycle.

The degree to which the stakeholder interests are aligned with the project objectives is characterized by magnitudes (Table 2)

$$Y = \left\| y_{ij} \right\|,\ i = \overline{1,n}\ ,\ j = \overline{1,p}\ ,$$

forming a set of elements of the matrix and taking values $y_{ij} \in [-1,1]$. Negative values make sense of the mismatch of project interests and goals.

Table 2. Matrix accordance with the interests of the stakeholders of the project objectives

	S_1	S_2	…	S_n
C_1	y_{11}	y_{12}	…	y_{1n}
C_2	y_{21}	y_{22}	…	y_{2n}
…	…		…	…
C_p	y_{p1}	y_{p2}	…	y_{pn}

We denote the relevance of each goal of the project lifecycle by a matrix of values

$$V = \left\| v_{jk} \right\|,\ j = \overline{1,p}\ ,\ k = \overline{1,m}\ ,$$

which form a Boolean matrix, that is, take a value of 1 (the target must be reached at this stage of the LC) or 0 (the target does not belong to this stage of the LC).

The degree of power (or participation) of the stakeholders in the individual stages of the LC is denoted by

$$W = \left\| w_{ik} \right\|,\ i = \overline{1,n}\ ,\ k = \overline{1,m}\ ,$$

which take on values $w_{ik} \in [0,1]$

Thus, we have a system of three matrices that can be represented graphically as a system cube (Fig. 1).

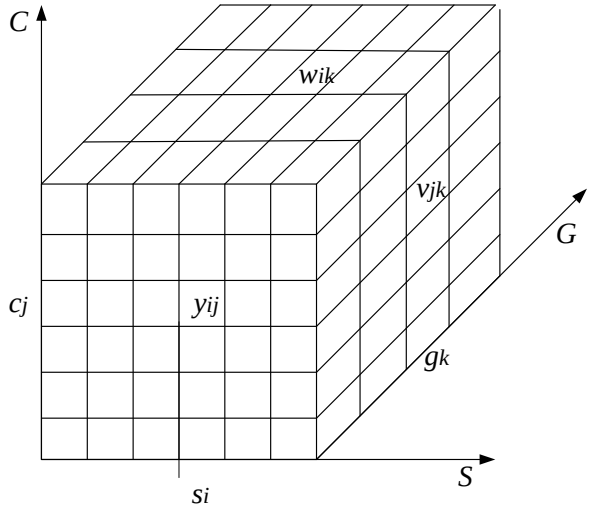

Fig. 1. System cube of interaction of goals and interests in the stages of the LC

The output of these matrices is the coefficient of harmonization (B), that is, the magnitude that characterizes the degree of harmonization of stakeholder interests and project goals during the LC stages. This factor takes values in the range from -1 to 1 and should be maximized to ensure project goals are met.

Thus, two optimization tasks can be formulated to manage a stakeholder harmonization project.

1) If the management task is to maximize the involvement of the individual (already selected) stakeholder in the project, then the problem of finding such values w_{ik} that give the maximum value to the objective function

$$B^{(1)}{}_{\max} = \sum_{i=1}^{n}\sum_{j=1}^{p}\sum_{k=1}^{m} y_{ij} v_{jk} w_{ik} \qquad (1)$$

with restrictions $0 \le w_{ik} \le 1$.

This problem is represented by a linear optimization model and is solved by the simplex method.

2) If management task is to select the most interested stakeholder from a given set for intensive communication with him during the project implementation, then the variables are

$$s_i = \begin{cases} 0 & \text{if the stakeholder is not included to a group} \\ 1 & \text{if the stakeholder is included to the group} \end{cases}.$$

The task is to search for a vector of values s_i that gives the maximum value to the target function

$$B^{(2)}{}_{\max} = \sum_{i=1}^{n}\sum_{j=1}^{p}\sum_{k=1}^{m} y_{ij} v_{jk} w_{ik} s_i \ . \qquad (2)$$

This problem is solved by Boolean programming methods.

Let's consider the issue of coordinating the performers and stakeholders interests in the implementation of the IT project lifecycle phases. The goals of IT projects can be divided into three groups:

1) development of software and information systems. Includes goals (second level - set C): development of software, modules, applications and information systems for consumer needs;
2) sale and maintenance of software and information systems. Sale of ready-made software (software) and information systems, with their subsequent support and support;
3) IT audit and IT consulting. IT audit (audit of information systems) provides independent verification of the efficiency of use and application of information technologies in the work.

Let's consider the specifics of the first group of projects. The selection of performers for these projects should be done in accordance with the objectives of the second tier.

In this case, the following phases of the program process (multiple G) are taken into account:

- creation of software specification;
- software development;

- software testing (includes validation and verification);
- development or evolution of software (software evolution).

The interests of software engineering professionals correspond to the basic areas of knowledge (set S):

- Software requirements;
- Software design;
- Software construction;
- Software testing;
- Software maintenance;
- Software configuration management;
- Software engineering management;
- Software engineering process;
- Software engineering tools and methods;
- Software quality.

Using these sets, you can build a matrix of interrelation of interests, phases of the project and its goals.

5 A Game Model Of Stakeholder Conflict Resolution

To effectively resolve conflicts of interest in IT management, the following competencies and communication technologies should be applied:

1) knowledge of the specifics of the IT market;
2) knowledge of the features of the IT professions (ERP programmer, HTML layout engineer, database administrator, site administrator, analyst, business analyst, web designer, web programmer, layout engineer, ERP systems consultant, content manager, manager Sales Manager, Internet Project Manager, Bridge Programmer, 1C Programmer, Website Editor, System Administrator, System Analyst, Information Security Specialist, Computer Games Writer, Software Tester) to understand what the project is working on a specialist is needed;
3) recruitment company planning;
4) possession of search and selection methods (direct search, head hunting);
5) application of methods of remote assessment and motivation of person-lu;
6) conducting interviews with the use of express analyzes and tests;
7) application of modern methods of adaptation of personnel for elimination of their career in IT;
8) presenting companies and projects to arouse interest from potential employees;
9) making decisions on rejections and objections, difficult clients and unusual situations.

In the project environment, there are inevitable conflicts between project team managers and stakeholders. The success of project managers often depends on their ability to resolve conflicts [18].

Conflicts can be caused by scarcity of resources (labor, material, financial, time), priorities for work schedules and other reasons. In the presence of different opinions, the project team members are responsible for the decision. The possibility of conflicts should be anticipated and resolved at an early stage and, as a rule, with the cooperation of all parties.

Here are the factors that influence the methods of conflict resolution:

- the importance and intensity of the conflict;
- limited time available to resolve the conflict;
- the relative power of the stakeholders involved in the conflict;
- the importance of supporting effective communications;
- motivation to resolve the conflict in the long or short term.

There are five basic methods used to resolve conflicts, the essence of which is presented in Table 2.

The last three categories of conflict (compromise, coercion, and cooperation) can be described using game theory.

To describe the game, you must first identify its participants. But in stakeholder management games, it is difficult to identify all players (current or potential). Therefore, the most important conflicts of interest for a particular project should be described.

Table. 2. Conflict resolution in terms of game theory

Stakeholder strategy	Project team strategy	The essence of the decision	Win or lose of the parties
Evasion	Avoidance	Deviation from actual or potential conflict situation, postponement of the solution to a later date	Temporary equilibrium
Adaptation	Smoothing	Underline common positions instead of areas of contradiction, abandoning one's position in favor of the needs of other	Losing one side
Compromise	Settlement	finding solutions that will be somewhat satisfactory for all parties	No winners
Forcing	Acceptance	Lobbying someone's point of view at the expense of others	One wins, others loses
Collaboration	Solving problems	Combining different perspectives and perspectives, willingness to cooperate and open dialogue	Both sides win

Games usually cover several periods during which players perform sequential or simultaneous actions. Actions can be related to prices, purchase volumes, or costs of work, etc. The strategies chosen at each stage determine each player's "payments", which can be expressed in value or any other way of measuring the amount of resources.

Consider setting the problem of conflict of interest in the interaction of the resource manager and suppliers, the result of which is a decision to compromise on resource prices [19]. We formulate an optimization problem in the form of a game of two people with opposite interests.

Let us denote:

$U = (u_1, u_2, \ldots, u_n)$ - vector of mixed resource manager strategy (player A) for vendor selection u_i;

$Z = (z_1, z_2, \ldots, z_m)$ - the vector of the mixed strategy of the supplier (player B) to choose the resources to be supplied z_j.

The constituent strategies are subject to the condition

$$\sum_{i=1}^{m} u_i = \sum_{j=1}^{n} z_j = 1 .. \tag{3}$$

where $u_i \geq 0$ $(i = 1, \ldots, m)$, $z_j \geq 0$ $(j = 1, \ldots, n)$.

The price of the game:

$$\nu = \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij} u_i^o z_j^o , \tag{4}$$

where a_{ij} – price for the *i*-th resource from the *j*-th supplier,

u^o – optimal resource manager strategy (likelihood of supplier selection),

z^o - optimal vendor strategy.

In order for the value ν to be the price of the game, but u^o and z^o optimal strategies, the following inequalities must be sufficiently fulfilled:

$$\begin{cases} \sum_{i=1}^{m} a_{ij} u_i^o \geq \nu, \ (j = 1, \ldots, n), \\ \sum_{j=1}^{n} a_{ij} z_j^o \leq \nu, \ (i = 1, \ldots, m), \\ z_j^o = \dfrac{1}{m}, \ (j = 1, \ldots, n), \\ \sum U_i^o = 1 \end{cases} \tag{5}$$

Using game theory models, you can determine the best solutions for pricing new products, plans for the development of new markets, enterprise cooperation, division of project performance, etc. Thus, the theory of game theory can be applied to all kinds of decisions, if their decision-making is influenced by other actors [20].

Conclusion

This paper addresses the issues of stakeholder management of the project. The application of mathematical models is proposed to solve the problems of stakeholder consistency assessment and conflict situations in the project implementation.

The essence of the process of stakeholder management of the project is considered: identification, planning, involvement of stakeholders. The main factors that

determine the stakeholder management processes are systematized. Based on the matrix projections “interests - project goals”, “project goals - life cycle stages”, “life cycle stages - stakeholder interests”, a systematic cube of interaction of goals and interests at the project life cycle stages is formed. Mathematical optimization models are formulated to solve the problems of forming multiple stakeholders, which harmonize with the project goals and maximize their involvement in communication actions. The areas of activity of IT companies, the main types of projects, development phases and the fields of knowledge that are involved in the IT sphere are considered.

The issues of the project Manager's competence in recruiting personnel in the it sphere for solving internal conflicts are considered. The application of game theory is justified for deciding on possible stakeholder conflicts. The optimization problem of determining the compromise price for resources with multiple suppliers is formulated.

Further research is being conducted towards developing a dynamic stakeholder structure model to plan effective stakeholder engagement in a virtual IT-project management office.

References

1. Busheyev, S., Busheyeva, N.: Formation of value in the activity of project-oriented organizations. Project management and production development 3 (31), 5–14 (2009).
2. Guseva, Yu., Sidorenko, M., Chumachenko, I.: Management of stakeholders of educational projects. Bulletin of NTU KPI 2(1224), 8-11 (2016).
3. Gaikov, A., Evseyeva, O., Baranov, O., Baranov, V.: Intelligent transport systems in Ukraine. Bulletin of NTU KPI 9(1052), 106-112 (2014).
4. Pasichnyk, V., Kunanets, N., Veretennikova, N., Rzheuskyi, A., Nazaruk, M.: Simulation of the social communication system in projects of smart cities. In proceedings of the 14th International conference on Computer sciences and Information technologies (CSIT 2019), Lviv, Ukraine, pp. 93–98 (2019).
5. Danchuk, V., Lemeshko, Y., Lemeshko, T.: Concept of system-synergistic approach in project management. Bulletin of the National Transport University 26(2), 128-133 (2012).
6. **Помилка! Закладку не визначено.**.
7. Tafti, S., Jahani, M., Emami, S.: Explaining Evolutionary Trend of Strategic Planning from Traditional Economy to Innovation Economy. Procedia-Social and Behavioral Sciences 58, 56-65 (2012), https://doi.org/10.1016/j.sbspro.2012.09.978.
8. Mukhin, V., Kuchuk, N., Kosenko, N., Artiukh, R., Yelizyeva, A., Maleyeva, O. etc.: Decomposition Method for Synthesizing the Computer System Architecture. In: Advances in Computer Science for Engineering and Education II. ICCSEEA 2019. Advances in Intelligent Systems and Computing, vol. 938, 289–300 (2019). Springer, Cham. DOI https://doi.org/10.1007/978-3-030-16621-2_27.
9. Macheridis, N.: Agility in entrepreneurial projects. Lund Institute of Economic Research, Lund University (2009).
10. A guide to the project management body of knowledge (PMBoK guide), Sixth edition, USA: PMI Inc. (2017).
11. Kadykova, I., Larina, S., Chumachenko, I.: Method for determining and adjusting the expectations of stakeholders in the context of strategic management of the project program. Innovative Technologies and Scientific Solutions for Industries 1 (7), 51–58 (2019). DOI: https://doi.org/10.30837/2522-9818.2019.7.051.

12. Kadykova, I., Larina, S., Chumachenko, I.: Management of internal stakeholders in the implementation of the program strategy. Managing the development of folding systems, 28, 68-74 (2016).
13. Lytvynenko, D., Malyeyeva, O.: A comprehensive method of balancing and harmonizing the interests of stakeholders in transport systems development projects. Innovative Technologies and Scientific Solutions for Industries 3(9), 91–98 (2019). DOI: https://doi.org/10.30837/2522-9818.2019.9.091.
14. Aliahmadi, A., Sadjadi, S., Jafari-Eskandari, M.: Design a new intelligence expert decision making using game theory and fuzzy AHP to risk management in design, construction, and operation of tunnel projects. The International Journal of Advanced Manufacturing Technology, vol. 53, issue 5–8, 789–798 (2011). DOI: https://doi.org/10.1007/s00170-010-2852-7.
15. Li, Y., Li, J.: Knowledge sharing in communities of practice: A game theoretic analysis. European Journal of Operational Research, 207 (2), 1052-1064 (2013). https://doi.org/10.1016/j.ejor.2010.05.033.
16. Bomba, A., Kunanets, N., Nazaruk, M., Pasichnyk, V., Veretennikova, N.: Model of the data analysis process to determine the person's professional inclinations and abilities. Advances in computer science for engineering and education 938, 482–492 (2019).
17. Smachilo, V., Kolmakova, O., Kolomiets, Yu.: The procedure for the analyzing stakeholder holdings. Economy and suspension, 12, 348-353 (2017), http://economyandsociety.in.ua/journal-12/19-stati-12/1334-smachilo-v-v-kolmakova-o-m-kolomiets-yu-v.
18. Kravets, P., Pasichnyk, V., Kunanets, N., Veretennikova, N.: Game method of event synchronization in multiagent systems. Advances in computer science for engineering and education 938, 378–387 (2019).
19. Malyeyeva, O., Yelizeva A.: Information technology of logistic purchases control in view the product life cycle. Radioelectronic and Computer Systems, 1(60), 119 – 126 (2013).
20. Sharma, R., Bhattacharya, S.: Knowledge dilemmas within organizations: Resolutions from game theory. Knowledge-Based Systems, 45, 100-113 (2013). https://doi.org/10.1016/j.knosys.2013.02.011.