Pattern Repository for Support of Project Management Capabilities

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Abstract. Project management (PM) capabilities define organizational abilities of delivering predictable project results in a changing environment. For evaluation and continuous improvement of the organizational PM capabilities, a PM maturity model is used. This model is a tool to benchmark existing PM processes against best practices and to identify the most suitable practices for implementation in an organization. Patterns are used for collection of the best practices and reusable solutions. The patterns are stored in the pattern repository, which allows not only identify the best practice for the implementation of PM maturity model but also supports proactive adaptation of PM processes according to changes in organization's or project's environment. This paper introduces the pattern repository as a support tool to enhance the PM capabilities. Design of the repository and integration with PM information system are presented as well as a usage example is provided.

Keywords: Pattern repository, Project management capability, Project management information system, Knowledge transfer

1 Introduction

Project management (PM) is a complex process of applying right knowledge, skills, methods, techniques and tools to project activities to meet project requirements [1]. One of the key success criteria is using of right things in appropriate project situations. Successful PM and success of projects depend on the project manager's competencies [2], personal capabilities, organizational PM capabilities [3] and other internal and external factors [4], [5]. Focus of this paper is the organizational PM capabilities as one of these factors and their support, evaluation and improvement in particular. Organizational PM is understood as framework used to align project, program and portfolio management practices with organizational strategy and objectives, and customizing or fitting these practices within organization's context, situation, or structure [6]. The organizational PM capabilities represents collection of people, process, and technology that enables an organization to deliver organizational PM [3]. Quality and effectiveness of the organizational PM capabilities is evaluated with PM maturity models (PMMM) [1]. PMMM is a formal tool used to assess, measure and compare organization's own practices against best practices with the intention to map out a structured path to improvement [7], [8].

One of the solutions for collecting and sharing the best practices is the pattern repository. The patterns can thus represent reusable solutions in terms of business process, services, resources, roles and supporting IT components for delivering a specific type of capability in a given context [9]. In the case of the organizational PM capabilities, the pattern repository contains standardized PM processes and recommended solutions for different organizational PM and project context situations. Patterns also help to integrate business and PM processes, and IT components (e.g. PM information systems (PMIS) and other organization management information) [10]. This integration allows proactive adaption of PM processes according to changes in project context situation.

PMMM are also typically used reactively and not proactively [11], [8]. Application of the pattern repository enables for proactive usage of PMMM and ensures PM process adaption during project execution with target to improve the organizational PM capabilities. This paper aims to introduce the pattern repository as a support tool to enhance the PM capabilities. The main contribution of this work is adaptation of the pattern repository for design of the organizational PM capabilities and increasing capability maturity. Data items constituting a PM pattern template and application scenarios of PM pattern have been identified.

Application of the PM pattern repository and the capability modelling helps to understand interrelation and complexity of organizational PM processes, and easier choosing and adaptation of the best practices to the organizational PM and project context situation. The PM patterns supports suitable best practices or solutions for process standardization to reduce its complexity and increase possibility to use right things in appropriate situation. All these modelling and standardization activities summarize to goal of the PM capabilities - deliver predictable project results in a changing environment.

The rest of the paper is structured as follows: Research methodology used in this paper is shortly explained in Section 2. Section 3 describes theoretical background of this research. The PM pattern repository design and application scenarios are presented in Section 4. An application example of the PM pattern repository is described in Section 5. Conclusion and future work are presented at the end of the paper.

2 Research Methodology

Research methodology used for design of the PM pattern repository is based on principles of the design science research [12] and consists of the following three steps (Fig.1):

1. Awareness of the problem of PM capability modelling and complexity of the PM capability improvement process, and identification of key functional requirement that need to be supported by the PM pattern repository. The problem analysis is based on PM capability, maturity models and capability modelling literature review. The result of this step is the list of key requirements to the PM pattern repository;

2. Design of the PM pattern repository according to the identified requirements and already existing solutions of the capability patterns. The result of this step is artefact "PM pattern repository" including the PM pattern template and application scenarios;
3. Evaluation of the PM pattern repository will be done empirically based on the PM pattern usage in case studies with different application scenarios. Completeness of the PM pattern template and algorithms used in the scenarios are evaluated during this step. Benefit of the PM pattern repository usage will be evaluated. This paper includes only initial evaluation of the PM pattern repository using one example and full evaluation is subject of further research.

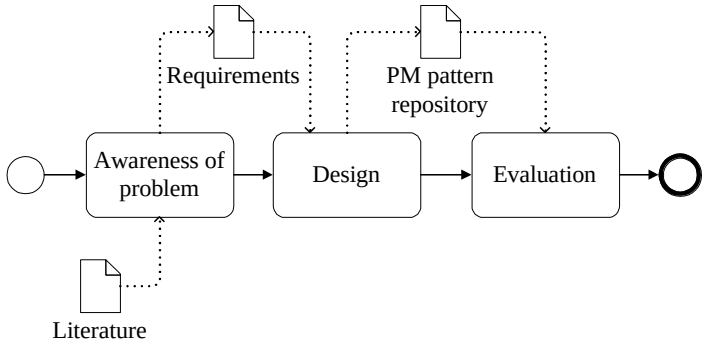


Fig. 1. Overview of research methodology

3 Background

Different types of capabilities are defined in PM literature – project delivery capabilities, personal capabilities and performing organizational capabilities. The PM capabilities also belong to organizational capabilities often evaluated during tenders and outsourcing together with technical capabilities [1]. As mentioned before the organizational PM capabilities includes people, processes and technologies [3]. This paper focuses on process (Section 3.1.) and technology (Section 3.2.) aspects. Effective PM also requires right people with right skills [3] and finding these people is one of organizational challenges. However, the people aspect of the organizational PM capabilities is out of this paper's scope.

An organization needs to know what specific PM practices, knowledge, skills, tools and techniques are necessary for it to successfully achieve the organization strategy and effective PM [3]. So it is necessary to identify current organizational PM capabilities, required improvements and establish a roadmap to implement these improvement [3]. Different PMMM can be used for this task (Section 3.3.). One of the options to formalize and evaluate the organizational PM capabilities is to perform a capability modelling (Section 3.4).

3.1 Project Management Processes

Processes in project-oriented organizations are divided in three groups: PM, product related and support processes [13]. The PM capability focuses on PM processes but processes from all three process groups overlap and interact throughout the project life cycle and should not be ignored. For example, ISO/IEC 12207 [14] standard of the software life cycle definition includes process description from all groups and ISO 9001 [15] also reviews and evaluates all three process groups.

General project PM processes are integration, stakeholder, scope, resource, time, cost, risk, quality, procurement and communication processes [13], [1]. The organizational PM capability requires that all of these general processes are supported but process implementation in each organization can differ. From the organizational PM capability perspective, processes belonging to the organization program and portfolio management level also need to be reviewed. The general program management processes are program communications, financial, integration, procurement, quality, resource, risk, schedule and scope management [16]. The general project portfolio management processes are portfolio strategic, governance, performance, communication and risk management [17].

3.2 Project Management Information Systems

The third element of the PM capabilities is technologies available to the organization. PMIS in many cases is one of IT components with a wide range of functions directly supporting PM. It is a standardized set of automated tools and techniques used in PM for planning, execution, management and closing of the project, as well as for collecting, combining and distributing project information [1].

From the PM capabilities view PMIS support implementation of PM processes and necessary measurements of PM performance and project context situations. Implementation of PM processes is ensured by configuration on PMIS according to defined requirements [18].

3.3 Project Management Maturity Model

PMMM is used to evaluate current PM capabilities and identify opportunities for continuous improvements of the PM capabilities (see Fig.2 for the process overview) [3]. Various PMMM has been developed. Some examples are:

- Organization project management maturity model (OPM3) [3] has been developed by PMI and supports implementation of the best practices defined in PMBOK [1], program management standard [16] and portfolio management standard [17];
- Capability maturity model integration (CMMI) [19].

The most part of the best practices defined in PMMM proposes organizational process changes that also includes people and technology aspects of the PM capability. Basic stages of the process capability improvement are standardize, measure, control and improve [3] with target to grove in terms of PM maturity (for example CMMI

levels – initial, managed, defined, qualitatively managed and optimizing) and improve organization value realization. Implementation of the best practices is tightly related to realization of organization's strategy and increase of business value delivered by the organizational PM capability [8].

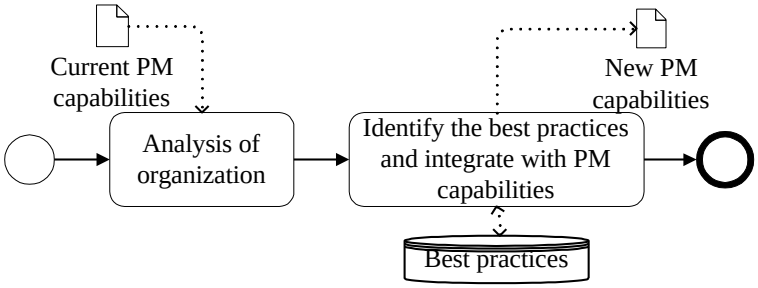


Fig. 2. Improvements identification process of organizational PM capability

3.4 Capability Modelling

The capabilities are modelled using concepts defined in the capability meta-model [20] (simplified view to main concepts given in Fig. 3). From the capability modelling perspective capability is the ability and capacity that enable an enterprise to achieve a business goal in a certain context [20]. Every capability has goals and achievement of these goals is measured by indicators or KPI. The context (context set, context element range, context element, context element value) defines circumstance affecting capability delivery and also defines context situations in which the capability being able to deliver. The capability delivery is supported by a process. The process variants can be constructed for dealing with specific capability delivery context situations. Patterns are used to support capability design. The patterns provide reusable solutions for capability delivery. They are also characterized by their context, which defines situation when this pattern is applicable.

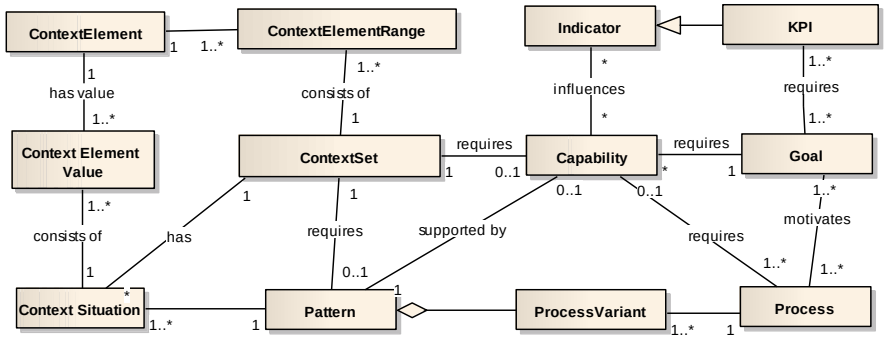


Fig. 3. Main concepts of capability modelling

The organizational PM capability consists of many interrelated sub-capabilities what makes its modelling more difficult. Organization of PM sub-capabilities models depends of organization. For example, project integration, scope, time and cost management can be modelled as one PM sub-capability or four separate. Communication and risk management sub-capabilities can be modelled as one for all levels (project, program and portfolio) or for each level separately. Summary of the main capability modelling concepts is given in Table 1.

Table 1. Main capability modelling concepts of organizational PM capabilities

Concept	PM capability description
Capability	Consists of different interrelated sub-capabilities: integration, stakeholder, scope, resource (team management), time (schedule), cost (financial), risk, quality, procurement, communication, strategic, governance, performance, etc.
Goal	Increased customer satisfaction, alignment of strategy and execution, increased productivity, competitive advantage, effective operations, improved cost control, improved market competitiveness, predictable delivery performance, improved communications and efficient decision making [6]
Context	Related to domain, structure of organization, culture, technologies, human resources and other characteristics
Process	PM processes (Section 3.1)
Pattern	PM practices, PMMM best practices (Section 3.3)

4 PM Pattern Repository

The PM pattern repository should collect the PM best practices and solutions (processes) that have been used for supporting the PM capabilities. To support this functionality following requirement to the PM pattern repository are identified based on the background literature review summarized in Section 3:

1. The PM pattern repository needs to contain solutions for different general project, program and portfolio management process improvements and also solutions for various project cases. One source of the patterns is PMMM and PM related standards;
2. The PM pattern description needs to contain:
   (a) basic information about pattern – name, problem and solution;
   (b) information about context situation in which solution can be used;
   (c) classification possibilities of the PM patterns according to PM processes, subprocesses and activities that help to identify related patterns;
   (d) information about process improvement stage for which pattern is used. This information is need to support sequential PM process capability improvement because stages cannot be skipped;

(e) information benefit and costs of pattern implementation that can be used for selection and evaluation of solution for implement;
(f) information about source of solution or best practice;

3. The PM pattern solution description needs to be standardized and machine readable to support easy integration to capability process and reuse in set up of PMIS.

The patterns are described according to a pattern template. For the capability design purposes (Fig. 3), the pattern template includes pattern name, problem, context, solution, keywords, usage guidelines and adjustment algorithm [9]. The PM pattern template inherits most of the data items from the aforementioned pattern template and some additional data items for the PM pattern repository are needed:

- The process capability improvement stage (standardize, measure, control and improve) needs to be defined;
- Information about business value or benefit and cost of the pattern implementation that can be expressed as constant or expression. These values are taken into account when evaluating which patterns are better suited for implementing PM capability improvements;
- Source of solution.

Summary of data items included the PM pattern template is given in Fig. 4 and actual descriptions of patterns according to the template are given in Section 5.

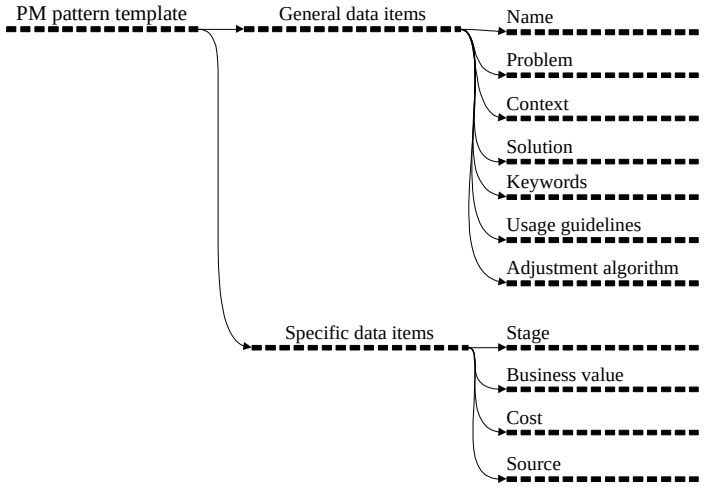


Fig. 4. Summary of data items in PM pattern template

The patterns from the PM pattern repository can be used within different scenarios:

1. New PM capability design. In this scenarios following steps are performed: 1) define capability goals, concepts and process; 2) indicate process dependences on context; 3) search appropriate patterns and 4) evaluate, chose and integrate suitable patterns. This scenario is demonstrated in Section 5;

2. Existing PM capabilities evaluation and improvement. This scenario follows improvement identification process of the organizational PM capabilities (Fig. 2): 1) according to capability goals, context, stage and other characteristics identify patterns and 2) evaluate, chose and integrate suitable patterns;
3. Proactive PM process tailoring based on changes in context situations. During PM process execution suitable patterns are identified and proposed according to context situation and indicators.

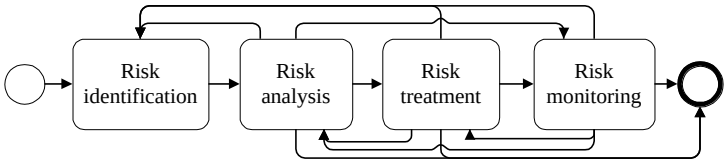
During these pattern application scenarios PMIS supports implementation of pattern solutions (if it is possible) and context dependent process variability and main contribution of PMIS is collection of data for the indicator measurements.

5 Example

As an example of the PM pattern repository application the risk management sub-capability based on general practices of project risk management is elaborated. Risk management is one of critical and complex processes in PM because of its impact and interrelates with the most of other processes. A summary description of the risk management sub-capability is given in Table 2. This example includes only the risk management process at the project level.

Table 2. Summary description of risk management capability

Concept	Description
Capability	Risk management
Goal	Effective risk management
Indicators	Percentage of occurred unidentified risks Proportion of risk cost (management vs. risk cost)
Context	Portfolio characteristics; Program characteristics; Project characteristics (size, are, type, problem area, priority etc.); Stakeholders' perspectives; Risk categories; Risk thresholds; Risk mitigation strategy; Risk level in project
Process	Base process of project risk management with possible cycles, return and forward steps



Examples of the patterns stored in the pattern repository are given in Table 3 – 7. The patterns have been defined according to the OPM3 best practices and for demonstration purposes only patterns related to risk identification are presented. OPM3 define only general best practices so different reusable solutions based on a context

situation can be identified and stored according to industry experience. More than one solution might be available for a single context situation.

The example patterns defined in Table 3 – 7 have been described according the PM pattern template including:

- General information:
  - Name;
  - Problem describes a problem or goal that proposed solution solves;
  - Keywords help to identify and classify patterns. In the case of the PM repository they help to identify related PM processes, sub-processes and activities;
  - Context elements used in this example are:
    - Project priority (possible values – normal and critical) that is used for characterization for risk identification patterns in the standardize stage;
    - Risk level in portfolio (possible values – high, normal, low) that is actual for the risk identification patterns in the measure stage;
  - Solution includes a proposed process defined using the BPMN notation;
  - Usage guidelines shortly describe planned implementation of the solution;
- Specific information for the PM patterns:
  - Stage of the capability process improvement that needs to be addressed with possible values: standardize, measure, control and improve;
  - Business value is a coefficient that characterizes benefit of solution implementation to PM capability. It is based on expert assessment and is comparable between similar patterns belonging to the same stage. Similarity of patterns has been evaluated according to the keywords;
  - Cost in this example is a coefficient (not money expression) representing cost of solution implementation. It also is based on expert assessment;
  - Source includes a reference to the best practice from OPM3.

Table 3. Pattern 1

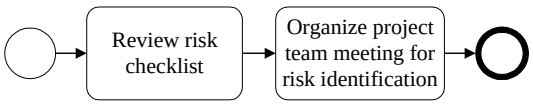
Data item	Value
Name	Pattern 1
Problem	Standardize risk identification for low priority project
Context	Project priority = normal
Keywords	Risk management; Risk identification
Business value	0.8
Cost	0.7
Stage	Standardize
Solution	
Source	OPM3: Standards are established
Usage guideline	Detailed activities for project risk identification

Table 4. Pattern 2

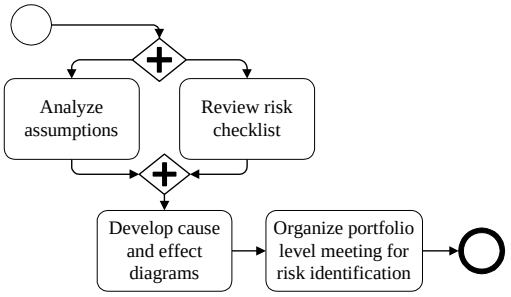
Data item	Value
Name	Pattern 2
Problem	Standardize risk identification for critical project
Context	Project priority = critical
Keywords	Risk management; Risk identification
Business value	1
Cost	1
Stage	Standardize
Solution	
Source	OPM3: Standards are established
Usage guideline	Detailed activities for project risk identification

Table 5. Pattern 3

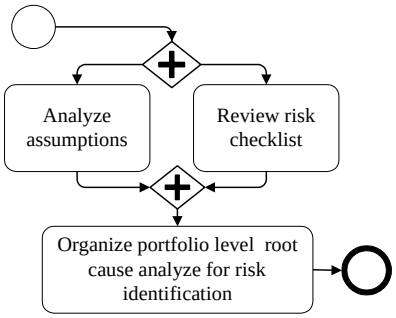
Data item	Value
Name	Pattern 3
Problem	Standardize risk identification for critical project
Context	Project priority = critical
Keywords	Risk management; Risk identification
Business value	1.1
Cost	1.2
Stage	Standardize
Solution	
Source	OPM3: Standards are established
Usage guideline	Detailed activities for project risk identification

Table 6. Pattern 4

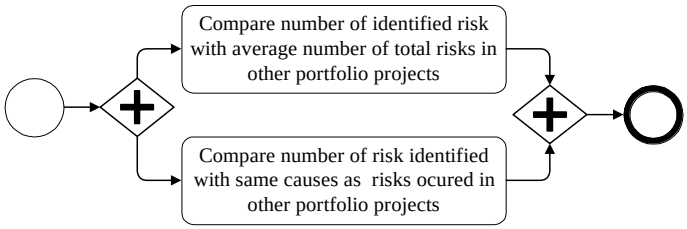
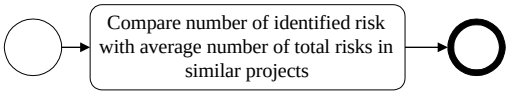
Data item	Value
Name	Pattern 4
Problem	Measure risk identification for high risk level portfolio
Context	Risk level in portfolio = high
Keywords	Risk management; Risk identification
Business value	0.3
Cost	0.5
Stage	Measure
Solution	
Source	OPM3: Measurement are established, assembled and analyzed
Usage guideline	Addition activities after risk identification and documentation

Table 7. Pattern 5

Data item	Values
Name	Pattern 5
Problem	Measure risk identification for normal and low risk level portfolio
Context	Risk level in portfolio = {normal, low}
Keywords	Risk management; Risk identification
Business value	0.2
Cost	0.3
Stage	Measure
Solution	
Source	OPM3: Measurement are established, assembled and analyzed
Usage guideline	Addition activities after risk identification and documentation

The patterns can be used to design context dependent variations of the risk identification sub-process described in Table 2. The risk identification sub-process consists of two basic activities - identify and document risks (Fig. 5.). During analysis of the process dependences on context it has been identified that variations of this sub-process occur due to two context elements – project priority in portfolio and risk level of portfolio. The project priority impacts the risk identification process and the risk level in portfolio affects measurement of the risk identification process. Process varia-

tion design has been performed in two step to achieve first two stages of the process capability improvement – standardize and measure.

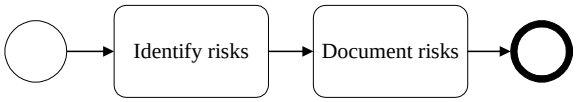


Fig. 5. Risk identification sub-process (initial process)

Step 1.: During the standardize stage, three patterns form the pattern repository have been extracted (search criterion was *Stage = standardize AND Keywords = risk identification*) – one for normal priority projects (Pattern 1) and two for critical projects (Pattern 2 and Pattern 3). In the case when more than one solution is available for the context situation, the selection is made according to the business value to cost relation or expert judgement. In this example, one should choose between Pattern 2 or Pattern 3). Based on the business value to cost relation Pattern 2 has been selected because its relation value is greater (Pattern 2: 1/1 = 1 and Pattern 3: 1.1/1.2 = 0.92). Following the usage guidelines of Pattern 1 and Pattern 2, these identified patterns replaces activity "identify risks" (Fig. 5.) with a set of more specific tasks. The risk identification process after the standardization is shown in Fig. 6.

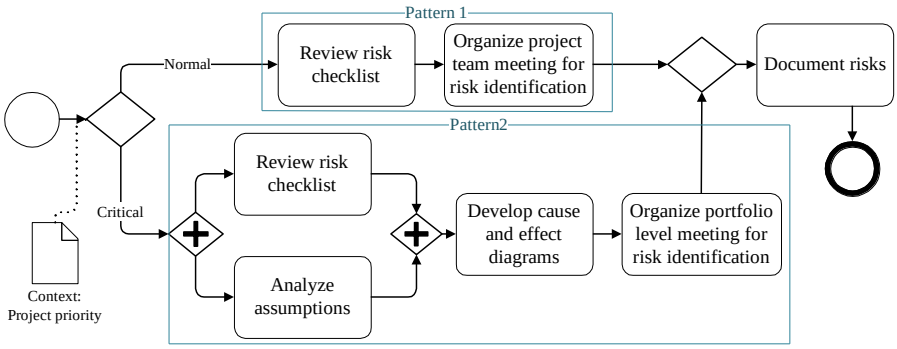


Fig. 6. Risk identification sub-process after Step 1

Step 2.: The measure stage adds performance measurements and analyze activities of the risk identification process**.** Two patterns have been extracted from the pattern repository at this stage (search criterion was *Stage = measure AND Keywords = risk identification*). One of the retrieved patterns is for high (Pattern 4) and another is for low risk level (Pattern 5) in portfolio. According to the usage guidelines, the identified solution processes are added after activity "document risks" (Fig. 6.). The risk identification process after adding the measurement activities is shown in Fig. 7.

The result after these two steps is a risk identification process in the second stage of process capability improvement. A part of this process implementation is possible to set up in PMIS that can also support process adjustment according to changes in context situation.

The illustrative example shows that the proposed PM pattern repository supports the defined requirements. One of the first conclusions is that correct keywords usage in the pattern description and search are important for effective usage of the PM pattern repository.

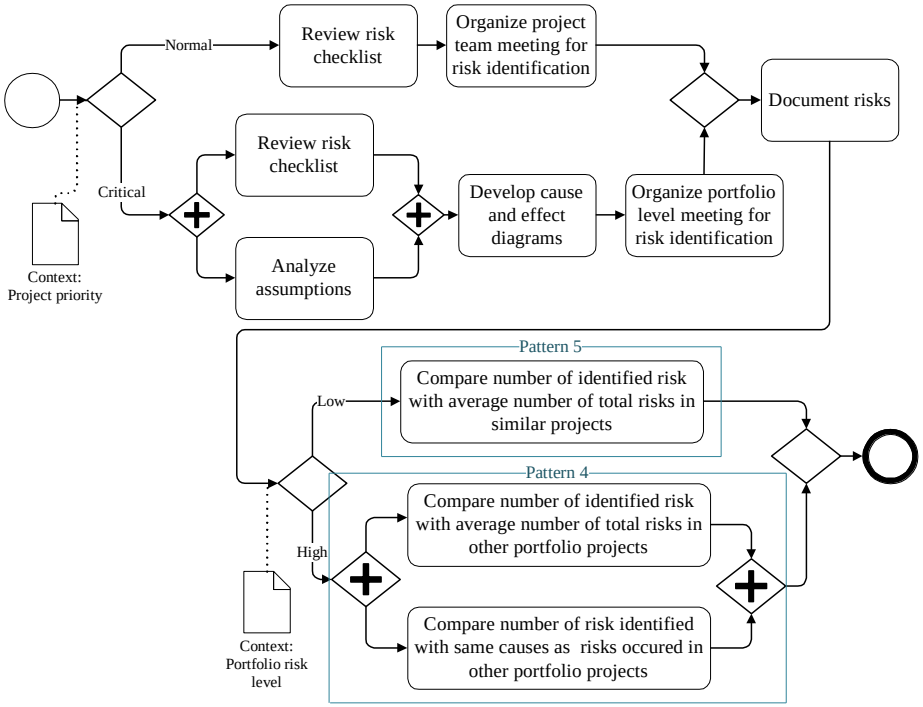


Fig. 7. Risk identification sub-process after Step 2

6 Conclusions and Future Work

This paper introduces possibilities of applying PM patterns from the PM pattern repository for design and improvement of the PM capabilities. Design of the PM pattern repository ensures collection of PM practices and reusable solutions.

Structured PM capability design using PMMM and the pattern repository helps to manage complexity of the PM domain. For example, that allows to set up PMIS according to the defined PM capabilities and development of context adaptive PMIS that will ensure automatization of PM processes and context dependent decision. Usage of the PM patterns helps to identify better solutions for different multi-contextual situations. Iterative process improvement by adding the patterns to PM processes step by step makes the process capability improvement easier to understand and manage. PM process capability improvement ensures more standardized processes that decrease overall complexity of PM and makes them more manageable and predictable.

Problems related to the PM pattern repository design are: 1) collection of best practices and reusable solutions because PMMM gives general guidelines but context situation related solutions need to be identified from industry case studies; 2) evaluation of the pattern quality, 3) formalization of pattern business value and cost evaluation because currently it based on expert assessment.

Future work includes creation of the comprehensive PM pattern repository according to PMMM (e.g. OPM3) best practices, detailed analysis of proactive usage of PMMM based on possibilities of the pattern repository and modelling of different PM sub-capabilities. Case studies of the organization PM capabilities and the pattern repository usage also will be performed. That will ensure empirical evaluation of the PM pattern repository according to the research methodology described in Section 2.

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