AN EVOLUTIONARY APPROACH FOR QUALITY MODELS INTEGRATION

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Abstract: The existing quality models (as ISO/IEC 15504, CMMI, MPS.BR, ITIL, COBIT) establish different processes and controls that must be adopted to achieve high software process reliability. Whereas it's possible notice similarities and overlapping areas among them, a systematic approach to integrate quality models is not widely explored in the literature. In this work we propose an evolutionary approach to integrate quality models. The approach defines a method that can be executed in a systematic way and has a meta-model and a mapping table as outcome. The method is composed by two stages: the meta-model development and the meta-model stabilization. As this is an ongoing research, this work is presenting the application and the results from the execution of the first stage. As a result, a meta-model representing the structure of four different quality models was developed and its applicability was verified.

1 INTRODUCTION

Several organizations, especially government, have been demanding from software providers that they prove high quality software development. This has motivated the creation of several software process quality models and standards.

Furthermore, software companies are investing effort on software processes improvement (SPI) to achieve several software quality certifications demanded by different software consumers. However, the integration of these efforts are not trivial because several process management models, techniques and best practices are available, like ISO/IEC 15504, CMMI, MPS.BR, ITIL e COBIT. Each one of them establishes different processes and controls that must be adopted to achieve high software process reliability and capacity.

Whereas it's possible notice similarities and overlapping areas among those models, techniques and best practices, the integration among them is not widely explored in the literature. The related work found present the integration among specific models by using ad-hoc methods. There is a lack of generic approaches to support the organization on selecting methods and integrating models.

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This has motivated this research, which intends to create an evolutionary approach to integrate software process quality models. The proposed approach uses meta-models to integrate software process quality models and includes the development of methods to do this. As future work, a software tool to support its usage will be designed and implemented.

The remaining of this paper is structured as follows. Section 2 presents related works; section 3 details the proposed approach to integrate software process quality models and presents the method execution in order to test the proposed approach; and, finally, section 4 addresses conclusions and future work.

2 RELATED WORKS

Generally, software process improvement uses models as basis. Adopting a standard software quality model can improve quality and control costs by more accurate estimations and planning.

There are several software quality models adopted by the industry. The following studies are related to the integration of quality models.

In (Pickerill, 2005) a relationship between IDEAL (developed by SEI) and Six Sigma is demonstrated. Using IDEAL as reference model,

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this works proposes the usage of both Six Sigma implementation methods (DMADV and DMAIC) to develop and implement process with CMMI.

(Siviy and Hallowell, 2005) has complemented this research, evaluating the usage of Six Sigma as a facilitator on CMMI implementation. The conclusions demonstrated that the implantation process and ROI verification have been accelerated.

(Rout, Tuffley and Cahill, 2001) presents a technical report that evaluates the compatibility between CMMI and ISO/IEC 15504-2. As a result, a mapping table is presented and the report states that the ISO/IEC 15504-2 significant elements are addressed by CMMI.

A definition of a meta-model to integrate CMMI and ISO/IEC 15504 is presented in (Lepasaar and Mäkinen, 2002). The meta-model was applied in both models to identify the existing structures.

On despite of high number of quality models available in the industry, they do not cover the integration among them. The related works do not present a systematic approach able to incorporate new models in an evolutionary way. Also, the integration presented is realized in an ad-hoc way, making difficult the integration of new models in the same structure.

The study in (Lepasaar and Mäkinen, 2002) distinguishes from other studies by proposing a meta-model to support integration. As stated in (OMG, 2005), (OMG, 2006), and (OMG, 2007), meta-models are utilized to support integration of processes, workflows, tools, database, and middleware's.

A similar idea is used in the approach proposed in this paper. The main difference herein is the proposal of an evolutionary approach and a method to build a meta-model in order to integrate a chosen set of quality models, in contrast of the ad-hoc ways used in the related works. The goal is to integrate new quality models to the meta-model whenever it becomes necessary.

3 EVOLUTIONARY APPROACH FOR QUALITY MODELS INTEGRATION

The analysis of the main existing quality models, such as CMMI (SEI, 2006), ISO/IEC 15504 (ISO, 1998), ISO/IEC 20000 (ISO, 2005), COBIT (IT Governance Institute, 2005), reveals distinct structures. Each model structure has a set of elements. By evaluating these elements individually, similar, or even equivalent, characteristics can be identified in different models. This section describes the evolutionary approach defined by the analysis, representation, comparison, and mapping among structural elements existing in the evaluated quality models.

3.1 Architecture Definition

This work proposes a method to build a meta-model with the aim of representing the structure of the analyzed quality models. UML was adopted as notation and OMG modelling architecture [(OMG, 2005), (OMG, 2006) and (OMG, 2007)] as architectural base.

The Quality Models meta-model is built by a method, detailed in the section 3.2. This method intends to create and maintain the meta-model and a mapping table. The mapping table registers how every structural element from quality models is represented in the meta-model.

We propose an evolutionary approach that allows the gradual evolution of the meta-model. This way, as the result of successive execution of the method for different quality models, the meta-model will show a continuous stability growing, being able to represent a high number of quality models.

3.2 Method Description

The proposed method intends to create and maintain the meta-model and the table mapping. Both meta-model and table mapping are created and incrementally expanded by analyzing each quality model.

The method shall be executed every time a new quality model is being integrated. The execution of the method for an specific model, shall bring as result that 1) the meta-model actualization to incorporate the specific characteristics of the quality model in evaluation, or 2) the quality model mapping to the meta-model, when the meta-model is already contemplating all characteristics.

This method has two stages of execution. The first stage proposes the meta-model development. Quality model structure analysis, quality model structure modelling, meta-model mapping, and meta-model adaptation are the activities performed during this stage. The second stage proposes the meta-model stabilization. Content mapping and pilot testing are the activities performed during this stage. In case defects are found during testing execution, they can be fixed by performing both meta-model mapping and meta-model adaptation activities.

Quality model structure analysis activity goals are: quality models analysis and structure identification. The identification of the structural elements and their relationships comes from the documentation reading. Some quality models have a graphical or textual representation of its structure in the documentation. This representation can be very helpful to the analysis. However, it cannot be considered as a definitive representation of the model and does not eliminate the need of an analysis.

Quality model structure modelling activity intends to formalize the quality model structure in a diagram. A class diagram from UML is the notation adopted. This notation allows the static representation of all structural models and their relationships. Only the conceptual modelling is done. This activity can be performed in parallel with quality model structure analysis activity. Every structural element is represented as a class and their relationships are represented as classes association.

Model mapping activity uses the Mapping Table artefact (Figure 1), where each column indicates the quality model analyzed and the last column is reserved to the meta-model elements. Every time the method is executed, a new column is included. The comparison is used to decide which elements are equivalents.

Mapping Table			
Model 1	Model 2	Model N	Metamodel
<element 1>	<element x>	…	<element a>
…	…	…	…
<element n>	<element z>	…	<element c>

Figure 1: Mapping Table.

Each element analysis leads to decide either if there is a correspondent element in the meta-model or if it is necessary creates a new element. This decision is made based on the equivalency analysis between the elements concepts, not only using their names. When the element concept already exists in the mapping table, the element name is included in the same line that the element is presented in the meta-model and in the column related to the quality model being analyzed. When the element concept does not exist in the mapping table, then a new line is included and filled out in both quality model and meta-model columns. In this case, the meta-model adaptation activity needs to be executed also. The element name to be given in the meta-model depends on how representative it is comparing with the other quality models. If a given element exists in only one quality model, then it will receive the same name in the meta-model column. If the element exists in several quality models, then the meta-model element will be named by the most popular one.

Meta-model adaptation activity involves the inclusion of new elements in the meta-model and their relationships adjustments. This activity uses the mapping table and the class diagram as input. As result of its execution, the meta-model is modified. The first step is the new elements inclusion. For each new line included in the mapping table a new class is created in the meta-model. Besides, the relationships between the new element and the existing ones are created. These relationships and their multiplicities are imported from the class diagram. The second step consists of adjustments on existing relationships. These adjustments are needed when the element is not new, and its relationships rules are different in the quality model that is being analyzed.

Content mapping activity intends to create an instance of the quality model. The quality model needs to be codified and stored according to the meta-model. This activity is the one that demands the higher effort in the method. The content transfer is executed over whole quality model. As many data is found, greater is the effort to execute this activity. Once the mapping is done, the tool can be used to support the quality models integration several times. This approach does not include the tools necessary to perform this task; neither restricts it to a specific software solution. The elaboration of a tool is not in the scope of this work. However, it is considered as future work on the ongoing research.

Pilot testing activity involves the meta-model verification and consists on using the mapped quality models content to help a SPI project.

3.3 Method Execution: First Stage

The first stage of the proposed method was applied in four quality models (CMMI, ISO/IEC 15504, ISO/IEC 20000 and COBIT) in order to test the method and produce both the meta-model and the mapping table. An additional analysis was done to verify the meta-model applicability against a quality model that was not used on its development (MR-MPS).

The activities defined in the second stage were not performed as they need a software tool and an organization with a SPI project. Those activities are characterized as future work.

3.3.1 CMMI

The CMMI version 1.2 was analyzed. The CMMI is presented in a single volume available online (SEI, 2006). Both continuous and stage representations were analyzed.

Quality model structure analysis: The available documentation presents a high level structure for this model. CMMI has processes area, maturity levels, purpose statement, introductory notes, related process areas, specific goals, specific practices, typical work products, sub-practices, generic goals, capability levels, generic practices, generic practice elaboration, process area categories, disciplines and discipline amplification. The introductory notes were considered not important to models integration.

Quality model structure modelling: The structure was modelled based on the information obtained in the previous activity. A conceptual class diagram was created to formalize the structure of the model.

Meta-model mapping: As CMMI was the first quality model analyzed, there was no meta-model to map the elements. In this case, the mapping was direct. A mapping table was created with all structural elements from CMMI.

Meta-model adaptation: No adaptation was needed as CMMI was the first quality model analyzed.

3.3.2 ISO/IEC 15504

The ISO/IEC 15504 version 1998 was analyzed. The reference model, described in the part 2 documentation was utilized (ISO, 1998).

Quality model structure analysis: The documentation presents a description of the structure. This standard presents process life cycle, process categories, processes, notes, purpose statement, process results, sub processes, processes attributes, capability levels and process outcomes.

Quality model structure modelling: The structure was modelled based on the information obtained in the previous activity. A conceptual class diagram was created to formalize the structure of the model.

Meta-model mapping: The existing mapping table was incremented during this analysis. Every element found (ISO/IEC 15504) was compared against the existing ones (CMMI) and the proper mapping was done. Two new elements, called process life cycle and sub-process, were included. The process category (ISO/IEC 15504) was considered equivalent to process area category (CMMI) based on the similarity of their contents and purpose. The processes (ISO/IEC 15504) were considered equivalent to process area (CMMI). In both cases the name adopted in the meta-model was the more generic: process area and process. The remaining elements were considered existents in the meta-model because of their equivalency to CMMI elements.

Meta-model adaptation: The meta-model was adapted to contemplate the new elements and to adjust the associations as needed.

3.3.3 ISO/IEC 20000

The ISO/IEC 20000 version 2005 was analyzed. Both specification and Code of Practice (ISO, 2005) were utilized during the analysis.

Quality model structure analysis: The structure of ISO/IEC 20000 was defined in this work by reading the available documentation. The identified structure has process, process areas, objective, requirements, notes, clarifications, good practices and references to other processes.

Quality model structure modelling: The structure was modelled based on the information obtained in the previous activity. A conceptual class diagram was created to formalize the structure of the model.

Meta-model mapping: New structural elements were not found during the ISO/IEC 20000 analysis. All elements were included in the mapping table and mapped to the meta-model. It was not necessary change the meta-model names, as they were already generic and were referring the concepts found in ISO/IEC 20000. On despite of having the process area element in both ISO/IEC 20000 and CMMI, they do not have the same meaning. The process area element in ISO/IEC 20000 has a similar concept and the same characteristics that process areas categories in CMMI and process categories in ISO/IEC 15504.

Meta-model adaptation: The third version of the meta-model presents structural characteristics compatible with CMMI, ISO/IEC 15504 and ISO/IEC 20000. It was not necessary create new concepts. Only the relationships were adjusted.

3.3.4 COBIT

The COBIT version 2005 was analyzed. The quality model is presented in a single documentation, which has its specification (IT Governance Institute, 2005).

Quality model structure analysis: The COBIT documentation presents a complete description of its structure, which is more complex than the others already analyzed and presents a high number of structural elements. COBIT presents domains, IT processes, business and IT objectives, metrics, control requirements, IT governance focus areas, IT

Mapping Table				
CMMI	ISO/IEC 15504	ISO 20000	CobiT	Meta-model
	Process life cycle			Process life cycle
Process area category	Process category	Process Area	Domain	Process category
Process area	Process (basic type)	Process	Process	Process
	Process (component type)			Sub process
Refer to	Note	Note		Note
Process area purpose	Process purpose	Objective	Purpose	Purpose
Specific goal	Processo outcome	Requirement	IT Goal / Business Goal	Goal
Specific practice	Processo outcome	Best practice	Activity	Practice
Sub practice	Processo outcome			Sub practice
Tipical work product			Work Product	Work product
Discipline				Discipline
Discipline amplification				Discipline amplification
Maturity Level				Maturity Level
Capability level	Capability level		Maturity Level	Capability level
Generic goal	Process attribute			Process attribute
Generic practice	Attribute outcome			Attribute outcome
Elaboration			Process Maturity Level	Attribute elaboration
			Role	Role
			Governance Focus Area	Governance Focus Area
			Resource	Resource
			Business Requirement / Generic Control Requirement	Requirement
			Metric	Metric
			Control Objective	Control Objective

Figure 2: Mapping table final version.

resources, roles, responsibilities, process activity, input and output products and maturity levels.

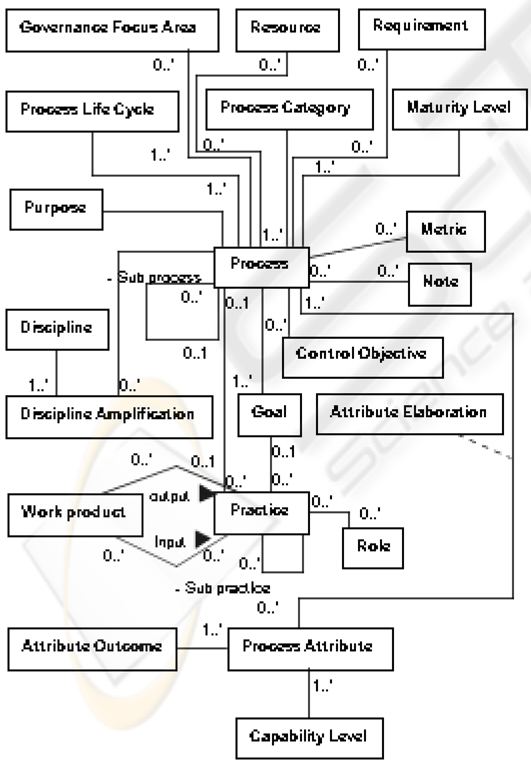

Figure 3: Meta-model final version.

Quality model structure modelling: The structure was modelled based on the information obtained in the previous activity. A conceptual class diagram was created to formalize the structure of the model.

Meta-model mapping: New structural elements were found during the COBIT analysis, as roles, governance focus area, IT resources, business requirements, control requirements, metrics and control objectives. All elements were included in the mapping table (Figure 2) and mapped to the meta-model. It was not necessary changing the meta-model names, as they were already generic and were referring the concepts found in COBIT. The analysis has shown that the element maturity level found in COBIT has the same meaning that the capability level in the meta-model.

Meta-model adaptation: The new elements found were included in the meta-model. Also, the association between work product and practices were adjusted to incorporate the concepts of input and output artefacts. The final version of the meta-model (Figure 3) presents structural characteristics compatible with CMMI, ISO/IEC 15504, ISO/IEC 20000 and COBIT.

3.3.5 Meta-model Applicability

The MR-MPS is a reference model of software processes, which is part of MPS.BR project (Brazilian Software Process Improvement). According to (SOFTEX, 2008), the MPS.BR intends to define and improve a software process improvement and assessment model. The MR-MPS quality model was utilized to verify the meta-model applicability. Its structure was analyzed and mapped to the meta-model.

The MR-MPS has processes organized in processes classes. Each process has a purpose statement, expected results and additional information. Additional information was not considered a structural element as it brings references to other standards to help on MR-MPS interpretation and process definition. Also, the processes have process attributes that show their institutionalization level and have expected results.

The analysis shown that it was not necessary any adaptation in the meta-model. All structural elements were already represented in final version of the meta-model (Figure 3). Also, the relationships were compatible with MR-MPS model. The compatibility between the model and the meta-model demonstrates the meta-model applicability to MR-MPS. This result is justified by the origin of MR-MPS, which is based in both CMMI and ISO/IEC 15504.

4 CONCLUSIONS

The organizations are investing effort to adopt and obtain several different certifications in order to prove their capabilities and maturity. However, the integration of these efforts represents an extra challenge to the organizations, especially in software engineering. Select some solution among all the existing ones and apply it in an integrated way is not trivial whereas it is necessary to maximize the results.

This paper described the initial results of an ongoing research. An evolutionary approach for quality models integration was created and the first stage of its application was demonstrated in a systematic way. As a result, a meta-model representing the structure of four different quality models (CMMI, ISO/IEC 15504, ISO/IEC 20000 and COBIT) was developed. As future work a tool to support the method execution and its testing in a real SPI project must be implemented.

From the theoretical point of view, this research has been contributing to the software engineering on exploring the main factors involved on integrating the analyzed models, techniques and good practices. It contributes to improve the existing studies and to provide a method to integrate some of the existing quality models. Last, it contributes to the experimental software engineering on evaluating possible ways to do empirical studies in software quality area, its difficulties and easiness.

From the researchers' point of view, this work contributes to their professional and academicals learning and development, by being part of a research that is being done with methodological rigor. Besides, it contributes to provide interaction between industry and academy, using the academic resources and knowledge to solve the problems found in the industry.

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