HOMOGENIZATION OF MODELS TO SUPPORT MULTI-MODEL PROCESSES IN IMPROVEMENT ENVIRONMENTS

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Abstract: Since almost two decades ago, process improvement has been evolving considerably. Proof of this is the increase in the amount of models (models and fact standards) that have been able to be referenced and taken as a basis on which to carry out process improvement. The heterogeneity of available models, together with the need to solve problems from many dimensions and organizational hierarchies, lead to organizations facing problems in improvement process projects which have to deal with different models at the same time. To balance these models, this paper sets out a homogenized structure as a support mechanism for the harmonization and integration of their different characteristics.

1 INTRODUCTION

It is increasingly important and necessary for organizations to take up work that allows them to broach process improvement in a multi-model environment. This is due to the fact that often the "addiction" to new or better practices in this kind of environments exists without any attention being given to the coordination and considerations needed to make the harmonization, integration and interaction of the models (Jalote, 1999) easier. Similarly, multi-model environments in software process improvement are present when an organization decides or needs to integrate into its processes different practices or characteristics that are present not in one, but in several models (Siviy et al., 2008a).

A difficulty in tackling process improvement in multi-model environments is the heterogeneity of how different models describe the process elements. This heterogeneity of those models is one reason why many organizations get overwhelmed and confused when making a decision about the choice and application of the model which is most pertinent to their needs. Such heterogeneity also comes about because these models describe elements of different knowledge areas and organizational requirements. In some cases similar practices may even exist. In general, each model specializes in a set of specific practices and in a different level of abstraction and detail. However, organizations can benefit from this heterogeneity and variety if they suitably select and complement the software processes from these models which fit well to their contexts.

Of the analysis carried out in (Pardo et al., 2009) and their upgrading with a systematic review, the most important works with related this proposal are (Biffl et al., 2006), (Ferchichi et al., 2008), (Siviy et al., 2008a), (Siviy et al., 2008b), (Siviy et al., 2008c) and (SPICE., 2008).

Related to the literature, this paper presents a common structure that allows us to carry out the homogenization of the process elements of two or more models as one of the aspects that is important in supporting the harmonization and integration of models. The proposed structure allows us to analyze

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the process elements described by different models under a common schema, to make harmonization easier. The structure is also a tool that supports the identification of differences and similarities, thereby making it more possible to understand the different models involved in the efforts in process improvement made by a given organization.

Apart from the present introduction, the paper presents: in section 2 the description of the structure for homogenization and an example of its application. Section 3 sets out the application of the structure and homogenization of some process entities of ISO 9001:2000. A set of lessons learned is summed up in Section 4. Section 5 features conclusions and future work.

2 STRUCTURE FOR HOMOGENIZATION

To define the structure for homogenization, it was first necessary to identify the process elements that it would be made up of and that were also common to any process model. Based on the analysis of the studies about the commonly-identified process elements presented in (Cugola et al., 1998), (Derniame et al., 1999) and (Fuggetta, 2000) and the most modeled process elements presented in (Benali et al., 1992), (Finkelstein et al., 1994), (McChesney, 1995), (Fuggetta et al., 1996) and (Huff, 1996), it was possible to establish a set of basic and common elements for any process model.

Likewise, when making a comparison to analyze the degree of correspondence with standard SPEM 2.0, it is possible to note that the process elements identified are present in the standard. This helps to prove the generality of the homogenization of our purpose. The process element “resource” isn’t defined in SPEM, however, this is just a generalization of roles and tools that may be found in a process model and that are defined in the standard.

Other possible elements can manage to shape the set of basic elements, like directly associated elements or decomposed elements from other elements, for example, steps and tasks of activities, in-out appliances, human resources, time and so on. Decomposition of elements allows us to detail and match the information of models with more granularity and/or detail. Thus, it will be possible to evaluate the granularity of each model throughout the structure. The generic structure is based on the following works (Fuggetta, 2000), (Cugola et al., 1998), (OMG, 2008), (Derniame et al., 1999) and (Acuña et al., 2001).

2.1 Modeling of the Structure

Figure 1 presents the conceptual modeling of the structure that uses the elements of a previously defined process model, covering the object model, attributes and its respective data types. As shown in this figure, in general each model grouped together all processes in different categories or processes groups, in the same way each process is formed by a set of elements or characteristics such as: activities, tasks, roles, products or appliances, measurements, and so on. This first version doesn’t aim to deal with characteristics of all existing models. It does set out to take account of the more common ones, as well as the ones defined in the models analyzed, making its future adaptation possible.

2.2 Structure Description

Common structure for the homogenization of different models is divided into four sections, which are described next:

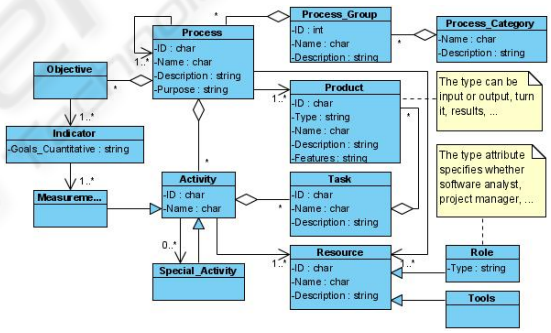

Figure 1: UML modeling of the structure for homogenization.

- Section 1: Description. Includes the process description, process group, process, activities and related tasks;
- Section 2: Roles and Resources. Includes the tools, resources, roles and work disciplines defined to carry out the process development, activities or tasks;
- Section 3: Control. Relates the work products or appliances, deliverables, results, goals and measurements that serve as verification milestones in the execution of an activity or task;
- Section 4: Additional information. Involves related processes and methods needed to obtain a purpose.

Table 1: Comparison of models at a high level.

Section	Stereotypes and elements	12207	CMMI	COMPETISOFT	COBIT	PMBOK
Section S1D: Description	SD1.1 Process group	X	X	X	X	X
	SD1.2 Processes	X	X	X	X	X
	SD1.3 Activities	X	X	X	X	
	SD1.4 Tasks	X	X			
Section S2RR: Roles and resources.	S2RR1 Roles			X	X	
	S2RR.2 Tools					X
Section S3C: Control.	S3C.1 Artefacts		X	X	X	X
	S3C.2 Goals			X	X	
	S3C.3 Metrics			X	X	
Section S4IA: Additional information	S4AI.1 Related processes		X	X	X	
	S4AI.2 Methods					X

In table 1 an example of the structure application is set out, comparing several models at a high level of abstraction. This comparison allows us to know if a model defines or not the process elements in comparison to other models, taking as a basis the process elements established in the structure.

If we analyze one of the homogenized models in the table 1, for example CMMI, we can notice that according to the process elements of section 1 or SD1, the match will be equal to: process groups (Category), processes (purpose, introduction notes, and specific or generic objectives), activities (specific and/or generic practices) and tasks (subtasks).

2.3 Steps for Homogenization of Models using the Structure

To describe the process elements making use of the proposed structure, we suggest three steps:

P1. Structure Analysis and Terminology. The analysis of the structure of a model can turn out to be one of the initial implicit steps in carrying out the implementation or improvement project. Homogenization supports an exhaustive analysis of terminology, syntaxes and identification of specific words for the models. Although it won't be necessary to perform a rigorous analysis on all models, it is important to bear in mind that the analysis will serve as a way to identify criteria that allow us to establish an objective matching of information and model process elements in relation to each one of the structure elements.

P2. Identification of Requirements. Once the analysis has been done, it is possible to carry out the identification of requirements of software process to be homogenized. That allows us to identify which information of the model will be matched and organized in the structure elements. The effort involved in the first two steps depends on the granularity level and the detail of the model.

P3. Correspondence. Element Correspondence is the last of the steps to perform in a model homogenization. Such correspondence shows the models reorganized in the four sections of process element described by the proposed structure. The object of homogenization is to prepare the models for harmonization in multi-model environments.

3 IMPLEMENTATION OF THE STRUCTURE

In this paragraph we describe the steps carried out for the homogenization of models and requirements contained in ISO 9001:2000 (ISO, 2000).

To perform a first homogenization we decided to take ISO 9001, for two reasons: (i) because it is one of the standards which is useful and widespread at the present time and (ii) because it is one of the most subjective standards about what to do and how to do it.

3.1 Homogenization of ISO 9001:2000

We will now give a brief summary of the application of the steps described, implementing the common structure in homogenization of the ISO 9001:2000 standard. The analysis of the standard was carried out in the same way as other authors (Paulk, 1993), (Paulk, 1994), (Paulk, 1995), (Mutafelija et al., 2003a), (Mutafelija et al., 2003b) and (Mutafelija et

al., 2003c), where the requirements are identified by analyzing the "Shall" and "Should" statements. A syntax that allowed us to better identify the practices required by the standard was established , thereby decreasing a large part of the ambiguity and subjectivity that is an integral part of trying to understand it; see table 2.

An example of the result of the homogenization is shown in Annex 1. On the Annex, clause 4 is organized and structured according to the quality management system. In this table we can see that not all the elements of the four sections of the general structure found any correspondence, this is because the standard "doesn´t define" or set out detailed information for that correspondence.

ISO 9001 neither defines nor documents clearly many of the requirements that it suggests should be put into operation (for example activities, tasks and appliances). Correspondence and formalization of the information presented in it with regard to process elements of structure, had made it more possible to understand the requirements associated with it. An example is the identification and correspondence of activities and appliances.

Due to the limitations on space, the information presented in Annex 1 have been summarized. For greater detail about the models analyzed, we suggest the corresponding reference be consulted.

Table 2: Syntax to identify the requirements in ISO 9001.

Syntax	Description
1. Shall [verb] 2. Shall [verb] … and [verb]	This statement indicates the actions, activities, tasks or procedures that the organization that will develop it will have. It is probable that this statement will be used to describe one or several actions or to derive processes.
3. Begins for [shall] or shall [verb] that	Identifies a list of derived requirements of processes, procedures, activities or tasks.
3. Shall be [verb]	Indicates the characteristics associated with a process, or possible roles or work products.
4. Shall [include]	Indicates the details that the organization must include in a process or work product
5. Shall be [verb] + [by], [to] or [on]	This syntax helps to identify the detail of some procedures or processes.

The proposed structure has been also applied to ISO/IEC 12207, CMMI-ACQ V1.2, COMPETISOFT, COBIT 4.0 and PMBOK.

4 LESSONS LEARNED

Having put this proposal into practice, we have learned a series of lessons:

- Correspondence of process elements is carried out according to the investigator's criterion. A set of basic criteria for supporting the analysis and identification of requirements in the models needs to be found and recorded, along with the steps suggested for homogenization.
- ISO 9001 neither defines nor sets out clearly many requirements that it recommends implementing (for example activities, tasks and appliances). Correspondence and formalization of the information shown on it according to the process elements of the structure, has made it easier to understand the requirements associated with it.
- Granularity and flexibility in the incorporation of process elements allow us to address the description of new elements that are only present in specific models. An example is the correspondence of subpractices of CMMI.
- Analyzing the models from only the identification of the amount of declarations and/or requirements, either indicates only their correspondence (strong, medium or weak) in relation to other quality models. It might not be the best option in mapping or comparison of models, because in this kind of mappings it is only possible to identify the matches at a high level of abstraction. This leaves to one side other characteristics that could turn out to be important.
- Differences in words and structures used in the different models, makes the comparison with a simple mapping at a high abstraction level improbable. Dealing with that problem by the translation of a model into the terms of words and structures of other model, is even more difficult and less flexible. An option in solving this problem is to define a guide or process that guides and provides the tools needed for the harmonization and integration of different models.
- Process elements are components of great importance in the homogenization of models. Besides this, they make it possible to perform more objective mappings and or fine grain comparisons. They allow us to identify at a low level of abstraction how a model can be complemented with another in terms of its process elements and not only according to its purpose.

5 CONCLUSIONS AND FUTURE WORK

It is important to emphasize that the models from different representations are not incompatible and that there is the possibility of mapping characteristics to harmonize complementation in the improvement projects. In this sense, this paper proposes a common structure as one of the aspects to support the homogenization of different models that are used to carry out the process improvement of the organization. The goal of this work, besides allowing the organization of the different elements that are belong to each one of the models in a common structure for homogenization, is to make better comprehension and identification of the relationships or differences between different models more likely. It will thus be easier to carry out the identification and analysis of the level of detail (depth or granularity), overlap, complementarity, synergy and all the other concepts that may be present in the harmonization of multi-model environments.

This work will be the starting point from which a line of work will be developed. This is related initially to two aspects mentioned previously: the depth and overlap levels of different models. Depth and granularity would be characterized by the level of detail and the description of each one of the elements present and defined in a model. The overlap would be represented by the level of similarity, coincidence or differentiation between processes that each one of the models is made up of. This comparison would be carried out to allow the organizations to choose the most appropriate process for providing better practices that help give solutions to their needs. Additionally, practical reports will be carried out and written up on and here is where the benefits of the homogenization and harmonization of models can be seen easily.

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REFERENCES

Acuña, S. T., Antonio, A. D., Ferré, X., López, M. and Maté, L., 2001. *The Software Process: Modelling, Evaluation and Improvement*. Handbook of Software Engineering and Knowledge Engineering. I. S. K. Chang. New Yersey (EE.UU), World Scientific. 1 Fundamentals: 193-237.

Benali, K. and Derniame, J. C., 1992. "Software process modeling: What, who and when." *Software Process Technology, Lecture Notes in Computer Science*.

Biffl, S., Winkler, D., Höhn, R. and Herbert Wetzel, 2006. "Software process improvement in Europe: potential of the new V-modell XT and research issues." *Software Process: Improvement and Practice* 11(3): 229-238.

Cugola, G. and Ghezzi, C., 1998. "Software Processes: a Retrospective and a Path to the Future." *Software Process: Improvement and Practice* 4(3): 101-123.

Derniame, J.-C., Kaba, A. B. and Warboys, B., 1999. *The Software Process: Modelling and Technology*. Software process: principles, methodology, and Technology. C. Montenegro. Germany, Springer: 1-12.

Ferchichi, A., Bigand, M. and Lefebvre, H., 2008. An Ontology for Quality Standards Integration in Software Collaborative Projects. In *First International Workshop on Model Driven Interoperability for Sustainable Information Systems (MDISIS'08) held in conjunction with the CAiSE'08 Conference*, Montpellier, France.

Finkelstein, A., Kramer, J. and Nuseibeh, B., 1994. "Software process modelling and technology." *Advenced Software Development Series* 3.

Fuggetta, A., 2000. Software process: A Roadmap. In *International Conference on Software Engineering (ICSE)*, ACM Press.

Fuggetta, A. and Wolf, A. L., 1996. "Software process." *Trends in Software* 4: 89-100.

Huff, K., 1996. "Software process modeling." *Trends in Software: Software Process*.

ISO, 2000. *ISO 9001:2000. Quality management systems - Requirements.* Ginebra, International Organization for Standardization.

Jalote, P., 1999. *CMM in Practice: Processes for Executing Software Projects at Infosys.*

McChesney, I., 1995. "Toward a classification scheme for software process modelling approaches." *Information and Software Technology* 37(7): 363-374.

Mutafelija, B. and Stromber, H., 2003a. Exploring CMMI-ISO 9001:2000 Synergy when Developing a Process Improvement Strategy. BearingPonit, Inc. & Hughes Network Systems. In *SEPG 2003*, Boston, MA.

Mutafelija, B. and Stromber, H., 2003b. *ISO 9001:2000 - CMMI V1.1 Mappings*, Software Engineering Institute: 31.

Mutafelija, B. and Stromber, H., 2003c. *Systematic Process Improvement Using ISO 9001:2000 and CMMI*.

OMG, 2008. "*Software & Systems Process Engineering Meta-Model Specification. SPEM 2.0.*" from http://www.omg.org/cgi-bin/doc?ptc/07-08-07

Pardo, C., Pino, F., García, F. and Piattini, M., 2009. Homogenización de marcos en ambientes de mejora de procesos multimarco. In *XII Conferencia Iberoamericana de Ingeniería de Requisitos y Ambientes de Software.*, Medellín, Colombia.

Paulk, M. C., 1993. "Comparing ISO 9001 and the Capability Maturity Model for Software." *Software Quality Journal* 2(4): 245-256.

Paulk, M. C., 1994. *A Comparison of ISO 9001 and the capability maturity model for software*, Software Engineering Institute, CMU/SEI-94-TR-12.

Paulk, M. C., 1995. "How ISO 9001 compares with the CMM." *IEEE Software* 12(1): 74-83.

Siviy, J., Kirwan, P., Marino, L. and Morley, J., 2008a. *The Value of Harmonization Multiple Improvement Technologies: A Process Improvement Profesional's View*, Software Ingineering Institute, Carnegie Mellon: 15.

Siviy, J., Kirwan, P., Morley, J. and Marino, L., 2008b. *Maximizing your Process Improvement ROI through Harmonization*, Software Engineering Institute (SEI). Carnegie Mellon University: 16.

Siviy, J., Kirwan, P., Renato, V., Peter, K. and Gerhard, G., 2008c. SEPG Europe 2008. In *Multimodel Improvement in Practice*.

SPICE., 2008. "*Enterprise SPICE.*" An enterprise integrated standards-base model from http://www.enterprisespice.com/.

Annex 1: Homogenization of Clause 4 of ISO 9001:2000 in the process elements of the common structure.

<table>
<tr><td colspan="2">SD1.1 Processes group</td><td colspan="2">4. System of Quality Management</td></tr>
<tr><td rowspan="5">SD1.2 Processes</td><td>ID</td><td colspan="2">Clause 4.</td></tr>
<tr><td>Name</td><td colspan="2">System of Quality Management</td></tr>
<tr><td>Purpose</td><td colspan="2">The organization shall establish, document, implement and maintain a system of quality management and continually improve its effectiveness in accordance with the requirements of this international standard.</td></tr>
<tr><td>Description</td><td colspan="2">General Requirements. The organization must: literally) identify the processes needed for the system of quality management and its application across the organization.</td></tr>
<tr><td>Objectives</td><td colspan="2">Are defined implicitly.</td></tr>
<tr><td colspan="3">SD1.3 Activities</td><td>S3C.1 Artefacts</td></tr>
<tr><td colspan="3">1. Clause 4.1 concerning the general requirements, referred to in subparagraphs a, b, c, d, e and f, a set of responsibilities and processes that the organization must take into account in the System of Quality Management, for example ensure the availability of resources and information, tracking, measuring, and so on.
Note in this clause also refers to processes to include: management activities, provision of resources, product creation and measurement</td><td rowspan="4">1. In clause 4.2.1, literal a, b, c, d and e, are listed artifacts which the documentation system of quality management should include. For example, the statements of a documented quality policy and quality objectives, quality manual, documented procedures required by this international standard, among others.
2. Clause 4.2.2, literal a), b) and c) lists what the quality manual should contain. For example, the scope of the system of quality management, including details and justification of any exclusion, the documented procedures established for the system of quality management, or reference to, and a description of the interaction between the processes' system of quality management.</td></tr>
<tr><td colspan="3">2. Note 1 of Clause 4.2.1 describes the term "documented procedure" as referring to a procedure that must be supported by processes to establish, document it, implement it and maintain it.</td></tr>
<tr><td colspan="3">3. Clause 4.2.3 Control of documents relating to the list in the literal a, b, c, d, e, f, g, a set of controls necessary to carry out this procedure (for example, approve, review, update documents, and so on).</td></tr>
<tr><td colspan="3">4. In clause 4.2.4 concerning the Control of records, records that are established, maintained, remain legible, readily identifiable and retrievable. There should be a documented procedure to define the controls needed for identification, storage, protection, retrieval, retention time and disposition of records.</td></tr>
<tr><td colspan="2">S4AI.1 Related processes</td><td colspan="2">The system of quality management ISO 9001 can relate clauses of its own or of others, for example in clause 4.2.1 General, subparagraph e), the clause 4.2.4. is related In clause 4.2.2 Quality Manual, literal a), clause 1.2. is related and in clause 4.2.3. Control of documents clause 4.2.4. is related.</td></tr>
</table>