An Improvement of Process Reference Model Design and Validation Using Business Process Management

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Abstract. During the design of a Process Reference Model (PRM), the modeler needs to describe processes. According to ISO/IEC 15504-2, each process shall be described in terms of a process purpose and process outcomes. The process purpose is "*the high level measurable objectives of performing the process and the likely outcomes of effective implementation of the process*". A process outcome is "*an observable result of a process*". The set of process outcomes shall be necessary and sufficient to achieve the purpose of the process. However, no method exists as ISO proposes requirements and guidelines (respectively in ISO/IEC 15504-2 and ISO/IEC 24774 for process description) for developing process models. So there is a need to support the development of a process model and the verification of the completeness of the process outcomes in the context of process design. This article proposes a structured approach to answer this challenge based on business process management and requirements engineering principles. We especially consider the use of both the transformative view and coordination view of a process to support the design and the validation of PRM processes based on a collection of requirements.

Keywords: Process Reference Model, ISO/IEC 15504, process design, process validation, process verification.

1 Introduction

In 2003, the International Organization for Standardization (ISO) published the ISO/IEC 15504-2 standard [4] for performing process assessment. This standard is part of a series providing the requirements to conduct a process assessment and to design process models; guidelines for process improvement or capability determination; and exemplar process models. These assessment standards are not limited to a specific field of activity; there can be applied to various industry sectors. The most

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known applications of ISO/IEC 15504 are software development life cycle processes (ISO/IEC 15504-5), Automotive SPICE [2], and Enterprise SPICE [3].

Performing a process assessment requires two process models. The ISO/IEC 15504-2 [4] is the standard which gives the minimum requirements for process model design. The first process model is the Process Reference Model (PRM). It contains ''*definitions of processes in a life cycle described in terms of process purpose and outcomes, together with an architecture describing the relationships between the processes*'' [23]. The second one is the Process Assessment Model (PAM) which is a framework ''*suitable for the purpose of assessing process capability, based on one or more Process Reference Models*'' [23]. A main issue in the design of a PRM is that ISO/IEC 15504 gives requirements on what should contain a PRM but there are no guidelines or recommendations in order to ensure that the set of outcomes is necessary and sufficient to achieve the purpose of the process and then the completeness of the process.

In Business Process Management (BPM) literature, a process has multiple definitions. In one hand, the ISO [18] defines "*a process as a set of interrelated or interacting activities which transforms inputs into outputs*". This is the *transformative view* of a process. On the other hand, business process researchers emphasize the fact that the processes require communicative actions between interested parties in order to fulfill the process purpose [1]. This is the *coordination view* of a process. In this context, several studies consider the process as a transaction between two interested parties: a customer and a supplier. In this study, we consider the use of these two views to support the design of PRM. In particular, the coordination view, which does not appear at the ISO standard level, will guide the modeler to verify the completeness of the process outcomes.

According to Keen [1], the transformative view is too restrictive. This definition excludes the processes that have no clear flows between sub tasks. That is the reason why we also propose to introduce methods which highlight these flows inside a process. Multiple studies [13, 14] recommend a way to express these transactions. In this paper, we thus propose to enhance the elaboration of process descriptions, conforming with the requirements given in the ISO/IEC 15504-2 standard, with the existing practice using *Goal Oriented Requirements Engineering* (GORE) modeling techniques [21], and a lifecycle model: the Action Workflow Loop (AWL) [13], extracted from BPM literature. We will show how we use the combination of GORE and AWL to support and validate a design of ISO/IEC 15504 compliant processes when this activity is based on a collection of requirements such as depicted in Fig. 1. The use of AWL will ensure the completeness of a process.

To summarize, the purpose of this paper is to propose a structured approach to support design and validation of process descriptions in the context of the elaboration of a PRM based on a collection of requirements using GORE techniques to design the processes with their outcomes and AWL which highlights the coordination view of the processes to ensure its completeness. Please note this paper does not intend to provide a method at the standard level to design PRMs. This paper is organized as follows: Section 2 exposes the related works concerning process model design. Section 3 discusses the selected method to ensure the completeness of the process.

Section 4 explains the structured approach we propose to support process validation. Section 5 focuses on its application on the ISO/IEC 27001 PRM design, a standard giving the requirements for Information Security Management System [22]. Finally, Section 6 draws conclusions.

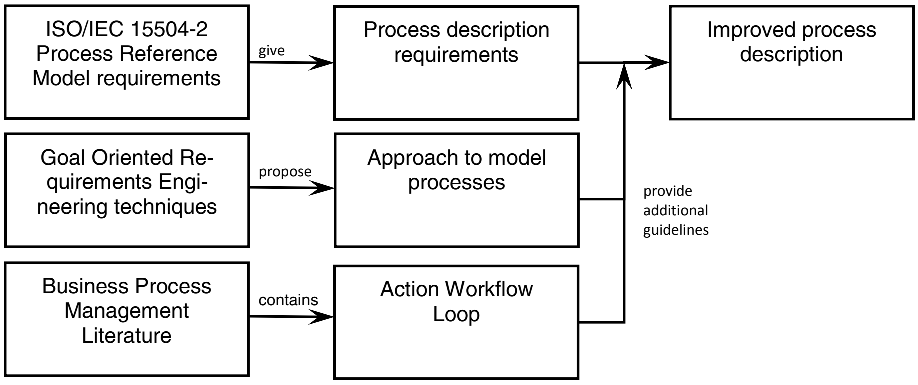

Fig. 1. Overview of the involved concepts

2 State of the Art

Process Reference Model design is subject of growing interest in the literature. Since ISO/IEC 15504 is not limited to software development processes, many initiatives proposed PRM and PAM for various domains such as automotive sector [2], enterprise processes [3], IT security [17], IT service management [5, 6], knowledge management [7], internal financial control [8], industrial processes [9], regulation compliance [10], public university research laboratories [11], and medical devices [20]. However, these papers presenting new process models do not focus on their design method. They present their new process model and its context of use and give very few details on how they were designed.

Regarding articles describing the design of a process model, we identified two different approaches. The first one [9] consists in extracting processes and their outcomes from subject matter experts in the corresponding community of practice, e.g., through interviews, workshops and surveys. But in very specific domains such as information security, this may be hard to achieve due to limited resources dedicated to this design and/or the difficulty to find the adequate experts to consult. Indeed it requires persons to be found with both expertise: in the ISO/IEC 15504 standard and in the application domain of the process model. Moreover, it may be difficult to reach a consensus on the processes and outcomes among the different experts through weakly structured interviews.

The second method uses a goal tree based methodology [6, 15]. From the experience of the authors, they noticed that experts of the community of practice do not like to read and analyze textual description of processes, and their comments tend to focus more on the form than on the core of the process model. The use of goal trees, thus, helps to refocus the experts on the core concepts of the model thanks to a graphical representation.

In a similar way, Rifaut and Dubois [10] defined a PRM from the Basel II regulation. They started by extracting a flat list of requirements from the regulation. They separated implementation practices (*How*) from business goals (*What*). Then, they used a GORE modeling technique to discover the purpose of the various requirements, and group them according to their high level goal. They used goal diagrams to structure outcomes and indicators. Rifaut and Dubois claim that the usage of GORE techniques demonstrates the full coverage of the regulation and allows keeping traceability between purposes and outcomes. Nevertheless, this method necessitates a formal collection of requirements including clear role definition and it does not ensure that the designed process is complete. We propose to use a light version of this method, explained in section 4, to design a first version of the processes.

3 The Action Workflow Loop

The ISO/IEC 15504-2 standard requires that the set of process outcomes constitutes the conditions necessary and sufficient to achieve the purpose of the process. But this standard does not explain how to verify the completeness of the process outcomes. As mentioned in the introduction, the ISO considers a process as the set of actions which transform the inputs into outputs [18]. But according to Keen [1], a process requires coordination. Based on this view, business processes follow multiples phases: requests, offers, agreements and commitments.

This theory is based on project lifecycle management. In 1988, Peter W. G. Morris [12] highlighted the existence of an invariant sequence in project management. At first, a demand exists. Then a study is made to answer this demand. This study, after an evaluation, receives the authorization to be implemented and developed. Once the project on action, it needs to be maintained and tested to find opportunities of new demands. In this section, we present how this concept has been transformed to fit the business process context.

In 1992, Medina-Mora et al. [13] applied this lifecycle concept to support work in organizations. He created the AWL which breaks down the business process as a loop constituted of four generic phases (see Fig. 2.). He describes the phases as follow:

- **Proposal:** the customer requests (or the performer offers) completion of a particular action according to some stated conditions of satisfaction
- **Agreement:** the two parties come to mutual agreement on the conditions of satisfaction […]. This agreement is only partially explicit in the negotiations, resting on a shared background of assumptions and standard practices.
- **Performance:** the performer declares to the customer that the action is complete.
- **Satisfaction:** the customer declares to the performer that the completion is satisfactory.

Therefore, these generic communicative steps can be used to describe a process. The process is achieved thanks to agreements between the governance and the performer of the process. In the context of our article, to highlight the existence of these four steps in the process outcomes is a good way to verify if the process is complete. Indeed, if the process outcomes consider the four phases, then the achievement of the process will perform the loop.

In [14], van der Aalst introduces a BPM lifecycle which is an extension of the AWL. The BPM considers also a lifecycle composed of four phases. While the three first phases does not introduce new concepts, the fourth phase, namely the diagnosis phase, analyses the process to identify problems and find opportunities for improvement. In our context, this phase is not relevant. The ISO/IEC 15504 requires the process outcomes to be the minimum activities to achieve the process purpose. This requirement excludes improvement activities from the process outcome list. This is the reason why we do not consider this BPM lifecycle in our study.

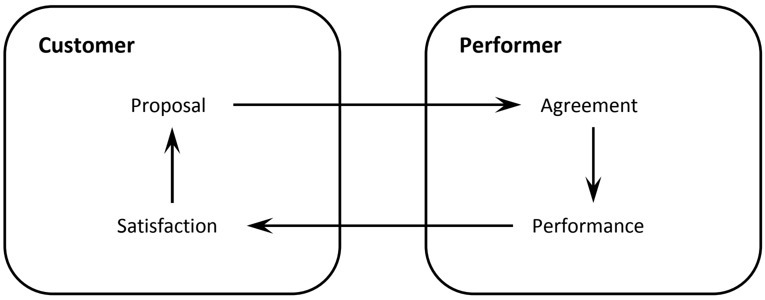

Fig. 2. The action workflow loop

4 A Structured Approach to Support Process Validation

In this article, we propose to combine the use of the GORE techniques based on the method given in [10] and the use of the AWL to design PRM and to ensure the completeness of the process descriptions in particular for process outcomes required by the ISO/IEC 15504-2. This approach is divided in four tasks described below. The next section will illustrate through examples this approach.

4.1 Reformulate Requirements in an Atomic Requirement List

At first, we broke down the collection of requirements into atomic requirements, which is a recognized best practice in *Requirements Engineering*. An atomic requirement is a requirement that cannot be further decomposed into multiple requirements. This can be done by splitting sentences containing multiple verbs and multiple objects. These requirements are collected in a list.

4.2 Elicit the Process Based on Requirement Purposes

In order to complete this task, the requirements from the list are considered as potential outcomes for the processes. A technical and semantic analysis is done to discover what the purpose of each requirement is. Once the purposes of all the requirements are identified, the requirements are gathered according to their purpose. These purposes constitute the processes of the PRM.

4.3 Organize the Requirements in Goal Trees

Once the processes identified, the requirements related to each process are organized in trees, i.e., each process is organized as a tree. The name of the process, based on the purpose of the requirements, is the root of the tree. The atomic requirements are the leaves of the trees. These requirements are clustered according to their implied observable result. The observable results are process outcome candidates. The intermediary nodes of the tree are these process outcome candidates. The outcome sentence is written according to the expected observable result of the clustered requirements. It considers also the recommendations from the ISO/IEC TR 24774 [19]. This technical report provides guidelines for process description such as "*An outcome shall be phrased as a declarative sentence using a verb in the present tense*".

4.4 Verify the Completeness of the Process Outcomes

Once these process outcomes identified, we still need to verify if their completion allows the achievement of the process purpose. At this given time, we use the AWL introduced in the previous section. The purpose of this task is to verify if the set of process outcomes covers all the phases of the loop. This verification is done by checking if each outcome corresponds to a phase of the loop, i.e., proposal, agreement, performance, and satisfaction. Note that an outcome can correspond to multiple phases.

An outcome corresponding to the *proposal* phase considers an activity which is collecting the information for the execution of the process. This phase can be the identification or the definition of the objectives of the process. An outcome corresponding to the *agreement* phase consists of verifying if the collected information is adequate. This phase can be the management approval of the objectives previously identified. An outcome corresponding to the *performance* phase is made up of all the core activities of the process. This phase can be the performance of the activities or the supply of the resource to fulfill the objectives of the process. Finally, an outcome corresponding to the *satisfaction* phase includes all the actions undertaken to monitor the activities completed during the previous phases. This phase can be the communication, the review or the monitoring of the previous activities.

If this verification fails, at least one outcome must be added or transformed to consider all the phases of the loop. In this case, a new iteration of the third step can be done, or new requirements can be proposed for addition in the source document (i.e. an ISO standard) to create a new process outcome. A full example of this approach is given in the next section.

5 An Application to the ISO/IEC 27001 Standard

The ISO/IEC 27001 [22] is a standard in the field of information security. This document gives a list of requirements, structured in clauses, which are necessary in the establishment of an Information Security Management System (ISMS). In the case of the translation of the ISO/IEC 27001 standard in a PRM, the proposed approach has been applied to design information security management processes. The full study is presented in [16]. That study focuses on generic management system processes which are elaborated through the reuse of another PRM [24] covering the requirements of an IT service management system given in the ISO/IEC 20000-1 standard [25], and also presents specific Information Security processes.

5.1 Reformulate Requirements in an Atomic Requirement List

At first, we broke down the ISO/IEC 27001 normative sentences into atomic requirements. For example, the requirement from the clause 4.2.1 of the ISO/IEC 27001: "*Identify and evaluate options for the treatment of risks*" This requirement is split into 2 atomic requirements: "*Identify options for the treatment of risks by applying appropriate controls*" and "*Evaluate options for the treatment of risks by applying appropriate controls*". At the end of this operation, the ISO/IEC 27001 standard yielded 273 atomic requirements. In the context of this paper, we limited the study to a subset of 55 atomic requirements. Indeed, most of the atomic requirements of the standard were already treated according to a methodology explained in [16] which reuses existing descriptions of management system processes.

5.2 Elicit the Process Based on Requirement Goals

To elicit processes from these requirements, we gathered the requirements according to their goal. In the previous sub section, the requirements "*Identify options for the treatment of risks by applying appropriate controls*" and "*Evaluate options for the treatment of risks by applying appropriate controls*" were identified. Their goal is to complete a risk treatment process. A "Risk Treatment" process is created. The purpose of risk treatment process is to select controls to reduce, retain, avoid, or transfer the identified risks. The other requirements are found by performing a key-word based search on the atomic requirement list. In this example, we used the key-word "*treatment*". A set of 26 atomic requirements from the list are linked to this process.

5.3 Organize the Requirements in Goal Trees

Based on the previous example, the requirements are organized in trees. During this task, process outcomes are written. In our example, the requirements "*Identify options for the treatment of risks by applying appropriate controls*" and "*Evaluate options for the treatment of risks by applying appropriate controls*" are brought together to develop the outcome "*Options for the treatment of risks are identified and evaluated*". As displayed on Fig. 3, the root node is the name of the process, the leaf nodes are the atomic requirements, and the intermediary nodes are the process outcomes.

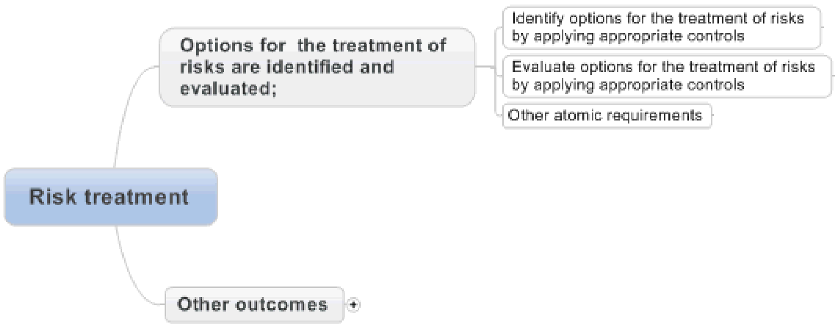

Fig. 3. Design of the risk treatment process goal tree

5.4 Verify the Completeness of the Process Outcomes

The next step consists to determine if the process outcomes cover the 4 phases of the AWL. This example explains the transformation of another process, the "*Risk Assessment*" process. This process is already modeled in a goal tree depicted in Fig. 4. The purpose of this process is to identify assets and the risks they face. The intermediary nodes of the tree depicted in Fig. 4 are the process outcomes. The first two outcomes of the tree sketched in Fig. 4 are: "*A suited risk assessment approach is selected according to the business context, and the legal and regulatory environment;*", and "*criteria for accepting risks are developed;*". These two outcomes make up the proposal phase of the process. Indeed, these outcomes are preparing the core activity of the process. The core activities of the process corresponding to the performance phase of the loop are the three next outcomes namely "*assets and their owners are identified;*", "*risks are identified using the risk assessment approach;*", and "*identified risks are analyzed and evaluated;*". The last outcome "*risks are monitored according to reviews, audits and ISMS scope modifications.*" makes up the satisfaction phase of the process.

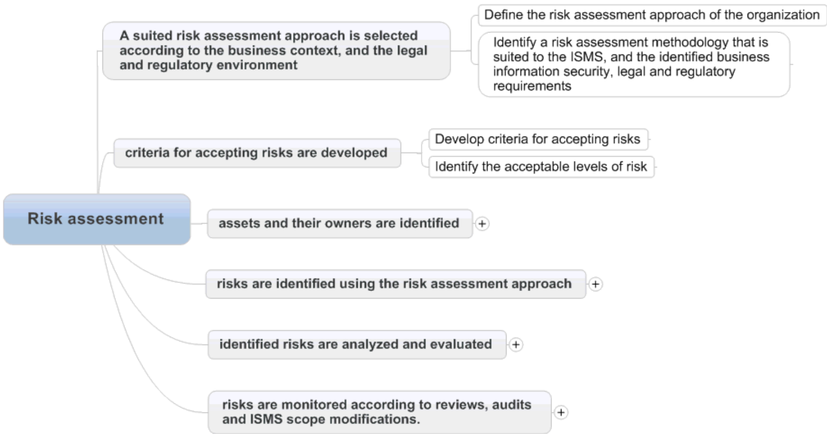

Fig. 4. First version of the risk assessment goal tree

At that moment, no process outcome was linked with the second phase of the AWL namely the agreement phase. We thus inspected the requirement list to find the requirements linked to the missing phase. The missing outcome was about an agreement on the criteria for accepting between the developer of this criteria and the management. We added the process outcome "*criteria for accepting risks are approved by the management;*". The new goal tree is depicted in Fig. 5, it shows the four phases of the AWL. In this case, AWL helped us to discover a missing outcome in our process.

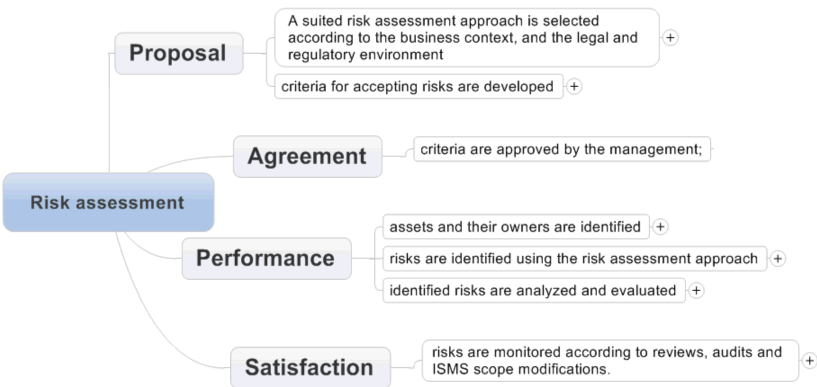

Fig. 5. Risk assessment process goal tree after the AWL Study

6 Conclusion

The approach to support ISO/IEC 15504 PRM design is based on GORE methods and the AWL. The GORE methods helped us to design a first version of the process descriptions. The AWL, stemming from BPM literature, provided a support to verify the completeness of the previously designed processes. This modeling approach is used in the context of the elaboration of a PRM based on the ISO/IEC 27001 requirements.

Such as depicted during the prior example, the AWL allowed us to identify missing elements in process descriptions. These missing elements concerned most of the time the agreement phase. The ISO/IEC 27001 often provides the requirements in a different section of the standard in particular the "Management responsibility" section. This approach has been applied to the ISO/IEC 27001 standard, the elaborated process descriptions consider the four phases of the loop and are, thus, complete. Some missing process outcomes have been identified thanks to this approach such as explained in the previous section. Currently, the requirements concerning approval are in the "*Top management commitment*" section of the ISO/IEC 27001 standard. So the requirement needing management approval is sometimes disconnected from the approval requirement. We think that the standard would be modified to move the approval requirements immediately after their requirements needing approval.

The perspective of this work is to support ISO/IEC 15504 process model designers to enhance their process description with a structured way to create processes and to write the process description. But it does not aim at becoming a prescriptive PRM design approach at the ISO standard level. This structured approach will also be useful in process verification. The AWL part of our approach can be used to verify *a posteriori* the design of a PRM. The process outcomes can be analyzed thanks to the AWL to check the completeness of the process and the quality of the process descriptions.

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