Practices and Techniques for Engineering Process Capability Models

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Abstract

Software Process Improvement, based on a Maturity Level or a Process Capability Profile, from a Capability Maturity Model or an ISO/IEC 15504-based model, is well established in the software industry as a successful practical means for improving software intensive organizations. In consequence there is an opportunity to understand how these models have been developed and consolidate this knowledge to support the development of new models by a broader community including the industry. This article introduces practices and techniques of a Method Framework for Engineering Process Capability Models as an element of a methodology on a Process Capability Profile to drive Process Improvement. This method framework is based on previous experiences to develop different process capability models. Its current version is composed of sequential practices, customization rules, guidelines for using the framework, a repository for examples of utilization and another repository for examples of techniques. This method framework is part of a methodology. An initial validation indicates a first confidence that this method framework is a useful proposal for developing methods and processes for engineering process capability models.

Keywords: Software Process Improvement (SPI), Process Capability Model, PRO2PI Methodology, CMMI, ISO/IEC 15504.

1. INTRODUCTION

Around the 1980's, Watts Humphrey and others at the Software Engineering Institute (SEI) elicited and generalized good practices from few software intensive organizations that had been working well. Those practices were organized as sequential and cumulative maturity level as the Capability Maturity Model for Software (CMM or SW-CMM) [1]. With the success of CMM as a model of practical guidelines for a feasible practical improvement of software intensive organizations, a new area emerged: Software Process Improvement (SPI). SPI uses one or more best practices reference models to guide a process improvement. As an evolution of CMM model two frameworks of models were established: ISO/IEC 15504 International Standard for Process Assessment [2] and the Capability Maturity Model Integration (CMMI) [3]. CMMI is aligned with ISO/IEC 15504 and the CMMI-DEV model [2] is the successor of CMM. ISO/IEC 15504 is also known as SPICE (Software Process Improvement and Capability dEtermination) [4]. ISO/IEC 15504 has been renamed by ISO/IEC as the ISO/IEC 33000 series [5]. The CMMI-DEV and ISO/IEC 15504-based models are the current most relevant models used in SPI projects.

Although there is a consensus about the type of best practices reference model used for SPI [1,2,3], there is no consensus about the term to design this type of model. Therefore the term **Process Capability Model**, as proposed by Salviano and Figueiredo [6], is used to mean models of best practices organized with the concepts of process capability or process capability maturity. In this sense a Capability Maturity Model, as, for example, the CMMI-DEV (CMMI for Development) model [3], is a Process Capability Model. An ISO/IEC Process Assessment Model, as, for example, the ISO/IEC 15504-5 model [2], is a Process Capability Model as well. An eSourcing Capability Model, as, for example, the eSCM-CL model [7], is also a Process Capability Model. A Process Reference Model, as, for example, the Competisoft Model [8] or the MPS.BR MR-MPS model [9], is a Process Capability Model as well. There are other models of best practices organized with different concepts. These models are not Process Capability Models. The ISO 9001:2008 Quality management systems – Requirements, for example, is a model of best practices organized as a set of requirements without considering the concept of process capability. Therefore, ISO 9001 is not a Process Capability Model.

Even though the process capability models have been evolved since CMM model, basically the current SPI area continues the same as it was established around CMM. There are, however, forces around the successful current SPI that urge for a revision and evolution of SPI area [10]. In order to support and balance these forces, an innovative methodology has been developed as an exemplar methodology for a revised SPI area. This methodology is named as PRO2PI (**Process Capability Profile to drive Process Improvement**) [11]. One of these forces is related with the need to develop more process capability models. Therefore there is an opportunity to understand how process capability models have been developed and consolidate this knowledge to support the development of new models. The industry will participate more in this development, as models for more specific business context, for more specific domain or even for a specific organization will be developed as customization of relevant more generic models. Therefore the development of process capability models has become an industry demand and not only by research and development institutes and normalization organisms. Furthermore, the recent SPI Manifesto, produced by a group of SPI experts from all over the world, that what is important about SPI is that “SPI must involve people actively and affect their daily activities, is what you do to make business successful and is inherently linked with change” [12]. In our opinion this manifesto is coherent with the PRO2PI Methodology and indicates the need for the development of more models.

The initial objective was to develop a method as part of the PRO2PI methodology. During the construction, we realized that the variety of situations, however, raised significant risks to develop a single method. Therefore, we decided to develop a more abstract methodological element to support the definition of methods. We developed a **Method Framework**. This term is already used with similar meaning, similar objective and similar reasons for the Method Framework for Engineering System Architectures (MFESA) [13] which confirms the usage of this term within this context. The major difference from the meaning of method framework is that the method framework described in this article does not define the contextual elements because these elements are already provided by the PRO2PI methodology.

This article is organized as follows. This first section provides an introduction to the article and the motivation for this research. The second section describes the goals for the work, the methodology used to guide the work and the actual process used in the development of this work. The fourth section reviews previous experiences in developing models in order to provide a practical basis for proposing the method framework. The fourth section introduces the method framework and provides orientation for the detailed description of its context and components in the next three sections. The fifth section presents the methodology that provides the context for this method framework. The sixth section introduces two components: the practices and the customization rules. The seventh section introduces another component: the current set of examples of techniques. The eighth section reviews how those processes from the previous experiences described in Section 3 can be considered as examples of the method framework. The ninth section describes how this method framework has been used to the development of two models in a complex system. The tenth section provides initial validation and comments about related work. Finally the eleventh section presents some conclusions.

2. RESEARCH GOALS, METHODOLOGY AND PROCESS

This section establishes a main general goal and three derived objective goals for the proposed method framework and the methodology and the process used to guide the development of the method framework. The word process is used with the same meaning in at least three contexts. Developing the method framework is a process. Using the developed method framework to develop a process for engineering a model is also a process. Finally using the developed process for engineering a model is a process as well.

The main general goal is that the method framework is a useful proposal to support the developing of methods and processes for engineering Process Capability Models. This general goal is detailed into three derived objective goals in such way that if the degree of achievement of these derived goal support the degree of achievement of the general goal. The first derived goal (Goal G1) is that the method framework could be considered as a generalization of a given set of processes used to successfully develop Process Capability Models. In this way the method framework is a generalization of previous experiences and these experiences could validate the method framework. The second derived goal (Goal G2) is that the method framework could be considered as part of the PRO2PI methodology because developing models is in the scope of this methodology. In this way the method framework could reuse methodological elements of this methodology. The third derived goal (Goal G3) is that the method supports the planning and monitoring of a process to develop a model for best practices in a given complex system. In this way the method framework could be validated in a practical experience.

The development of this method framework followed the Process Capability Levels from ISO/IEC 15504 and CMMI as a methodology [2,3] because, as already mentioned in the previous paragraph, using the method

framework could be consider as a process. The set of Process Capability Levels provides a methodology to guide the improvement of a process from a Incomplete process (level 0), to a Performed process (level 1), then a Managed process (level 2), Established process (level 3), Predictable process (level 4), and finally a Optimizing process (level 5) [6]. First we participated and studied successful processes to develop models in order to construct knowledge about developing models. This is related with capability level 1 for a “process capability model engineering” process area. Then we planned, performed, monitored and controlled five successful processes to develop five different process capability models. This is related with capability level 2 for this same process area. The development of this method framework from an analysis of these five previous successful experiences in model development prepare for capability level 2. The engineering of a process capability model will be guided by a planned, performed, monitored and controlled process that is produced using the method framework.

Using this methodology, a process was planned and performed with the following eight activities to develop the method framework presented in this article: (1) preparation for the work; (2) identification and initial analyses of previous experience from our research group and from others groups; (3) revision of PRO2PI methodology to include the method framework; (4) development of a preliminary version of the method framework; (5) more disciplined revision of the previous experiences identifying including a relationship between the process used in each previous experience with the preliminary method framework; (6) revision of the method framework in such way that all previous experiences could be considered as examples of instantiation of this method framework; (7) usage of the method framework to plan a process to develop two process capability models for a complex system; and (8) revision and consolidation of the method framework.

3. STRUCTURED REVIEW OF PREVIOUS EXPERIENCES

This section reviews five previous successful experiences in which we experiment different processes to develop different process capability models. In addition four more experiences from others are presented. We also participated in some of these experiences from others. For each one of these nine experiences a structured review is presented with a phrase name (**in bold type**), a brief description, the activities of the actual planned and performed process used to develop the model, and examples of techniques used to develop the model.

3.1 Process for a model for education:

This model is actually just a new process area to cover the teaching of a technical course [14]. This process area is defined as a new process for the ISO/IEC 15504-5 model. The strategy was to abstract a process area from the current process used by the teacher. For the development of this process capability model for education, a process with the following activities was defined and used: (1) description of the current process used by the teacher; (2) analyses of the guidelines defined by the organization; (3) description of an improved process, following the ISO/IEC 15504-5 model, to be used by the teacher; (4) definition of a new process area for ISO/IEC 15504-5 such that improved process is an exemplar implementation; (5) assessment of the current process; and (6) revision and consolidation of the new process area. A technique defined and used for this process to gather best practices is to abstract a process area from an actual process.

3.2 Process for the MARES model

A specialization of the ISO/IEC 15504-5 model for Small and Medium Enterprises (SME) was developed as part of o project to develop a Method for Process Assessment in Small Software Companies (MARES) [15]. A process for the MARES Model, with seven activities, was planned and followed: (1) state of the art of process improvement in SME review and study of ISO/IEC 15504-5; (2) state of the art of methods and models for SPI in SME; (3) requirements definition for the proposed model; (4) development of a draft model; (5) evaluation through four case studies using the draft model; (6) revised draft model; and (7) evaluation through two new case studies. This process used two well known techniques: State of the art literature review to gain knowledge and to gather best practices, and case studies to validate a draft model.

3.3 Process for a CMMI specialization to CBSE

For a development of a process capability model for Component Based Software Engineering (CBSE) a process was defined and used [16]. The eight activities of this process were: (1) review the state of the art and state of the practice, in this case, for CBSE, (2) identify a process capability model more appropriate to be specialized for the domain (in this case CBSE), (3) identify or define a set of additional process areas to cover the major CBSE specific aspects, (4) represent these new process areas using the format of the base model, (5) identify process areas from the base model that needs customizations for CBSE and perform those customizations (6) identify other generic process

areas from other relevant models that are relevant for the domain and include them in the model, (7) consider practices from relevant organization that already implement good CBSE, include those practices as additional sources, and revise the model to cover these practices, and (8) use the model in CBSE organizations, analyze the results and revise the model. A technique defined for this process to gather best practices is to translate process areas from a given model (in this case the ISO/IEC 15504-5 model) to new process areas for another model (in this case the CMMI-DEV model).

3.4 Process for a CMMI specialization to banking domain

In the development of a specialization of the CMMI-DEV process capability model for software development in the banking domain [17], a process for a CMMI model specialization was defined and used with the following seven activities: (1) characterization of the domain, (2) selection of some process areas, (3) initial description of the domain, (4) exploration of the domain description and specialization of the selected process areas, (5) revision of the domain description and the process areas specialization, (6) validation; and (7) revision and consolidation. A specific technique predefined for this process is to describe a domain using phrases and to relate them to some practices of a model in order to determine if a practice from a model has higher, same or less relevance for that domain.

3.5 Process for the SPICE for Research model

For developing an ISO/IEC 15504-based process capability model for University Research Laboratory (SPICE for Research Model) [18, 19] a process was defined and used for the construction of this model. The six activities of this process are as follows: (1) state of the art review, (2) best practices survey, (3) process capability model draft design, (4) process capability model draft development, (5) process capability model validation, and (6) process capability model version 1.0. University Research Laboratory (URLab) is a unique environment that performs knowledge-intensive activities. The SPICE for Research considers the best practices investigated in some URLabs and the technical and scientific literature on knowledge management, research management, organizational management, and capability models. Two different communities validated SPICE for Research: the community of managers of research and the community of researchers with experience in process improvement [12]. Two specific techniques predefined for this process are using questionnaires to obtain information from experts in the domain and performing extensive literature review to understand best practices for the domain.

3.6 Generic process for consolidated models

There are a set of process capability models that can be considered as more relevant and more consolidated models, including the original SW-CMM model, CMMI models (CMMI-DEV, CMMI-SRV and CMMI-ACQ), ISO/IEC 15504 models (ISO/IEC 15504-5 and ISO/IEC 15504-6), other ISO/IEC conformant models (OOSPICE, Automotive SPICE, Enterprise SPICE and others), the e-SCM models, the MPS.BR model, the MOPROSOFT model and the COMPETISOFT model. For neither one of them, we could find a complete documented process about how each one was developed. There are only general information about the development, as, for example, the ISO rules and procedures to develop an International Standard. Up to now, we did not produce activities for the process used to develop these models.

3.7 Process for a leadership model

In a development of a process capability model for leadership of Integrated Virtual Teams, Tuffley [20] defined and used a process with the following five activities: (1) literature review; (2) process capability model draft development; (3) cases study using the draft model (4) results analyses and (5) model consolidation (with possible cycles of activities 2, 3 and 4).

3.8 Method for models from requirements transformation

Barafort et al. proposed a method to transform a set of requirements into a process capability model [21]. They followed this method to develop a process capability model for IT Service Management from the ISO 20000 requirements. This method has the following nine activities: “(1) identify elementary requirements in a collection of requirements, (2) organize and structure the requirements, (3) identify common purposes upon those requirements and organize them towards domain goals, (4) identify and factorize outcomes from the common purposes and attach them to the related goals, (5) group activities together under a practice and attach it to the related outcomes, (6) allocate each practice to a specific capability level, (7) phrase outcomes and process purpose, (8) phrase the base practices attached to outcomes, (9) determine work products among the inputs and outputs of the practices” [21].

3.9 Process for a model for SaaS

Cancian developed a draft process capability model as a reference guide for assessing software development process practiced by SaaS (Software as a Service) providers [22]. In order to accomplish its objectives, quality requirements that providers should meet were elicited. After having been summarized and analyzed, the requirements were mapped to existing standards and reference models. From this mapping, a reference guide was proposed. A process was defined and used for the construction of this draft model, with the following five activities: (1) literature review, (2) gathering of requirements, (3) complementation and determination of the priority among those requirements, (4) mapping of those requirements, and (5) construction of the reference guide.

4. A METHOD FRAMEWORK FOR ENGINEERING PROCESS CAPABILITY MODELS

The current version of the method framework for engineering process capability models is composed of a methodological context and five methodological components, and the relationship between them (Figure 1). The methodological context is the other elements of PRO2PI and this method framework is a methodological element of PRO2PI (see Figure 1).

Figure 1: Method Framework

Each methodological element of PRO2PI Methodology is identified by the PRO2PI initials followed by specific initials. Some elements have an additional identification based on the name of a compact disk album which covers the diagram of the methodological element. The set of elements of PRO2PI Methodology is also identified as “*Maritimo*” [23]. Its diagram is shown in Figure 1 over the cover of “*Maritimo*” album. The Method Framework is identified as PRO2PI-MFMOD (Method Framework for Engineering Process Capability Models as an element of the PRO2PI Methodology). This Method Framework is also identified as “*Livro*” [24]. Its diagram is shown in Figure 1 over the cover of “*Livro*” album.

The five components are a set of seven sequential practices, a set of seven customization rules, guidelines for using the framework, a repository for examples of utilization and another repository for examples of techniques. The customization rules define how the sequential practices can be used to generate activities for a method or process. The Guidelines for using the framework provide guidelines for using the other four components of the framework. The next four sections describe the other five components.

5. THE METHOD FRAMEWORK'S CONTEXT: PRO2PI METHODOLOGY

PRO2PI is a multi-model process improvement methodology driven by process capability profiles. PRO2PI supports process improvement using elements from multiples reference models and other sources. These elements are selected or defined and they are integrated as process capability profile. A process capability profile that drives a process improvement under PRO2PI methodology is also named as a PRO2PI. Figure 1 presents the conceptual elements of the PRO2PI methodology, the relationship among them and the name of each one.

PRO2PI-SMOD is a sustainable model for the dissemination and evolution of PRO2PI methodology. PRO2PI-REPO is a repository for PRO2PI assets. PRO2PI-MMOD is a metamodel for a process capability profile and process capability model. Using PRO2PI-MMOD, PRO2PI-EUMOD1 is an exemplar unified process capability model with elements from selected relevant models, and PRO2PI-EN1 is a notation to represent a PRO2PI. PRO2PI-PROP is a set of properties for a PRO2PI. PRO2PI-MEAS is a set of measures to qualify a PRO2PI. PRO2PI-CYCLE is a process for process improvement cycles including a function to define, update or use a PRO2PI.

PRO2PI-WORK is a method for a workshop to establish a process capability profile to drive a process improvement cycle. This method was developed to guide the implementation of the first three phases of PRO2PI-CYCLE in a low capability, small organization. In addition, two customized variations of this method were defined. PRO2PI-WORK4A is a method for a workshop with emphasis in the assessment of current practices and PRO2PI-WORK4E is a method for a workshop with emphasis in education on process improvement. PRO2PI-MFMODE is a method framework for engineering process capability models that is described in this article.

6. THE METHOD FRAMEWORK'S PRACTICES AND CUSTOMIZATION RULES

PRO2PI-MFMODE defines seven sequential practices to guide the development of a method or a process to develop a process capability model: (1) strategic decisions, (2) sources analysis, (3) strategy for development, (4) model

design, (5) draft model development, (6) draft model validation, and (7) model consolidation (Figure 2).

The first practice of PRO2PI-MFMOD is related with strategic decisions after a decision and commitment for model development. Two key strategic decisions are about the domain and context of the model and how the community of interest will be involved. The ISO/IEC 15504's requirements for models required the documentation about how that community was involved.. These strategic decisions can be related with any one of the following six practices. In the second practice (Sources analysis) we identified, gather and analyzed sources for good practices. These sources can include literature review, surveys, and others. These sources are based on the context and characteristics of a segment or domain. The third practice (Strategy for development) is related with the definition of the strategy to be used to develop the model. One key issue is how the community of interest will be involved in this development. Another issue is using selected good practices from process capability models (SW-CMM, ISO/IEC 15504-5, iCMM, CMMI-DEV, OPM3, COBIT, eSCM-SP/CL, MR-MPS, COMPETISOFT, ...), other reference models (ISO 9001, PMBOK, ISO/IEC 12207, SWEBOK, EFQM, PNQ, RUP, ...) and/or any other sources.

The fourth practice (Model design) is related with the design of the process capability model. ISO/IEC 15504 establish as general structure for model design as Process Reference Model and Process Assessment Model. PRO2PI-MMOD as a metamodel provides a reference for this design. The fifth practice is the draft model development. The sixth practice is the validation of the draft model. The seventh practice is the consolidation of the process capability model.

As part of the method framework, these seven sequential practices must be customized as activities of a method or even by a process. This customization is oriented by combinations of eight simple customization rules (CR1 to CR8). These customization rules are described as follows, in terms of the relationship between one or more method framework's practice and one or more method or process's activity:

- CR1: A practice corresponds to an activity (one practice to one activity);
- CR2: There is no activity that corresponds to a practice, because the results to be produced by the practice execution are already predefined by the method or process (one practice to zero activity);
- CR3: There are no activities that correspond to one or more consecutives final practices, because the life cycle of the method or process ends before those final practices (many final practices to zero activity);
- CR4: Two or more activities correspond to one practice, because the activities are more detailed customization of the practice (one practice to many activities);
- CR5: An activity corresponds to two or more consecutive practices, because the activity is a more general and simplified customization of the practices (many practices to one activity);
- CR6: There are consecutive activities that correspond to an activity followed by a previous activity, allowing cycles (go back pointer);
- CR7: In case of parallel activities, the other customization rules apply for each parallel sequence of activities and for the fork and joint connections; and
- CR8: There is one or more technique that is specified for one or more activities.

The next sections provides representations of those processes (described in Section 4) as customizations of the method framework and explain these customizations in terms of applications of these customizations rules. In this way, the next section supports the understanding of these customizations rules.

7. THE METHOD FRAMEWORK'S EXAMPLES OF TECHNIQUES

This Method Framework's components is a repository of descriptions of techniques. These techniques may be used to support one or more activity. Each technique in this repository has been used in at least one experience. The current version has five techniques. Each technique is described in this section.

7.1 Systematic literature review

Systematic literature review is a well known technique that can be used in this context to guide the gathering of information about best practices for a specific domain or segment. This technique can be described as a three-stage process based on a more general process described by Kitchenham, Budgen and Pearl Brereton [26]: (1) Convert a relevant problem or information need into an answerable question; (2) Search the literature for the best available evidence to answer the question; and (3) critically appraise the evidence for its validity, impact and applicability. This technique was used in the process for the MARES model [15], in the process for the SPICE for Research model [18,19] and the process for a model for SaaS [22].

7.2 Survey using a standardized questionnaire

Survey using a standardized questionnaire is a well known technique that “can be used to characterize the knowledge, attitudes, and behaviors of a large group of people through the study of a subset of them” [25]. In this context of engineering process capability models, this technique can be used to collect data to be analyzed to provide insights for proposing best practices. These best practices can be represented by the model. Kasunic describes a seven-stage process for this technique: (1) Identify research objectives; (2) Identify and characterize target audience; (3) Design sampling plan; (4) Design and write questionnaire; (5) Pilot test questionnaire; (6) Distribute the questionnaire; and (7) Analyze results and write report [25]. This technique was used in the process for the SPICE for Research model [18,19] and the process for a model for SaaS [22].

7.3 Abstract a process area from an actual process

This technique guides the definition of a process area based on analyses, abstraction and generalization of actual instances of a process. This technique was conceived and used during the development of a new process area to cover the process to teach a technical course [14].

7.4 Translation of a process area

This technique guides the definition of a process area for a given process capability model by translation the definition of the desired process area from the notation of another process capability model to the notation of the given model. This technique should be used when the desired process area is already available in another model and these two model have different notations. This technique was used to include process areas related to reuse process into the CMMI-DEV model [16]. These process areas were equivalent of process areas available in ISO/IEC 15504-5 model. The selected process areas were translated from ISO/IEC 15504-5 notation to the CMMI-DEV notation. In order to use this technique a translation procedure must be developed from a specific source notation to another specific destination notation.

7.5 Process area adaptation using statements on the target domain

This technique guides the definition of a process area as an adaptation of a more generic available process area to a specific target domain or segment. This technique was conceived and used during the development of a specialization of the CMMI-DEV process capability model for software development in the banking domain [17].

This technique can be described as a four-stage process: (1) produce a description of the domain with a set of initial phrases, (2) analyze each practice of a process area, assign if for that domain this area is less important, as important, more important; (3) explain the assignment in terms of the phrases; (4) if there are explanations not covered by the phrases, review the domain description to incorporate new phrase.

8. THE METHOD FRAMEWORK'S EXAMPLES OF UTILIZATION

This Method Framework's components is a repository of examples of utilization. Although the previous experiences described in Section 3 did not use this Method Framework, their processes can be described in terms of the method framework's seven practices. These descriptions can be considered as examples of utilization. The current version of this component contains these descriptions. This section presents Table 1 with the activities of each one of the nine processes described in Section 3 and indicate how each practice is related with the activities.

The process for a model for education customizes the method framework applying the following customization rules: (a) rule CR2 is applied related with practice 1 because the strategic decisions were already taken before the process was defined; (b) rule CR4 is applied because the activities 1, 2 and 3 are more detailed than the correspondent practice 2; (c) rule CR5 is applied because the activity 4 is more general and simple than the correspondents practices 3, 4 and 5; (d) rule CR4 is applied again because the activities 5 and 6 are more detailed than the correspondent practice 6; and (e) rule CR7 is applied because the process finished with the validation of the model draft version, and then there is no activity that correspond to the final practice 7.

The process for the MARES mode customizes the method framework applying the following customization rules: (a) rule CR2 is applied related with practice 1 because the strategic decisions were already taken before the process was defined; (b) rule CR4 is applied because the activities 1 and 2 are more detailed than the correspondent practice 2; (c) rule CR1 is applied because the activity 3 corresponds to practice 3; (d) rule CR5 is applied because the activity 4 is more general and simple than the correspondents practices 4 and 5; (e) rule CR1 is applied because the

activity 5 corresponds to practice 6; and (f) rule CR4 is applied again because the activities 6 and 7 are more detailed than the correspondent practice 7.

Table 1 - Practices of PRO2PI-MFMOD and activities of seven processes

Process for	Prac. 1	Prac. 2	Prac. 3	Prac. 4	Prac. 5	Prac. 6	Prac. 7
PRO2PI-MFMOD	①	②	③	④	⑤	⑥	⑦
a model for education		①→②→③	④	⑤→⑥			
the MARES model		①→②	③	④	⑤	⑥→⑦	
a CMMI specialization to CBSE		①	②	③	④	⑤	⑥
a CMMI specialization to banking		①	②	③	④	⑤	⑥
the SPICE for Research model		①→②	③	④	⑤	⑥	⑦
(generic) consolidated models	①	②	③	④	⑤	⑥	⑦
a leadership model		①	②	③	④	⑤	⑥
models from requirements transformation		①→②	③	④	⑤	⑥	⑦
a model for SaaS		①→②	③	④	⑤		

The process for a CMMI specialization to CBSE customizes the method framework applying the following customization rules: (a) rule CR2 is applied related with practice 1 because the strategic decisions were already taken before the process was defined; (b) rule CR1 is applied four times because each one of the activities 1, 2, 3 and 4 corresponds to the practices 2, 3, 4 and 5; (c) rule CR5 is applied four times because each one of the activities 5, 6, 7 and 8 is more general and simple than the correspondents consecutive practices (3 and 4), (3 and 4 again), (2, 3, 4 and 5), and (6 and 7); (d) rule CR6 is applied three times because the activity 4, that corresponds to practice 5, is followed by activity 5 that correspond to practices starting in practice 4, the activity 5, that corresponds to practice ending in practice 5, is followed by activity 6 that corresponds to practices starting in practice 4, and the activity 6, that corresponds to practice ending in practice 5, is followed by activity 7 that corresponds to practices starting in practice 2.

The process for a CMMI specialization to banking domain customizes the method framework applying the following customization rules: (a) rule CR2 is applied related with practice 1 because the strategic decisions were already taken before the process was defined; (b) rule CR1 is applied because the activity 1 corresponds to practice 2; (c) rule CR2 is applied for the no correspond activity for practice 3 because the strategy for the development (the result of practice 3) was already defined before the process; (d) rule CR4 is applied two times because each one of the consecutive activities (2 and 3) and (4 and 5) corresponds to the practices 4 and 5 respectively; and (e) rule CR1 is applied two times because each one of the activities 6 and 7 correspondents to practices 6 and 7 respectively.

The process for SPICE for Research customizes the method framework applying the following customization rules: (a) rule CR2 is applied related with practice 1 because the strategic decisions were already taken before the process was defined; (b) rule CR4 is applied because the activities 1 and 2 are more detailed than the correspondent practice 2; (c) rule CR2 is applied for the no correspond activity for practice 3 because the strategy for the development (the result of practice 3) was already defined before the process; and (d) rule CR1 is applied four times because each one of the activities 3, 4, 5 and 6 correspondents to practices 4, 5, 6 and 7 respectively.

The generic process for consolidated models was not analyzed in details. Therefore it customizes the method framework applying the following customization rules: (a) rule CR1 is applied related with practices 1 to 7; and (b) rule CR6 is applied because the following activity after activity 7, that corresponds to practice 7, may go to an activity that corresponds to practice 1.

The process for a leadership model customizes the method framework applying the following customization rules: (a) rule CR2 is applied related with practices 1 and 3 because the strategic decisions and the strategy for development were already taken before the process was defined; (b) rule CR1 is applied because the activity 1 corresponds to practice 2 and the activity 5 corresponds to practice 7; (c) rule CR4 is applied because the activities 3 and 4 are more detailed than the correspondent practice 6;

The process for models from requirements transformation customizes the method framework applying the following customization rules: (a) rule CR2 is applied related with practices 1 and 3 because the strategic decisions and the strategy for development were already taken before the process was defined; (b) rule CR4 is applied because the activities 1 and 2 are more detailed than the correspondent practice 2, the activities 3 and 4 are more detailed than the correspondent practice 4, the activities 5 and 6 are more detailed than the correspondent practice 5, and the activities 8 and 9 are more detailed than the correspondent practice 9; (c) rule CR7 is applied because the process finished with the draft model development, and then there is no activity corresponding to the final practices 6 and 7.

The process for a model for SaaS customizes the method framework applying the following customization rules: (a) rule CR2 is applied related with practices 1 and 3 because the strategic decisions and the strategy for development were already taken before the process was defined; (b) rule CR4 is applied because the activities 1 and 2 are more detailed than the correspondent practice 2 and the activities 3 and 4 are more detailed than the correspondent practice 4; (c) rule CR1 is applied because the activity 5 corresponds to practice 5; (d) rule CR7 is applied because the process finished with the draft model development, and then there is no activity that correspond to the final practices 6 and 7.

9. USING THE METHOD FRAMEWORK IN THE BRAZILIAN PUBLIC SOFTWARE

This session introduces the issues of application of this method framework for building process capability models in the context of the Brazilian Public Software (SPB after the Portuguese name: *Software Público Brasileiro*) Complex System [17].

SPB is an initiative from the Brazil's Planning, Budget and Management Ministry with active participation of many other governmental entities, including the Science and Technology Ministry. SPB introduces a new concept and operational structure to produce software, aimed at improving efficiency of the governmental system. This initiative began officially in 2006. At that time, the Free Software Production Model adopted by the Federal Government was strongly stimulated by national policies. One of the experiences of code opening gave to Brazilian policy makers the perception that the government and several sectors of the Brazilian society were interested in sharing and improving the software knowledge. In few months, thousands of software developers accessed the site where this experience was and formed a virtual community.

An one year project is under way to consolidate a technical framework for SPB. Two parts of this project are subprojects to identify and consolidate, as process capability models, best practices in the SPB context. One model is for best practices for establishing and operation of a community to evolve a software. The other model is for best practices for service delivering related with a software. A process for both subprojects is defined and used to managing the development of each model. This process is defined using the method framework.

The first activity is the planning for one year project to develop the model. This activity is activity 1 of this process and correspondents to practice 1, therefore we identify it as (A1-P1). This planning is based in a three phase overall process. For each phase we planned a process that followed the seven practices and produced a version of the model.

The process for phase 1 is composed of seven activities: (A2-P2) sources identifications and initial analyses, in which we identified and analyzed some models and other sources; (A3-P1) strategy decisions, in which we decided to use the technique "Process area adaptation using statements on the target domain" in order to understand better the SPB domain and also decided to identify specialists in the SPB domain to validate the result; (A4-P2) source analyses, in which we selected one model as the source; (A5-P3/P4) model design, in which we selected three process areas from the selected model as the strategic for development and defined the format for the representation of the result; (A6-P5) draft model development, in which we use the technique to produce adaption of the three selected process areas; (A7-P6) initial validation, in which we involved the specialist to do the validation; and (A8-P7) model consolidation, in which we focused more in obtain a better understanding of the SPB domain.

The process for phase 2 is composed of five activities: (A9-P1) strategic decisions, in which we decided to involve the SPB community in the validation of the model; (A10-P2/P3/P4) model design, in which we proposed some process areas to be developed, based on our knowledge about the SPB domain and the source models; (A11-P5) draft model development, in which we develop these two process areas; (A12-P6) initial validation, in which we

gathered feedbacks from members of the SPB community during a workshop; (A13-P7) model consolidation, in which we used the feedbacks to revise the model and included more process areas

The process for phase 3 is composed of ten activities. The first one is strategic decisions (A14-P1), in which we decided to produce a set of process areas covering all aspects of an community for a model and service delivering for the other model in SPB and to improve the involvement of SPB community. Activities A15 to A19 are composed as two parallels sequence of activities. One sequence is related with the involvement of the SPB community and it has one activity: (A15-P2) source analyses, in which we established a forum to exchange ideas with the community and use the results as sources for best practices. The other sequence is related with the development of the model and it has four activities: (A16-P2/P3) strategic for development; (A17-P4) model design; (A18-P5) draft model development; and (A19-P6) draft model validation.

As there was no customization rule for parallel activities, a new customization rule was defined: “CR7: In case of parallel activities, the other customization rules apply for each parallel sequence of activities and for the fork and joint connections”.

The parallel sequence of activities joint into a strategic for development activity (A20-P3), in which we revised the strategic based on the results of previous parallel activities. The next activity is draft model development (A21-P4/P5). After that there are two parallel activities: (A22-P2); and (A23-P6). These two parallel activities joint into a model consolidation last activity (A24-P3/P3/P4/P5/P6/P7).

Therefore this 24 activities process can be described as instantiations of the method framework’s seven practices using its customization rules.

10. INITIAL VALIDATION AND RELATED WORK

Although this is a work in progress, the achievement of the three unfolded objective goals is commented as an initial validation. The achievement of Goal G1 is evidenced by Section 8, including Table 1, showing that the activities of each one of the nine identified processes can be expressed as applications of the seven of the eight customizations rules on the seven PRO2PI-MFMODE’s practices. The customization rule 7 was not used in these identified processes. It was used in the process described in Section 9.

The achievement of Goal G2 is evidenced by Section 5, including Figure 1, showing PRO2PI-MFMODE as one element of PRO2PI methodology. Finally the achievement of Goal G3 is evidenced by Section 9 showing that the activities of the planned process for engineering two process capability models for SPB complex system can be expressed with applications of the eight customizations rules on the seven practices of PRO2PI-MFMODE. Both processes are at final activities. Both processes were reviewed during their execution due to perceptions from their management that they could be improved.

This article integrates and evolves the contents of two conference papers published in 2009 [29, 30]. The first conference paper introduced the method framework and described in details its set of practices and sets of customization rules [29]. The second conference papers described in details the current set of techniques [30]. This article introduces a second version of the method framework that includes a revision of the components and includes the Guidelines for using the Framework as a new component.

There is another research project in this subject. This other project is using two techniques to identified process capability models and the processes used to develop them. The two techniques are Systematic literature review and Survey using a standardized questionnaire. This systematic literature review identified 53 process capability models for software domain [31]. We plan to combine this method framework with the results of this other research project.

11. CONCLUSIONS

This article introduced PRO2PI-MFMODE as a Method Framework for Engineering Process Capability Models. This method framework supports the definition of methods or processes to engineer a process capability model. This method framework is composed of the PRO2PI Methodology as a context and five components. The five components are a set of seven sequential practices, a set of eight customization rules, guidelines for using the framework, a repository for examples of utilization and another repository for examples of techniques.

The achievement of the three derived objective goals indicates a first confidence that PRO2PI-MFMODE is a useful proposal for developing methods and processes for engineering process capability models.

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