STRUCTURE OF PROCESS-BASED QUALITY APPROACHES - ELEMENTS OF A RESEARCH DEVELOPING A COMMON META-MODEL FOR PROCESS-BASED QUALITY APPROACHES AND METHODS

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Abstract

The paper describes the basic idea and the first steps of a PhD research program, having the goal to develop a common meta-model for different software quality approaches and methods. At this time, we focus on presenting the structure of 6 widespread quality approaches emphasizing the similarities amongst them. Understanding the structure of quality approaches helps converting textually described approaches into graphical representation. A graphical representation could help supporting organizations in using multiple quality approaches and methods in the same time.

Keywords: Software Process Improvement, CMMI, ISO 9001:2000, modeling quality approaches, structure of quality approaches.

1 INTRODUCTION

Several quality methods, standards and models have been developed in the last few decades to guide software developing organizations in defining and institutionalizing their processes. These approaches are essential in improving the company’s own quality system, but each of them uses an own view on quality.

However, software companies (want to / are forced to) use more quality approaches simultaneously, they often struggle with interpreting them, due to different terminology and their different point of view on quality.

In the day-by-day consultancy work, we experienced that software companies often implement quality approaches separately, without unifying or harmonizing the common elements. Problems connected to process interpretation and implementation usually come when companies have separated process descriptions for different quality approaches and methods. In this case, project managers have to choose between approaches. Due to the different standards, projects are focusing in different ways on quality. Some (eg. ISO 9001:2000) projects are focusing on measurement of customer satisfaction and customer relationship management but not on technical solution and product integration. Others (eg. in CMMI-based projects) may concentrate on requirements development, management and traceability, but not on handling the customer's property.

The situation may become more complicated, when the processes built on different quality approaches include different descriptions of same areas (eg. change management or measurement).

Our work has the scope to give a solution to the problem described: defining a meta-model would be useful to harmonize the quality-related concepts from different approaches.

The PhD research program planned for 4 years (2007-2010) has the following main steps:

- comparing elements of selected quality approaches;
- selecting the possible main elements to be used for the meta-model;
- examining the content and structure quality approaches and methods;
- examining quality of transformations, especially information loss during transformations;
- research in the field of enterprise modelling and selecting the useful concepts of the field;
- developing the first version of the methodology/meta-model and testing it at Hungarian and Dutch companies;
- refinements on the meta-model, based on practical results, developing final version.

The meta-model would make use of elements found to be common in more quality approaches, structuring them in a way that would be acceptable in connection with more quality approaches.

In the first phase of our research we focused on studying modelling techniques and on understanding basic elements of well known quality approaches and methods, in order to be able to choose the common elements that would form the basis of the meta-model. Here we present results of our investigation.

In order to model the quality approaches, we considered important to know the elements and structure of them, therefore ***our research question was the following: What are the elements of quality approaches?***

We provide brief literature reviews connected to different steps of the research at the beginning of chapters 2, 3 and 5.

Chapter 2 of this paper summarises the process modelling evolution, based on G. Cugola's and C. Ghezzi's point of view. In chapter 3 we present our research aspects. Afterwards (in chapter 4) we describe the base structure of the most used (software) quality approaches (as ISO 9001:2000, ISO 9004:2000, ISO 90003:2004, CMMI-DEV v1.2, ISO-IEC 12207-95 and ISO-IEC 15939-2002). We show a comparison of the elements of quality approaches mentioned with the elements of a process. In chapter 5 we present the application of modelling process to Nelson and Monarchi quality modelling framework. Finally, in chapter 6 we present an idea for harmonising common areas of quality approaches. We conclude by presenting a summary of the results obtained in exploring the structure of quality approaches.

2 PROCESS MODELLING

In "Software Processes: a Retrospective and a Path to the Future" Cugola et al. (1998) have shown (table 1.) the main steps of software process evolution starting from the early 60's. In table 1 strengths and weaknesses of lifecycle models, methodologies, formal development, automation, management and improvement are shown.

#	Name	Examples	Strength	Weakness
1.	Lifecycle models	Waterfall model	Well structured, clear documentation	Idealised processes

#	Name	Examples	Strength	Weakness
2.	Methodologies	Jackson System Development (JSD), JSP	Based on experiences from previous projects	Informal notation, increased paperwork
3.	Formal development	Program development by stepwise refinement	Transforms specification to correct implementation	Not scalable, applicable only for small programs
4.	Automation	Software Development Environments (SDEs)	Automation of some areas of software production	Requirements specification, design decisions cannot be automated
5.	Management and improvement	ISO9001: 2000, CMMI, TSP, PSP	Indirect assurance of quality products	Increased bureaucracy

Table 1. – Evolution of software processes

After these approaches, a new era came for processes: process modelling and process programming. In process modelling there are several research works, like Process Modelling Languages (PML) – introduced by Osterweil (1987), Little JIL process modelling language (Osterweil (2007)), Oz Web – the first "decentralized" PSEE was developed at Columbia University., Endeavors, BPM or enterprise modelling Wortmann et al. (2007).

Process modelling can be classified in several ways, eg. by architectures and modelling approaches.

The minimalist process modelling approach describes only the most important elements of processes, and it is easily understandable for people. The maximalist approach describes and validates the whole process model. Processes built in maximalist way can be processed by computers, but are more difficult to understand by humans.

From the architectural point of view top-down process approaches start from the idea to the implementation, bottom-up approaches try to model the manifested processes.

We have chosen the following goal in the Ph.D work: to understand the structure of the process based quality approaches, and create a common meta-model in a minimalist way, which will be easily understandable for quality managers and project managers. Using this meta-model, processes could be built in a top-down or a bottom-up way.

3 RESEARCH METHODOLOGY

At the beginning of the work, our goal was to have practically useful results; therefore the following two aspects were considered important:

1. to analyse the structure of the ***widespread approaches***,
2. to ***describe the structure*** of approaches analysed in a very ***simple*** and understandable ***format***.

In order to satisfy the goal 1, in the project IKKK-GVOP-2004-3.2.2 we analysed the actual situation of software processes having table 1. in mind (IKKK 2008). Major Hungarian software companies were surveyed about their processes and development methodologies. We came to the conclusion that nowadays, management and improvement approaches are widely used. In the following, we concentrate on quality approaches focusing on management and improvement of software processes.

Process-based quality approaches are often textually described, and in order to model them we need to know what their basic elements are.

In Hungary, the most used and "mandatory" quality approach is ISO 9001:2000 - Quality management systems – requirements. At present 439 IT-related companies are ISO 9001:2000 certified. See IMCC

(2008) for the list of ISO 9001:2000 certified Hungarian software companies. Besides ISO 9001:2000, most used approaches are the Capability Maturity Model Integration (CMMI) and (Automotive) SPICE (Software Process Improvement and Capability dEtermination, also known as ISO/IEC 15504). While software companies use CMMI, suppliers of multinational car factories prefer Automotive SPICE as a second approach.

Further well-known standards connected to software processes are ISO 9004:2000, ISO 90003:2004, ISO-IEC 12207-95 and ISO-IEC 15939-2002.

Knowing what quality approaches companies are using, we selected the next approaches:

- CMMI for Development, Version 1.2
- ISO 9001:2000 Quality management systems – requirements
- ISO 9004:2000 Quality management systems – Guidelines for performance improvements
- ISO/IEC 90003:2000 Software Engineering – Guidelines for the application of ISO9001:2000 to computer software
- ISO/IEC 15939-2002 – "Information technology - Software measurement process"
- ISO/IEC 12207-95 – "Information technology - Software life cycle process"

Having in mind our second research aspect, we chose UML class diagrams for describe the structure of quality approaches. However, the approaches analysed could be described in several ways in UML class diagrams, to keep the simplicity, we used only the aggregation relationship between the elements.

4 STRUCTURE OF QUALITY APPROACHES

In this chapter we briefly present the structure of quality approaches selected in the previous chapter.

ISO 9001:2000 is an international standard which contains general requirements for quality management systems (QMS). The requirements included in this standard are so general that can be applied at any company.

Fig. 1 - The Structure of ISO 9001:2000, ISO 9004:2000 and ISO/IEC 90003:2000

Looking at this standard, we can see that it contains 9 chapters, which could contain subchapters and the subchapters also can contain further subchapters. Requirements of this quality approach can be found at subchapter and sub-subchapter level in sentences. Figure 1. shows the structure of ISO 9001:2000 and two, other ISO 9001:2000-connected standards.

The structure of ISO 9004:2000 “Quality management systems – Guidelines for performance improvements” and ISO/IEC 90003:2000 “Software Engineering – Guidelines for the application of ISO9001:2000 to computer software” are identical to ISO 9001:2000 because these are using ISO 9001:2000 as a basis, containing the same chapters. The only difference amongst them is that the latter two define guidelines instead of focusing on requirements.

As we already mentioned, other two widespread approaches are CMMI and SPICE. CMMI is an integrated model, it integrates ideas from CMM, SPICE and further international quality standards, therefore most of the requirements of the SPICE model can be derived from CMMI. Here we focus on CMMI.

The actual version of CMMI, v1.2 defines 3 constellations: CMMI for Development, CMMI for Acquisition and CMMI for Services. Different constellations include different sets of process areas of the model. Looking at its structure, the model contains required, expected and informative components. Informative components are guidelines, specific and generic practices are the concrete, expected requirements. Required components are derived from expected components. A CMMI practice is considered performed if there are enough evidences and affirmations available to prove the accomplishment, a goal is achieved if all the connected practices are performed, a process is implemented when all its goals are achieved. For more details see SCAMPI (2008).

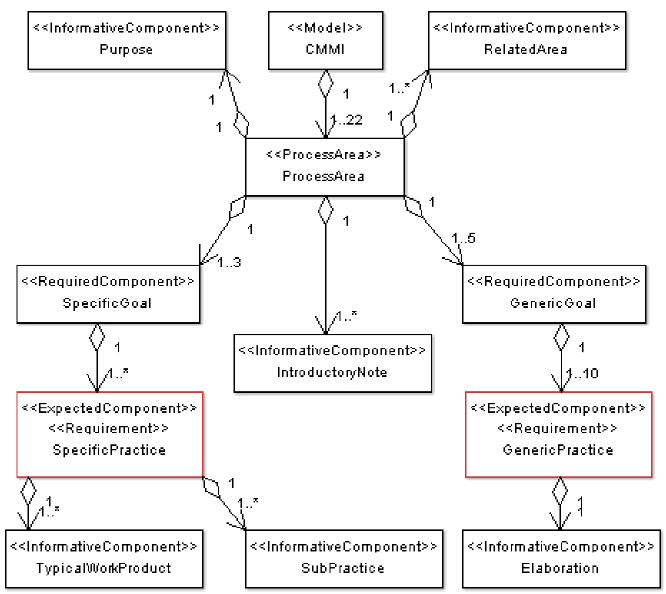

Fig. 2. - The Structure of CMMI-DEV v1.2

Standard ISO/IEC 15939-2002 – “Information technology - Software measurement process” defines process activities and sub activities required for the measurement process.

ISO/IEC 12207-95 – “Information technology - Software life cycle process” describes processes, activities, tasks, entry and exit conditions, responsibilities and documentation requirements for software lifecycle processes.

In this chapter have shown the structure of 6 different quality approaches. In each of them we found the elements *requirements* or *guidelines*. In ISO standards, requirements and guidelines are usually textually described, in sentences. In other approaches, like CMM, CMMI or SPICE different levels and categories of requirements can be found.

We started to analyse further approaches and methods like Agile methods and IT Infrastructure Library (ITIL) and we made similar observations.

We found in the presented 6 approaches several types of elements: eg. chapter, requirements, guidelines, process, process description, activity, process activity, activity description, task, option, entry and exit condition, documentation requirement, responsibility, process area, specific and generic goal, specific and generic practice, typical work product, subpractice, practice elaboration etc.

It is generally accepted by the software community that software processes are described by using the elements: *inputs*, *activities*, *outputs*, purpose, entry and exit criteria, roles, measures, and verification steps (see SEI (2006)). We considered the same elements as starting point for our disquisition and compared them to elements commonly used by software quality models.

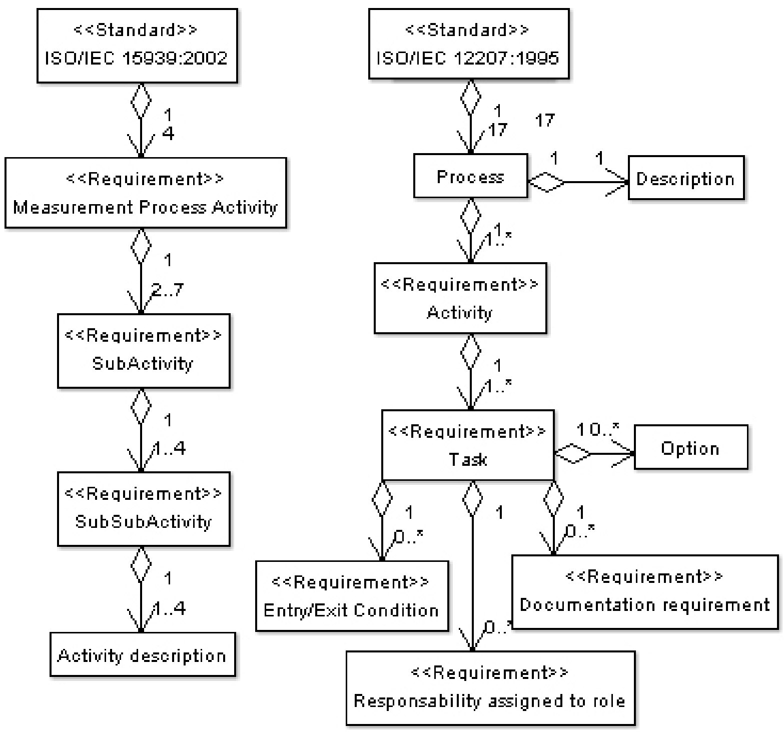

Fig. 3. - The Structure of ISO/IEC 15939-2002 and ISO/IEC 12207-95

We found several coincidences amongst elements of quality approaches and process elements. Process, process description, activity, process activity, activity description and task are proportional to the *activity* element of processes. Documentation requirements and typical work products are proportional are similar to *inputs* and *outputs*.

We found software quality model - element types which have no similarities to process elements. Such elements are eg. benefits, critical success factors, features or key performance indicators in ITIL.

Obviously, in order to model textual descriptions, it is not enough to analyse the structure, it is also important to know the content (fig. 4.). A content-based quality framework (Balla et al. (2001)) and support tool (Kelemen et al. (2007)) was already developed showing the objects and quality aspects of different quality approaches. We also consider important researches exploring the differences and similarities amongst quality approaches regarding the content, terminology, ROI etc. (Balla et al. (2001), Kelemen et al. (2008a)).

5 QUALITY OF MODELLING PROCESS

Exploring the structure of different process-based quality approaches and methods is just one step in transforming the textually described models to a more understandable and shorter graphical representation. Important question is how the quality of transformation can be assured?

However, the research area dealing with the quality of modelling process is still evolving (Nelson et al. (2007)), there are modelling frameworks already available. Such frameworks are the Lindland et al. (1994) framework (a recent revision in Krogstie et al. (2006)), the Wand and Wang framework (Wand et al. 1996) and Nelson's and Monarchi's model quality evaluation framework (Nelson et al. (2007)). These frameworks are concentrating on different objects and transformations, define several types of quality such as perceptual, descriptive, semantic, syntactic, pragmatic, inferential, physical, knowledge, tool, social or empirical quality.

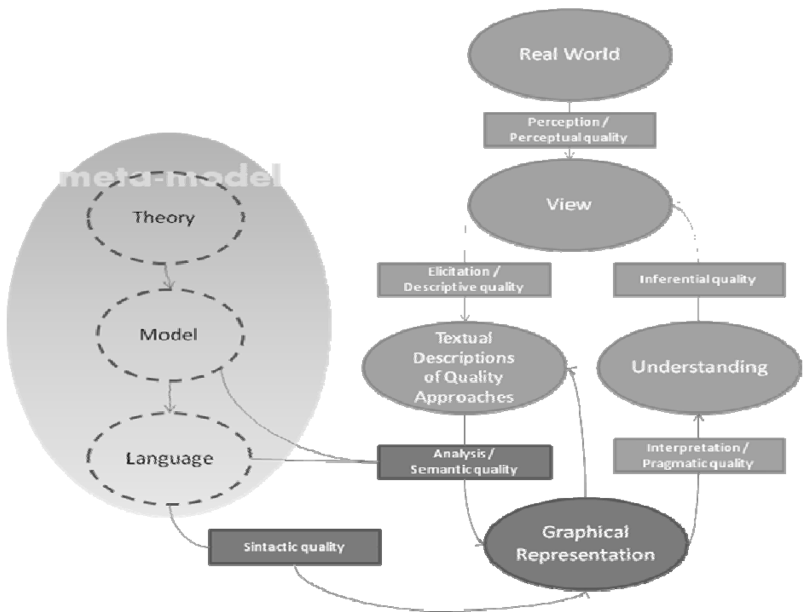

Fig. 4. – The quality approach modelling process in Nelson and Monarchi quality evaluation framework

Two main metrics of quality of modelling are completeness and validity. If B (the result of transformation) is missing some components that are present in A (the source of transformation) then B is incomplete (Nelson et al. (2007)). If the perception, elicitation, analysis and interpretation are complete and valid, there is a confidence that the overall method is complete and valid (Nelson et al. (2007)).

Nelson and Monarchi framework is known as the most recent from these all, it uses concepts from the other two frameworks.

In Nelson and Monarchi framework there are the following basic objects and transformations:

- Objects: The real world, View, Description, Representation, Understanding
- Transformations: Perception, Elicitation, Analysis, Interpretation, Implementation
- Analysis objects: Theory, Model, Language

If we use the Nelson and Monarchi framework in our modelling process besides developing a qualitative meta-model we need to focus on the semantic and syntactic quality in order to achieve a qualitative graphical representation. Pragmatic and inferential qualities are also important, because without these we cannot be sure that the user understands and forms the same view as the descriptor. In our point of view, perceptual and descriptive qualities are not so important because we already have the textual description of quality approaches.

6 CONCLUSION

In conclusion we can state that the idea to build a common meta-model for making the harmonisation of different of quality approaches and methods easier, seems both useful (as we emphasized in chapter 1) and feasible (chapter 2, 3).

In the first chapter we summarised the problems of simultaneously using multiple software quality models and standards. Modelling these approaches could provide a solution for the problems mentioned (as shown in chapter 2.). Process modelling architectures, approaches and modelling languages are available, which could serve a basis for the meta-model, some of them were mentioned.

Analysing the content of quality approaches we found that several approaches are focusing on the same problems (eg. change management can be found CMMI, ISO 9001:2000 and ITIL), but from different quality point of view.

Certainly, it is not enough to know the content of quality approaches, it is advisable to analyse their structure as well. Knowing the structure of quality approaches could serve a strong basis in identifying the main elements of the meta-model. Therefore, in chapter 4. we have shown the structure of 6 different quality approaches. Common elements were identified, examples of similarities and differences to process elements were shown.

We consider important to discover which parts of textual approaches can be modelled, and what are the elements/parts that cannot. In all the transformations the quality of modelling process must be assured. Some ideas connected to this subject were presented in chapter 5.

The way towards such a meta-model to model process-descriptive quality approaches requires further steps. We plan to continue the research with the following steps:

- analysing the structure and content further well-known quality approaches and methods;
- having discovered the main elements of quality approaches, selecting the possible main elements to be used for the meta-model;
- analysing process modelling languages, models and methods.
- examining information loss during transformations.

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