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DEVELOPMENT OF PROCESSES FOR MONITORING PROGRAM IMPLEMENTATION IN STAKEHOLDER-ORIENTED RESOURCE MANAGEMENT

Abstract. Accounting for the influence of stakeholders on human resource management processes enhances a program's feasibility and ensures the sustainable development of management processes. The **object** of this research is the resource management processes within programs. The research **subject** is the models, methods, and processes of stakeholder-oriented management of program resource provisioning. The study **aims** to develop a set of models for stakeholder-oriented management of program resource provisioning. The paper addresses the following **tasks**: to develop a conceptual model of stakeholder-oriented management of program resource provisioning; to develop an aggregated model of stakeholder-oriented management of program resource provisioning; and to simulate the process of stakeholder-oriented formulation of resource requirements for programs. The research **methodology** is based on applying process-based, project-based, and program-based approaches to management, combinatorial analysis, and a configuration-based approach to solving the problem of resource allocation in a multi-project environment. The **results** of the study include the development of a set of models for stakeholder-oriented management of program resource provisioning, namely: a conceptual model of stakeholder-oriented management of program resource provisioning; an aggregated model of stakeholder-oriented management of program resource provisioning; and a model of the process for stakeholder-oriented formulation of program resource requirements. The scientific **novelty** of the proposed results lies in developing a set of models whose application will contribute to advancing resource provisioning management processes in programs. The stakeholder-oriented management of program resource provisioning was modelled. The application of the developed models was considered using a test case. **Conclusions**: the developed stakeholder-oriented models for managing program resource provisioning enable the formalization of the resource management process while considering the requirements for both project and program team composition. The generation of resource provisioning configurations allows for selecting an option that meets requirements regarding functionality, redundancy, cost, composition, and redistributive capability. For the given example, the cost of implementing configurations was reduced by a factor of 1.06-1.24. The number of resource allocation options within the program ranges from 18 to 46,230, allowing the selection of a configuration that enables resource redistribution among program projects based on a donor–acceptor interaction model without additional resources. A promising direction for future research is developing an information system for managing program resource provisioning.

Keywords: project portfolio management; stakeholders; human resources; resource provision of project offices; program implementation monitoring processes; project team; configuration.

Introduction

Problem Statement The implementation of recovery programs requires modern management approaches that enable achieving planned outcomes with defined performance indicators. The influence of a multi-project environment on the ability to form resource provisioning may lead to the emergence of negative and positive risks during the execution of a recovery program.

A formalized representation of resource requirements that accounts for stakeholders' interests and influence on resource management processes will facilitate the formation of a coherent resource profile for the program.

The complex nature of programs imposes additional requirements on the organization of integration processes and communication and coordination mechanisms. In forming a program's resource provisioning, it is essential to consider stakeholder engagement management, as stakeholders can become a source of requirements for program resource provisioning and significantly impact the temporal and financial parameters of program implementation.

Since resource provisioning is directly related to cost and schedule management within the program's projects, developing a methodological framework for stakeholder-oriented resource management in programs is a pressing task.

Analysis of Recent Research. The development of modern society is associated with the need to address the issue of sustainable development of transformation programs, which are implemented in an aggressive BANI environment [1].

Priority areas for recovery programs include the restoration of territories, transport and municipal infrastructure, regional development and decentralization, digitalization, public administration reforms, and anti-corruption efforts.

Program lifecycle management entails identifying projects implemented within the program and establishing interconnections among elements of the multi-project environment [2].

Table 1 presents an analysis of approaches to

resource allocation depending on the type of program and implementation conditions.

Cybersecurity and data protection issues require additional attention due to the implementation of programs by geographically distributed teams operating in various physical locations. Preventing resource leaks is also of critical importance.

Resource leaks, in the context of human resources, i.e., the leakage of confidential information through employees or challenges related to staff retention, are exacerbated by migration processes and significantly impact the sustainability of program resource management processes [3–5].

A classification of resource leaks and an analysis of their underlying causes are presented in Table 2.

Table 1 – **Approaches to Program Management**

Type of Program	Management Approaches	Examples
State Target Programs	Approved methodologies for monitoring, risk management, and budget optimization. Centralized program management with standardized approaches to program team formation.	State Target Program "Great Construction," State Target Program on Waste Management, etc.
International Programs	Management methodologies and approaches defined at the international level	World Bank Emergency Recovery Project, EIB Ukraine Solidarity Fund, Swiss Cooperation Programme, Japan International Cooperation Agency (JICA)
Sectoral Programs	Management approaches approved by the respective ministries and adapted based on the degree of centralized governance	Healthcare reform, education reform, "New Ukrainian School" Program

Table 2 – **Classification of resource leaks**

Type	Description of Resource Leaks	Cause	Mitigation Measures
Technical resource leaks	Data leakage due to technical errors	Memory leaks, File descriptor leaks, Handle leaks	Use of specialized hardware and software tools
Critical Knowledge Leakage	Data leakage through employees	Insider leaks, improper access	Improvement of information handling processes/ procedures, implementation of information security measures
Human Resource Leakage (Turnover)	Departure/resignation of key personnel	Staff retention issues, headhunting, migration, mobilization	Enhancement of HRM processes, functional redundancy planning

As discussed in [6], enhancing project team resilience involves psychological analysis of candidates, which is important for implementing programs in a BANI environment; however, it does not consider the necessity of ensuring redundancy.

The issue of developing a unified stakeholder interaction system for projects is addressed by Ahmed Abdulaziz Alnhari and Rizwan Qureshi [7]. The proposed approach enables the identification of stakeholders and their involvement in defining the management strategy.

Klaus-Rosińska, A., and Iwko, J. [8] emphasize the importance of engaging stakeholders in project management to ensure sustainable corporate governance. The recommendations proposed may be applied to increase the level of project maturity.

The involvement of stakeholders in human resource management processes contributes to improved project performance indicators [9].

Proposed approaches to resource allocation [10] employ expert-based methods based on economic-mathematical modeling and expert evaluations to distribute resources among international innovation projects. Research on project management under resource constraints, commonly known as the resource-constrained project scheduling problem (RCPSP), is presented in the works of Luo, J., Vanhoucke, M., Coelho, J., & Guo, W. [11], and Van Eynde, R., & Vanhoucke, M. [12].

The MPLIB1 and MPLIB2 datasets are used to evaluate the effectiveness of solutions to the multi-project resource-constrained project scheduling problem, allowing for consideration of the specifics of multi-project management [13].

The formation of geographically distributed project teams within programs should consider the strategies proposed in Resource Reallocation Strategies for Sustainable Efficiency Improvement [14]. For projects managing critical infrastructure, human resource management approaches must consider the requirements of Safety-Oriented Systems [15].

The reviewed resource allocation approaches are effective when applied to operational activities and the implementation of individual projects.

However, they are less effective in ensuring the sustainable development of recovery programs.

This is due to their failure to consider the influence of human resource management strategies on inter-project resource interaction within recovery program projects and the prioritization of resource provisioning for elements of the multi-project environment.

Identification of Previously Unresolved Aspects of the General Problem. Purpose and Objectives of the Study

Considering program resource management as a combination of the management processes of individual projects that constitute a program fails to account for the potential of donor–acceptor interaction between elements of the multi-project environment and limits the possibilities for resource reallocation during program implementation.

The object of the study is the resource management processes of programs.

The subject of the study is the models, methods, and processes of stakeholder-oriented resource management for programs.

The study aims to develop a set of models for stakeholder-oriented resource management in programs.

This article addresses the following objectives:

– to develop a conceptual model of stakeholder-oriented resource management for programs;

– to develop an aggregated model of stakeholder-oriented resource management for programs;

– to simulate the process of stakeholder-oriented formulation of program resource requirements.

The research **methodology** applies process-, project-, and program-based management approaches, combinatorial analysis, and configuration-based approaches to address resource allocation in a multi-project environment.

Research Results

Implementing recovery programs involving many stakeholders requires adherence to the principles of resource allocation among the projects within the program, as defined in regulatory documents and mandatory for execution.

In general terms, the process of resource provisioning can be represented as follows:

– n is the number of projects included in the program;

– m is the number of stakeholders interested in the processes of resource provisioning for the program and/or its individual projects;

– w_i is the number of functions performed within the i-th project;

– z_i is the number of resources (team members) involved in the i-th project;

– $P = \{P_1, \ldots, P_n\}$ is the set of projects that are part of the program;

– $A_i = \{A_{1,1}, \ldots, A_{i,wi}\}$ is the set of functions performed in the i-th project of the program;

– $St = \{St_1, St_2, \ldots, St_m\}$ is the set of stakeholders interested in the processes of resource provisioning for the program and/or its individual projects;

– $R_i = \{R_{1,1}, \ldots, R_{i,zi}\}$ is the set of resources involved in the i-th project of the program;

– $T_i = \{T_{1,1}, \ldots, T_{i,zi}\}$ is the set of redundancy coefficients for the resources involved in the i-th project of the program.

Mandatory resource requirements are defined by stakeholders involved in human resource management processes and are formalized as elements of the set of mandatory resource requirements:

– $REQ_{i,j}$ is resource requirements defined by the j-th stakeholder for the i-th project of the program;

– REQ_{pmt} is the set of resources forming the program management team;

– REQ^+ is the set of resources that must be included in the program team;

– REQ^- is the set of resources that must not be included in the program team;

– $REQ = \{ REQ_{pmt}, REQ^+, REQ^-, REQ_{i,j}\}$ is the set of program resources.

Fig. 1 presents the conceptual model of stakeholder-oriented resource management for programs.

Based on the program's life cycle analysis, stakeholders involved in human resource management processes are identified.

Stakeholders may be interested in managing human resources for the program or its individual projects.

Based on the analysis of stakeholder requirements $REQ_{i,j}$, generalized and harmonized resource requirements are formulated, encompassing both mandatory and optional components, which may be modified.

Project and program teams are formed from the organization's resource pool, and the program's resource provisioning is structured. Stakeholder interest and influence over management processes evolve throughout the program's implementation and require ongoing monitoring, followed by adjustments to the resource requirements.

Fig. 2 presents the aggregated model of stakeholder-oriented resource management for programs.

The inputs to the stakeholder-oriented resource management process for programs include:

– Program information;

– Register of potential stakeholders;

– Organizational assets;

– Functional and non-functional requirements;

– Potential conflict of interest.

The functional elements of the process (process activities) include:

– Program Life Cycle Analysis;

– Analysis of the impact of stakeholders on HRM processes;

– Formation of resource requirements for the program;

– Resource requirements coordination.

Executing the functional elements of the process develops harmonized resource requirements, which are then followed by the formation of the program's resource provisioning plan.

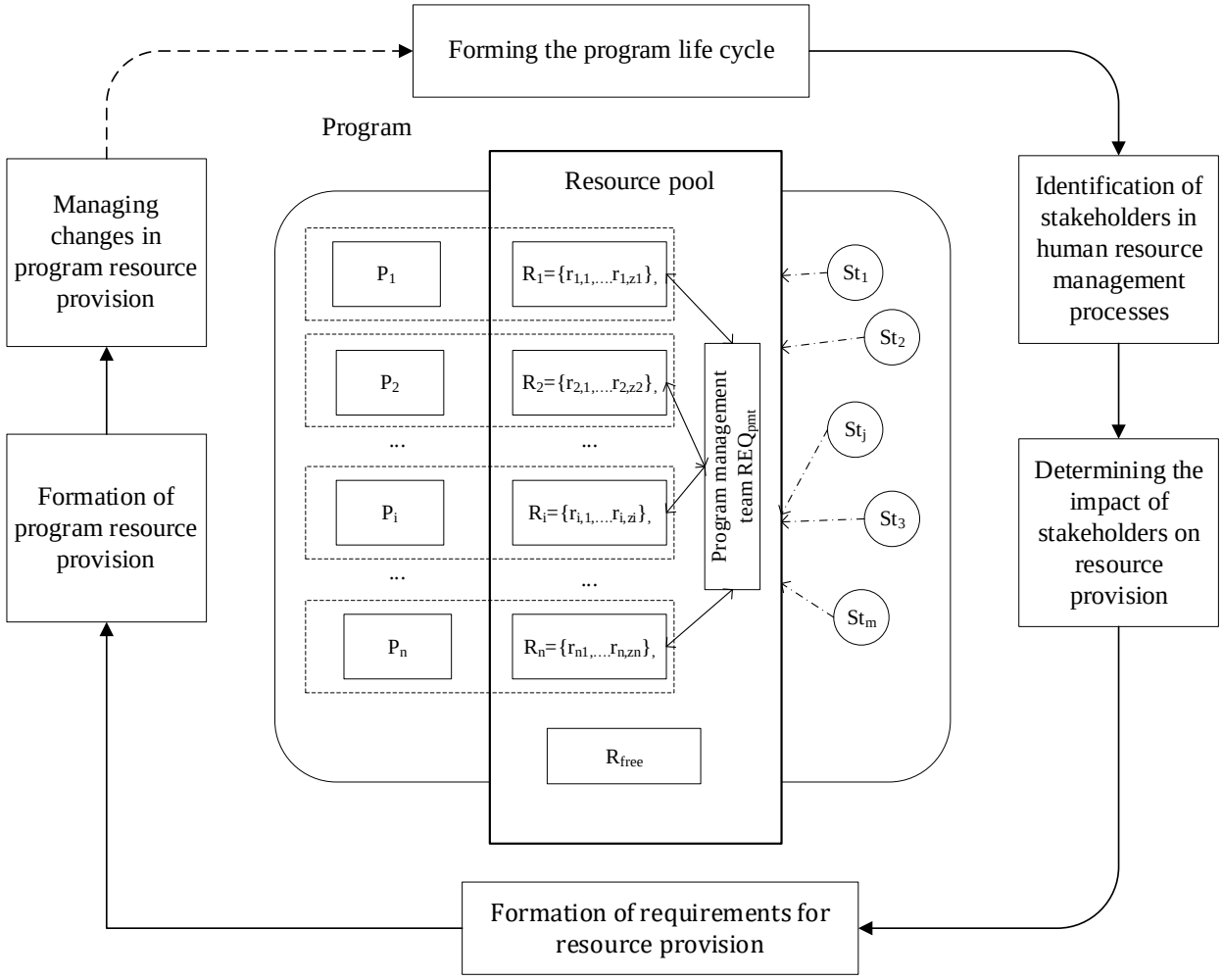

Fig. 1. Conceptual model
of stakeholder-oriented resource management for programs

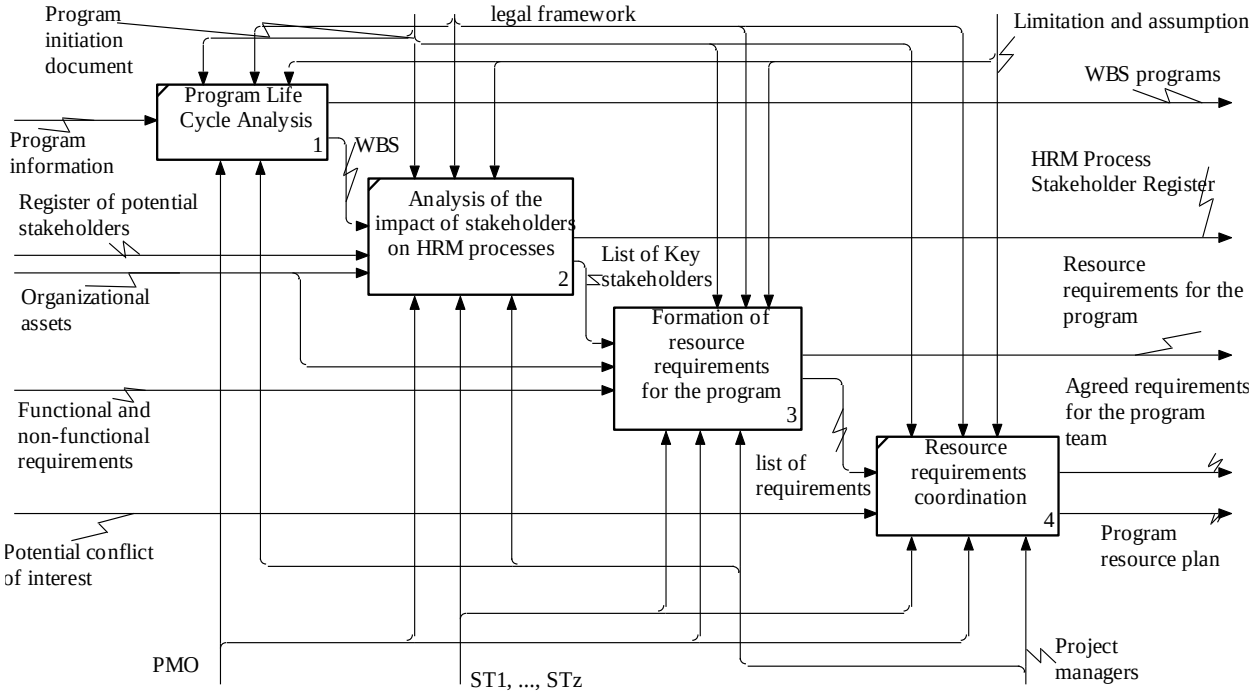

Fig. 2. Aggregated Model of Stakeholder-Oriented Management
of Program Resource Provisioning

The outputs of the stakeholder-oriented resource management process for programs include:

– WBS programs;
– HRM Process Stakeholder Register;
– Resource requirements for the program;
– Agreed requirements for the program team;
– Program resource plan.

The decomposition of the stakeholder-oriented process for forming resource requirements for programs is shown in Fig. 3.

The informational inputs to the stakeholder-oriented process for forming program resource requirements include:

– List of Key stakeholders;
– Organizational assets;
– Functional and non-functional requirements;
– Project triangle parameters;
– Pool resource information.

Applying formal transformations [16, 17] within the process's functional elements (Forming the REQ program (prerequisites), REQ project formation, defining requirement parameters, resource feasibility assessment) generates harmonized stakeholder-oriented resource requirements.

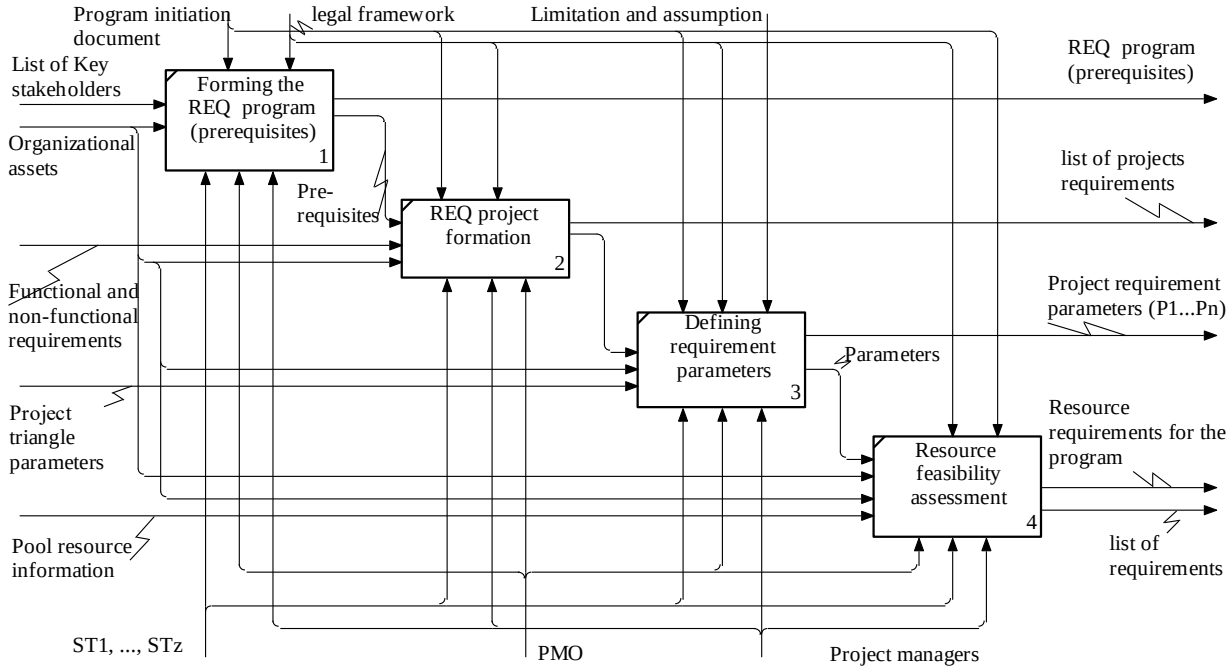

Fig. 3. Modeling of the stakeholder-oriented process for forming program resource requirements

The outputs of the stakeholder-oriented process for forming program resource requirements include:

– REQ program (prerequisites);
– list of projects requirements;
– Project requirement parameters (P_1...P_n);

Resource requirements for the program.

Let us consider an example of applying the developed models. The program team comprises three projects: P_1, P_2, P_3.

The aggregated functions are represented by $A = \{A_1, \ldots, A_9\}$, and their distribution across the projects is presented in Table 3.

Table 4 shows the program's modified responsibility matrix, which describes candidates' functional capability to perform functions and the cost of task execution.

Table 3 – **Distribution of aggregated functions across projects**

Project	**A_1**	**A_2**	**A_3**	**A_4**	**A_5**	**A_6**	**A_7**	**A_8**	**A_9**
P_1	-	-	+	+	+	+	+	-	-
P_2	+	-	-	+	-	-	+	+	+
P_3	+	+	+	-	+	-	-	-	-

Table 4 – **Modified Responsibility Matrix of the Program**

R\A	**A_1**	**A_2**	**A_3**	**A_4**	**A_5**	**A_6**	**A_7**	**A_8**	**A_9**
R_1	5	0	0	0	4	0	0	0	0
R_2	0	0	2	0	5	0	0	0	0
R_3	0	0	0	4	0	0	0	3	0
R_4	0	0	0	0	0	2	4	0	0
R_5	0	0	3	0	0	0	0	0	1
R_6	0	2	0	0	0	0	0	0	3
R_7	0	0	4	0	0	0	2	0	0
R_8	4	0	0	3	0	0	0	0	0
R_9	3	5	0	1	2	1	0	0	0
R_{10}	0	3	0	0	0	0	0	4	0
R_{11}	0	0	5	0	0	4	0	0	0
R_{12}	0	0	0	0	3	0	2	0	0
R_{13}	0	0	0	0	0	5	0	2	0
R_{14}	0	0	0	3	0	0	0	0	4
R_{15}	0	0	0	0	0	0	3	5	0
R_{16}	0	0	2	0	0	3	0	0	3
R_{17}	3	0	0	0	0	0	0	4	0
R_{18}	0	2	0	0	0	0	0	0	4
R_{19}	0	0	0	0	2	0	2	0	0
R_{20}	5	0	3	4	2	1	0	0	0
R_{21}	4	0	0	0	3	3	0	0	1

As a result of stakeholder analysis, the following resource requirements were formulated:

– resource q_9 must not be included in the program team due to a potential conflict of interest, while R_{20}, R_{21} remain in the resource pool as available reserve resources:

$$REQ^- = \{R_9, R_{20}, R_{21}\};$$

– resources R_1, R_5, R_7, R_8, R_{11}, R_{12}, R_{15}, R_{16}, R_{19} must be included in the program team:

$$REQ^+ = \{ R_1, R_5, R_7, R_8, R_{11}, R_{12}, R_{15}, R_{16}, R_{19}\}.$$

Requirements for resource redundancy coefficients in the program's projects:

$$T_1 = \{0, 0, 3, 2, 2, 2, 3, 0, 0\};$$

$$T_2 = \{2, 0, 0, 2, 0, 0, 4, 3, 4\};$$

$$T_3 = \{2, 2, 4, 0, 3, 0, 0, 0, 0\}.$$

As a result of the modeling, the defined program resource configurations are presented in Table 5.

An analysis of the configurations was conducted according to the following criteria:

– Number of resource allocation options within projects;

– Number of resource allocation options within the program;

– Minimum cost of the program configuration;

– Maximum cost of the program configuration.

The results of the analysis are presented in Table 6.

Table 5 – **Team resource configurations**

№	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_{10}	R_{11}	R_{12}	R_{13}	R_{14}	R_{15}	R_{16}	R_{17}	R_{18}	R_{19}
1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
2	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
4	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
6	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1
8	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 6 – **Configuration Analysis**

Configuration No.	Resource Allocation Configurations in the Project			Number of Resource Allocation Options in the Program	Minimum Cost of Program Configuration	Maximum Cost of Program Configuration
	P_1	P_2	P_3			
1	18	1	1	18	119	126
2	6	1	3	18	116	123
3	201	1	10	2010	111	130
4	67	23	30	46230	107	133
5	201	23	3	13869	112	133
6	24	2	30	1440	110	128
7	201	2	10	4020	108	130
8	18	2	30	1080	109	127

The conducted configuration analysis demonstrated that the first project possesses greater flexibility in terms of intra-project resource reallocation (ranging from 6 to 201 options depending on the configuration). In contrast, the fourth configuration offers the highest flexibility for inter-project resource reallocation at the program level (46,230 reallocation options).

According to the cost criterion, the fourth configuration yields the minimum program cost - 107; however, the maximum configuration cost reaches 133 under resource reallocation within projects. The application of resource allocation methods within program projects [16, 17] enables selecting a resource distribution option aligned with the prioritization of evaluation criteria.

Conclusions and Prospects for Further Development

The outcomes of this study include the development of a set of models for stakeholder-oriented management of program resource provisioning:

- a conceptual model of stakeholder-oriented

management of program resource provisioning;

- an aggregated model of stakeholder-oriented management of program resource provisioning;
- a model of the process for stakeholder-oriented formulation of program resource requirements.

Stakeholder-oriented resource management for programs was modelled.

The generation of resource provisioning configurations enables selecting an option that meets functionality, redundancy, cost, composition, and potential requirements for reallocation.

In the illustrative example, implementation costs were reduced by 1.06 to 1.24.

The number of resource allocation options within the program ranges from 18 to 46,230, allowing for selecting a configuration that supports resource reallocation among program projects based on donor–acceptor interaction without additional resources.

A promising direction for future development is creating an information system for managing program resource provisioning.

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Розвиток процесів моніторингу виконання програм при стейкхолдер - орієнтованому управлінню ресурсним забезпеченням

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Анотація. Актуальність. Урахування впливу стейкхолдерів на процеси управління людськими ресурсами дозволяє підвищити реалізуємість програми, забезпечуючи сталий розвиток процесів управління. **Об'єктом дослідження** є процеси управління ресурсами програм**. Предметом дослідження** є моделі, методи та процеси стейкхолдер-орієнтованого управління ресурсним забезпеченням програмам. Метою дослідження є розробка комплексу моделей стекйхолдер-орієнтованого управління ресурсним забезпеченням програми. У статті вирішуються завдання: розробити концептуальну модель стейкхолдер-орієнтованого управління ресурсним забезпеченням програми; розробити агреговану модель стейкхолдер-орієнтованого управління ресурсним забезпеченням програми; провести моделювання процесу стейкхолдер-орієнтованого формування вимог до ресурсів програм. **Методи** дослідження грунтуються на використанні процесного, проєктного та програмного підходу до управління та застосування комбінаторного аналізу та конфігураційного підходу для вирішення завдання розподілу ресурсів в мультипроєктному середовищі. **Результатами** роботи є розробка комплексу моделей стейкхолдер-орієнтованого управління ресурсним забезпеченням програми, а саме концептуальна модель стейкхолдер-орієнтованого управління ресурсним забезпеченням програми; агрегована модель стейкхолдер-орієнтованого управління ресурсним забезпеченням програми; модель процесу стейкхолдер-орієнтованого формування вимог до ресурсів програм. **Наукова новизна** запропонованих результатів полягає у розробці комплексу моделей, застосування якого сприятиме розвитку процесів управління ресурсним забезпеченням програм. Проведено моделювання стейкхолдер-орієнтованого управління ресурсним забезпеченням програми. Розглянуто застосування розроблених моделей для тестового прикладу. **Висновки:** розроблені моделі стейкхолдер-орієнтованого управління ресурсним забезпеченням дозволяють формалізувати процес управління ресурсним забезпеченням програм та враховувати вимоги як до складу команд проєктів, так і до складу команди програми. Генерація конфігурацій ресурсного забезпечення дозволить обрати з варіантів конфігурацію, що буде задовольняти вимогам щодо функціональності, резервування, вартості, складу, можливості перерозподілу. Для наведеного прикладу маємо зниження вартості реалізації конфігурацій в 1,06-1,24 рази. Кількість варіантів розподілу ресурсів в програмі знаходиться в діапазоні від 18 до 46230, що дозволяє обрати варіант ресурсного забезпечення програми, який дозволить проводити перерозподіл ресурсів в проектах програми на підставі донорно-акцепторної взаємодії без додаткового залучення ресурсів. Перспективним напрямком є створення інформаційної системи управління ресурсного забезпечення програм.

Ключові слова: управління портфелями проєктами; стейкхолдери; людські ресурси; ресурсне забезпечення проєктних офісів; процеси моніторингу виконання програм; команда проєкту; конфігурація.