IT Project Risk Management Model

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Abstract The chapter develops a knowledge-based IT project risk management model, which, unlike the existing ones, allows to take into account the dynamic and incremental way of executing IT projects, whereby the requirements for the information product and the ways of their realization are refined taking into account new information and experience gained. According to the model, the inputs to the risk management decision-making process should be stored in the knowledge base of the project, based on which the rules for the operation of the expert system are formulated.

It is suggested to use such components of the knowledge base as the risk database and the risk management knowledge repository. The Risk Database contains information on the tasks of IT project implementation, a concise description of problem situations, directions for solving the problem, quantification of risks, and the effectiveness of risk management measures. Updated risk database information, along with implicit knowledge (project stakeholder experience and qualifications, domain laws, etc.), is used to replenish the risk management knowledge repository to derive conclusions and patterns reflecting key project risk management policies.

Keywords IT project · Risk management · Buffer management · Scrum methodology · Risk management models

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1 Introduction

In the article, a knowledge-based Risk Management Models (RMM), which, unlike the existing, allows for considering a dynamic and incremental manner of an IT project's execution implying that requirements to the information product and the means of their fulfillment are adjusted based on new information and analysis of experience, is developed. According to the model, input data for the Risk Management (RM) decision-making process should be stored in the project's knowledge base, based on which the rules for the expert system are formulated.

IT projects are characterized by unclear initial customer requirements, constant changes related to intangible deliverables, a high level of complexity in terms of the use of intellectual and technological resources, and therefore uncertainty due to lack of information to make project management decisions. In addition, as numerous studies show, the implementation of IT projects often violates the deadlines, exceeds the budget and develops functionality that does not meet user requirements. A high level of uncertainty increases the risk of failure to achieve the intended results and threatens the successful implementation of the project.

Therefore, effective RM is a prerequisite for proper implementation of IT projects. In the context of project management, risk is associated with events that have certain implications for the project. Accordingly, RM includes processes that maximize the likelihood of achieving project goals by actively managing threats (risks that can adversely affect a project) and opportunities (risks that can positively impact it). These processes involve the use of specific RM methods and models, the choice of which depends on the particularities of the implementation of the IT project.

In the Sect. 3, it is advisable to consider the project as a system that can be in several states that meet a certain degree of risk to quantify the risks of an IT project. It is suggested to use Markov chains as a simulation tool to determine the probability of a system. It shows properties of potential states of IT project implementation, conceptual model of IT project RM and project implementation states.

In the Sect. 4, there is a such model, where inputs are based on information resources such as historical data, experience, stakeholder feedback, observations, forecasts and expert opinions.

2 Related Works

A wide range of RM issues is covered in the works of Kuznetsov et al. [1], Ramazanov et al. [2], Kaminski [3] and others. Some aspects of project management are covered in the works of Galitsyn and Suslov [4], Teslenko [5] and Danchenko [6]. The issues of project RM are devoted to the work of Rach [7], Sviridova [8] and Skopenko et al. [9]. Foreign experts in IT project management, such as Archibald [10], Boehm [11], Schwalbe [12], Demarko, and Lister [13], attach great importance to RM processes. Goldratt [14] and Leach [15]. Recent publications on the use of methods and models in IT project RM include the works of foreign authors Machak [16], Chotkirtikul [17], Jeon [18] and Kumar [19]. Among Ukrainian scholars, the works of Tesli [20], Babenko et al. [21, 22], Shorikov et al. [23], Rishniak [24, 25], Melnyk [26], Kolesnikov [27], Onishchenko [28], and others.

At the same time, insufficient attention is paid to the application of methods and models in RM, taking into account the particularities of the implementation of IT projects, in particular the methodologies used in the creation of software. In this regard, an urgent scientific and applied challenge is to improve the RM processes of information technology projects by developing appropriate methods and models that combine the benefits of different methodological approaches to software development.

3 Possible States of IT Project Implementation

In order to quantify the risks of an IT project, it is advisable to consider the project as a system that can be in several states that meet a certain degree of risk. In this regard, it is suggested to use Markov chains as a simulation tool to determine the probability of a system being in a certain state in n steps:

- state $\omega1$. The implementation of the project does not cause any threats that may adversely affect the expected results and objectives of the project. The deviations from the targets are not significant and the risk level in the project is within acceptable limits. The quantitative risk assessment indicator (time or cost buffer) is in the green (safe) zone. Staying the project in state $\omega1$ at the time of completion means that from a budget and schedule standpoint, the project has been completed successfully, so this status is desirable for the project. If positive events occur and the effects of negative events are negligible, the project continues to be in state $\omega1$, while as a result of significant negative events, the project may go into state $\omega2$ or $\omega3$;
- state $\omega2$. There are threats in the implementation of the project that can adversely affect the expected results and objectives of the project. Negative events occur at the level of the circumstances of the project implementation and may adversely affect the achievement of the project objectives in terms of obtaining the expected results. This situation indicates the need for additional risk analysis and possible steps to return the project to the desired state $\omega1$. Buffer depletion is in the yellow (relatively safe) zone. Staying the project in the state of $\omega2$ at the time of completion means that from a budget and schedule standpoint, the project has been conditionally successful since no time and cost savings were used. If positive events occur and the effects of negative events are negligible, the project continues to be in state $\omega2$ or return to state $\omega1$, while as a result of significant negative events the project may go into state $\omega3$;

Table 1 Properties of possible states of IT project implementation

State properties	Possible states of project implementation		
	Stateω1	Stateω2	Stateω3
The nature of the state	Desirable	Acceptable	Unacceptable
The nature of threats	Almost nonexistent	Can negatively affect the expected results	Negatively affect the expected results and strategic goals
The feasibility of risk management measures	Taking measures is not appropriate	Additional risk analysis, possible action	Action is necessary
Buffer usage rate	Low	Acceptable	High (unacceptable)
Part of the heat chart	Safe	Conditionally safe	Unsafe
The success of the project	The project was successfully completed	The project was conditionally successful	Project failed

- state ω3. The implementation of the project creates threats that adversely affect the expected results and objectives of the project. Negative events affect the expected results and strategic goals. This situation indicates the need to take measures to return the project to the desired state ω1 or intermediate state ω2. The rate of buffer depletion is in the red (dangerous) zone. Staying the project in the state of ω3 at the time of completion means that from the budget and schedule positions the project was not completed successfully, as there were violations of time limits and exceeding the budget limits. If positive events occur and / or RM measures are taken, the project may return to ω2 or ω1 in one step, while new significant negative events result in the project remaining in ω3 [29]. The main properties of the possible states of the project are specified in Table 1 [1–4].

The form of the IT project RMM describes the processes associated with it according to the project implementation status, depending on the buffer usage indicator (Fig. 1).

According to the developed conceptual model, IT project RM (detection, analysis, strategy development and control) involves continuous communication between project stakeholders, periodic risk control and prompt response depending on the degree of risk determined by the project buffer utilization indicator (time and/or costs) [5, 28].

Within these processes, the identification and assessment of risks in the project are determined. The result is a risk response plan, which is part of the project and input management plan for the risk monitoring and management process. Starting with the implementation of an IT project, it is possible to realize the identified and the emergence of unidentified risks [6, 27]. IT project risk management (PRM) is carried out by analyzing the current status of the project and making decisions on managing its parameters based on the information received; Managed project

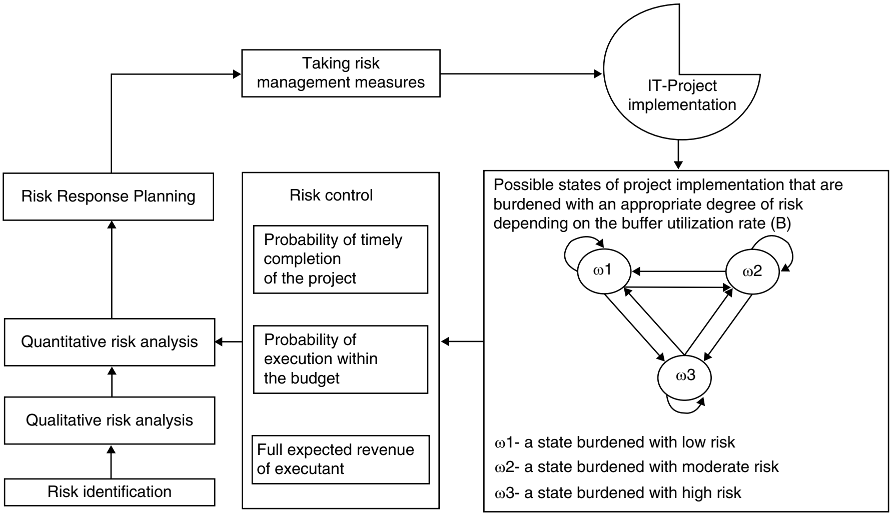

Fig. 1 Conceptual model of IT project risk management. (Source: developed by the author)

parameters are aspects or constraints that affect the end result, such as lead time, budget and project content.

Information on the emergence of new and the implementation of identified risks is also input to the risk control process. Based on the analysis of the information received, a decision is made on the feasibility of taking measures to minimize threats and maximize opportunities [7]. If such actions, in the management's view, are necessary for the success of the project, risk control measures are taken. However, if there are good reasons to believe that the risk response measures provided by the plan will not be sufficient to ensure the success of the project, changes to the risk response plan may be amended. As a result of refraining from taking corrective action or taking action to maximize opportunities and minimize threats, the project can move from one execution state to another. Accordingly, the main task in the RM process is to provide the conditions under which threats have minimal impact on the status of the project, while the opportunities—the maximum [8, 9, 25, 26].

Thus, within the framework of an IT PRM model, the use of Markov chains enables one to estimate the likelihood of the project being in the desired state. The estimates obtained, in turn, provide information and reason for taking RM measures in case of unfavorable deviations from the expected level or strengthening of positive trends, if such deviations are favorable. In Fig. 2 shows the presence of a conditional project in three possible states, depending on the values of the buffer usage indicator during its execution [29].

According to the above state distribution, we have a set of project states that form a complete group of events:

$$\Omega = (\omega_1, \omega_2, \omega_3) ,$$

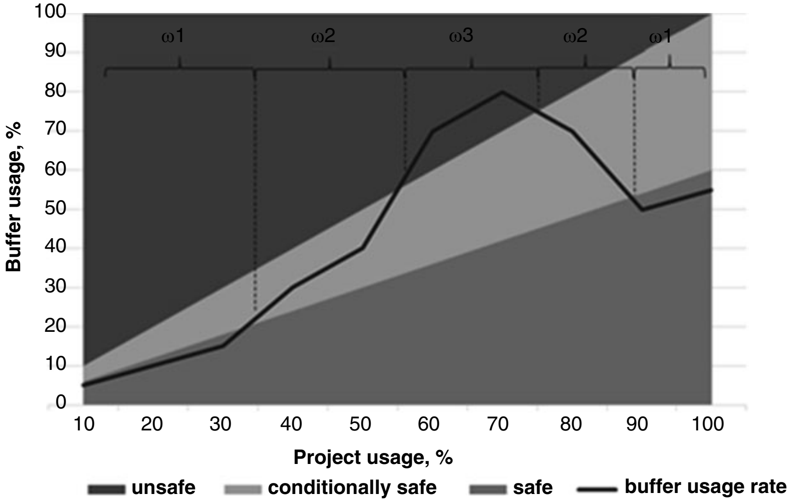

Fig. 2 Project implementation states (Source: developed by the author)

where ω_1—state 1, ω_2—state 2, ω_3—state 3.

The transition probabilities from one state to another correspond to the elements of the matrix:

$$P = \begin{pmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{pmatrix},$$

where p_{ij}—the probability of the system going from state i to state j, $i,\ j = 1, 2, 3$.

The probability of finding a project in a certain initial state is determined by the vector of initial probabilities:

$$\overrightarrow{\pi_0} = \left(\pi_1^0, \pi_2^0, \pi_3^0\right),$$

where π_i^0—the probability that the project is in an initial stage ω_i, $i = 1, 2, 3$.

Then, according to the Markov property, the probability of finding the project in a certain state in n steps ($n = 1, 2, \ldots, N$) is obtained as the product of the vector of initial state on the matrix of one-step transition in degree n:

$$\overrightarrow{\pi^{(n)}} = \overrightarrow{\pi_0} \cdot P^n, \tag{1}$$

where $\overrightarrow{\pi^{(n)}}$—vector of project state probabilities in n steps [12, 13].

Links and transitions between project states can be displayed as an oriented graph (Fig. 3) [14, 15].

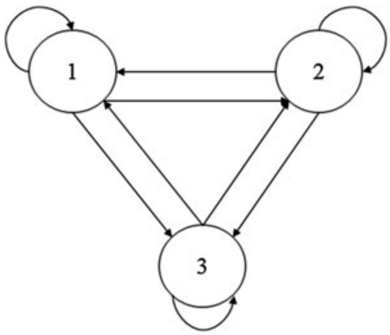

Fig. 3 Graph of states and transitions between project states. (Source: developed by the author)

All vertices of the graph shown in Fig. 3, are significant, that is, they mingle with any vertex that follows it. Therefore, at the interval corresponding to the time interval between system observations, the project can move from one state to another. All three vertices correspond to significant states. A chain that contains only significant states forms a single equivalence class and is homogeneous (ergodic). However, given that all vertices have a loop ($i \to i$), the chain is regular [30].

4 A Knowledge-Based IT Risk Management Model

To exploit the benefits of using knowledge management techniques to reduce uncertainty, it is advisable to develop a knowledge-based IT RMM. The practical implementation of the model involves the use of knowledge management methods and the development of a decision support system based on information obtained with such methods. The proposed knowledge-based IT RMM is shown in Fig. 4 [23].

According to the knowledge-based IT PRM model, which is part of the Information Analysis and Risk Response block (Fig. 1), IT PRM is based on explicit and implicit knowledge. The input to the RM decision-making process should be stored in the project knowledge base [24]. The project participants use information from the knowledge base about the nature of the tasks and their place in the project.

Inputs are based on information resources such as historical data, experience, stakeholder feedback, observations, forecasts and expert opinions:

1. explicit knowledge available, which includes lessons learned, databases, historical data, etc., is updated and entered into a risk database. The risk database must contain qualitative and quantitative indicators regarding the classification, criticality, and likelihood of risks;
2. updated information from the risk database, together with implicit knowledge (experience and qualifications of project stakeholders, domain laws, etc.), is

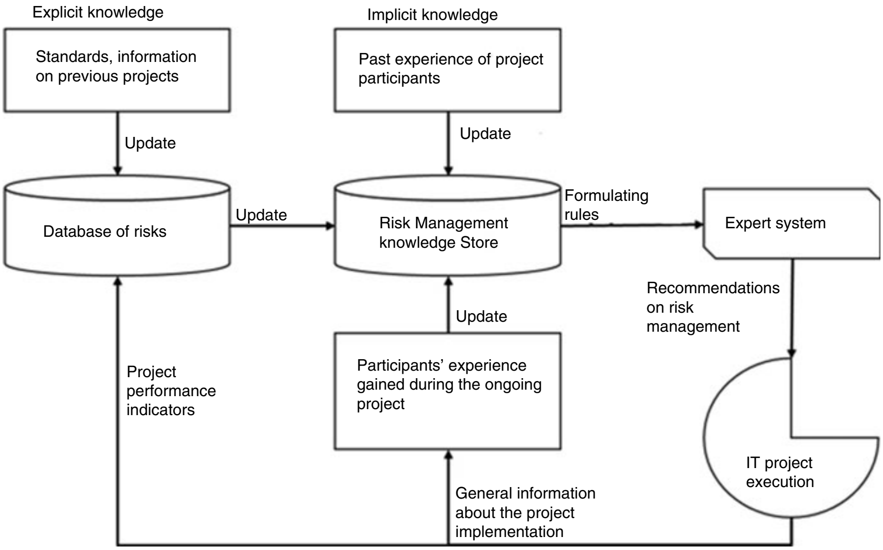

Fig. 4 A knowledge-based IT risk management model. (Source: developed by the author)

used to derive conclusions and patterns reflecting basic RM policies, as well as relevant assessments and assumptions;

3. based on the conclusions and patterns obtained, rules are formulated for the operation of an expert system, which helps the user to identify and solve problems through a series of consecutive questions and answers;
4. the recommendations provided by the expert system can be applied to PRM;
5. starting a project based on information at its execution (explicit knowledge, which includes data on the value of the buffer utilization indicator) and stakeholder feedback (implicit knowledge), the knowledge-based RM system receives new data and the cycle is repeated [10, 20–22].

5 Discussion of the Results

In order to update the data received from stakeholders regarding the identification of patterns and the accuracy of the estimates provided, it is advisable to keep statistics of performers by such parameters as the accuracy of the performed assessments, experience, task complexity, role in the project, involvement in the execution of critical tasks, contribution to the knowledge base.

Another important issue is the development of an integrated approach to the development of a knowledge-based system in terms of knowledge utilization.

Handzic and Durmic [31] distinguish four generations of knowledge management models:

1. technocratic. Technocratic models focus on formalized knowledge bases with an emphasis on information and communication technologies. The disadvantages of this approach are to balance research and use of knowledge, to choose the exact content and, accordingly, to make significant efforts to ensure evolutionary development, flexibility and usability;
2. people and organization oriented. Such knowledge management systems view knowledge as a competitive advantage that determines a firm's strategy;
3. context-oriented. As a departure from earlier approaches, the use of context-oriented systems implies that the effectiveness of knowledge management methods is determined by the context of knowledge use;
4. integrated. Integrated models acknowledge the evolutionary and contextual nature of knowledge management, in which knowledge management is considered both socially and technologically.

The proposed knowledge-based IT RMM integrates technocratic aspects (knowledge base), approach to knowledge as a competitive advantage and context-oriented (RM). The model also allows to take into account the dynamic and incremental nature of the implementation of IT projects, whereby the requirements for the information product and the ways of their implementation are refined taking into account new information and experience gained [16, 18, 19].

Therefore, in order to implement the proposed methodological provisions, a model was developed that, unlike the existing ones, takes into account the features of IT PRM (reserves, timely execution, communication, knowledge accumulation, software development methodologies) and allows solving the following problematic issues:

- the probability of successful execution of an IT project in terms of terms and budget is determined by calculating the probability of the project being in the desired Markov state through a set number of steps;
- the number of mark states corresponds to the number of intervals of the project buffer usage indicator and the number of steps to the number of sprints required to complete the project;
- the model takes into account the features of cascading (project buffer formation) and flexible (using sprints) methodologies used in software development [11, 17];

In order to improve information support for decision-making, a knowledge-based RMM has been developed in the project, which takes into account the dynamic and incremental nature of IT project implementation.

In order to put this model into practice, it is advisable to perform modeling of IT PRM processes based on data on real IT projects.

6 Conclusions

In order to implement the proposed methodological provisions, a model was developed that, unlike the existing ones, takes into account the features of IT PRM (reserves, timely execution, communication, knowledge accumulation, software development methodologies) and allows solving the following problematic issues:

- the probability of successful execution of an IT project in terms of terms and budget is determined by calculating the probability of the project being in the desired Markov state through a set number of steps;
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- in order to improve information support for decision-making, a knowledge-based RMM has been developed in the project, which takes into account the dynamic and incremental nature of IT project implementation.

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