Defining Process Capability profiles build on CMMI Persistence and Habitual Practices

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Received: July 09, 2018 Accepted: August 22, 2018

ABSTRACT *This method presents the process capability profiles of software organizations with the particular business model. The proposed method is made up of a process, artifacts and guides that assist to acquire process profiles, based on the precise characteristics (business model, enterprise growth stage and value discipline) of each software company. Therefore, the application of the method permits selecting a set of attuned processes and wrinkled up with the business model proposing more objective improvement actions to a software organization. A partial result attained during a pilot evaluation of the method in a software company is also presented.*

Keywords: *Process Capability Profile, Software Process Improvement, Capability Model and Business model, Persistence and Habitual Practices.*

1. Introduction

Software development process is a vital impact in Small and Medium size Enterprises (SME) that are usually renowned in making across the industry. Standards and definitions of SME is different from one country to another country. In a sector, small enterprise comprises of employees from 5 to less than 30 and medium enterprise contains the employees from 30 to 75 based on the standards of SME. The size capacity of small enterprise contains 10 to 75 and medium enterprise size capacity contains 50 to 249 in the case of European Union (EU) [1].

Software maturity models have been a successful approach in evaluating and predicting review process capability. Many organizations in Information Technology(IT) and Information Technology Enabled Service (ITES) sectors has helped in process capability leading to improve the statistical confidence, achievements of successful quantitative and accurate prediction. A trend analysis is used to predict the future movement of a stock which is a part of technical analysis based on past data. This paper is to study and review the metrics data collection and analysis used to drive quantifiable results in a software organization for assessing and managing the software review process efficiencies for development and their capability profiling. This leads to a strong correlation among the reported process maturity to process capability profile suggesting continued and sustained process improvement initiatives subsequent to the appraisal [1].

1.1 CMMI Development V2.0

The latest CMMI Development Ver. 2.0 is designed to congregate the challenges of the changing global business landscape. The performance of V2.0 has energies the business by means of standards and building key capabilities [2].

The core of V2.0 CMMI Development is a established set of universal best practices organized by critical business capabilities which develop business performance. There are major common challenges that deals with the critical capabilities to any organization, including

- Business and Emerging Products
- Performance improving
- Structure and Supporting Skill
- Business Management Flexibility
- Preparation and Handling Work
- Choosing and Dealing Providers
- Provide Quality
- Workforce management
- Supporting Implementation

1.2 CMMI Development V2.0 Key Improvements

1. **Improve business Performance**
   Performance of business goals are joined directly to operations which has improved by some key drives such as measurable, quality, performance against time, budget, customer satisfaction and other key.
2. **Leverage Current Best Practices**
   The best practice of trusted source is CMMI V2.0 which is frequently updated in order to replicate business changeable needs on the platform of recent online.
3. **Build Agile Resiliency and Scale**
   In order to focus the performance, a stronger agile process with scrum project is provided as open guidance.
4. **Increase Value of Benchmarking**
   Evaluation method of benchmarks gets better consistency and reliability based on new performance orientations which have reducing lifecycle costs and preparation time.
5. **Accelerate Adoption**
   CMMI benefits have provided a highly availability access in online and also adoption guidance [2].

2. Related Work

Software process model serves as groundwork for the process definition, assessment and improvement. It guarantees the handling of the same concepts, significance with the finest software engineering practices and compatibility with globally accepted standards.

The representation of continuous model describes each named process for assessment capabilities namely, design proposal, necessities of elicitation, configuration management etc. For this case, organization is processes capability profile of assessment outcome for each named process which involves the capability levels.

Though the capability of each process is assessed independently but this does not mean that processes are not related to each other and it is not possible to develop one method without improving the relevant processes.

The architecture of software process model is no absolute answer which is highly suitable. The criteria of model particularity and purposes of its application should be employed. The staged representation model is more appropriate for the marketing purposes because it gives for the organization a single rating which is enough evidence for its potential customers and it is easy to judge against process maturity of the diverse organizations but it is not enough complete and flexible because it provides the improvements of solitary sequence which is used to measure the software improvement that it does not allow in more detail. The representation of continuous model is highly complex to relate the maturity of various groups that allows the selection of order for process development and best assemble of business purpose of an organization [1].

The organizations should decide the process assessment model more appropriate to their main goal but it is desirable to benefit of advantages of both models. In order to improve the quality of software service or products of Serial Peripheral Interface (SPI) aims to exploit the benefits of economic which it follows by Small and Medium size Enterprises (SME). Reason is that SPI can get better quality of their software process, increase readability, customer satisfaction and reduce the cost and time of building quality software products while reduces risk and fail [3].

Almomani has proposed to the current practices of software process that evaluation based on SPI which gets a chain of iterative and continuous. These processes continuously change and develop as new practices which can be added as well. In order to manage the activities of software development process, SPI gives attention to weakness of current practices and organization's software requirements. The outstanding quality models namely, six sigma, ISO 9001, Capability Maturity Model Integration (CMMI) and Software Process Improvement and Capability determination (SPICE)[4].

Tailoring CMMI for the benefits of SMEs is not a petty task, due to its complexity, the need for enough resources such as skilled professionals, challenging deadlines and high implementation costs, is not reasonable by SMEs firms [5].

In recent trend, defining a suitable method for SMEs appears to be visible by taking into consideration some existing CMMI Key Process Areas (KPAs) and agile methods and practices. CMMI has an increase number of software organization by using agile software development methods. In 2015, CMMI is appraised software organization which is more than 70% of CMMI reported using one or more agile methods [6,7].

M.A Munoz Mata et al[8] has proposed the framework based on web tool and process pattern for enabling the benefits of certain agile approaches. This framework was measured with suitable result based on management aspects as well as software engineering. Delphi method and qualitative method is used for achieving the model to focus the group [9].

In this approach, survey was done using a questionnaire and data collection was selected. It is related to agile practices and CMMI practices in SMEs. Based on population of this study SPI affects managers, quality assurance engineers, contains of business analysis and developers in the company. The survey questionnaire developed online at Google Docs. It is free service, and easy to create, share, and analyze the data. The link for the survey questionnaire was sent to 64 respondents in a company through email and using social media. The respondents were asked to fill in the online questionnaire. The respondents were selected randomly. Simple random sampling was used so all the individuals have an opportunity to be chosen equally then the generalization can be done to the sample to bigger population [10].

The data was collected over a period of three months. Out of total 64 requests sent to respondents, only 40 responses were received. In this research, respondents consisted of 3 senior developers, 2 business analysis,1 manager associate ,4 project mangers,17 developers,10 team managers,2 quality assurance engineers and one person who did not specify his job. The collected data was examined using statistical analysis method, which represents the survey data in bars, graphs, and pie charts [11].

For determining Critical Success Factors (CSF), it is important to determine the possible CSFs in order to validate the implementation of this model. The experts should do the validation based on high level of abstraction. The guideline for the right application of this model can be represented by CSFs, therefore, compliance can identify the model successful or not. For the determination of CSFs, the literature review was conducted to find out the most common CSFs. The following CSFs are the most common CSFs for any SPI model in light of previous studies [12].

- Commitment
- Staff Involvement
- Training
- Resources
- Process Action Teams
- Staff Experience
- Guidance
- Reviews – Feedback
- Implementation Methodology
- Monitoring
- Communication
- Return on Investment
- Awareness of SPI

As organization performs its self-assessment to define its current 'as is' capabilities, tools, such as those as described by RAND Groups 1 and 2, can be employed to collect the needed information. These tools, coupled with a thorough analysis by the organizations' executive leadership and performers, are essential to develop the desired 'to be' capabilities. CMMI requires repeatable risk, decision making, and strategies of mitigation which has been adapted to applications of several product developments [13]. CMM® and CMMI® both these models are developed by university of Carnegie Mellon, whereas Business Development Capability Maturity Model (BD-CMM®) are develop by Shipley associates. To develop any research institute capability, CMM can be applied and scaled as the fundamental concepts.

In an approach to evaluate initial capabilities, initial laboratory capability assessments should be carried out internally by a laboratory manager or quality officer to produce a baseline and to identify target areas for improvement of project. These assessments and improvement projects are liable to focus upon the general development of laboratory services in under-resourced settings, these data should also be incorporated into any assessment of research capabilities. These assessments can be time-consuming, particularly as they can encompass a huge array of areas including technical skills, quality management, equipment, biosafety / biosecurity, supply chain and laboratory management. Hence, the reduction of duplicative risk or wasted effort by selecting from the best begins which is the suitable assessment method. In order to correctly measure their maturity and capability of well defined mission statement has critical to allow the institutes [14].

In under-resourced areas, laboratories are often occupied by the international community seeking to assist in their growth and development and, as described elsewhere, lack of alignment of expectations or goals can hinder these collaborative relationships. A formally adopted mission statement makes clear the planned end state of an institute. While initial baseline assessments may divulge gaps which prevent these aims from being achieved, knowing the goal(s) simplifies the definition of developmental milestones as the institute's research capacity matures. Understanding the mission and role of an institute in the health and research communities, and capturing these in a simple statement, allows for the correct assessment technique to be selected, as well as enabling useful goals and milestones to be developed. These procedures allow resources to be properly focused on achieving the aims of the institute rather than addressing gaps of lesser importance to the overall mission, which may be the result of measuring inappropriate metrics [14].

In contrast to traditional journal publications, scientific networks can also be analyzed to better understand the dynamics and the process of how research collaborations are initiated and continued. The networks and end result can be modeled to show relationships among collaborative activity and events such as meetings, white papers, presentations, conferences, and their outcomes [15]. Scientific networks, especially face-to-face communications, united with earlier-mentioned English language skills and consistent Internet access are decisively significant for scientists working in under-resourced areas. Overall, organizations with more mature research capabilities, in performance with government and stakeholders, will help create 'innovation ecosystems' that will catalyze economic growth, especially in under resourced areas [16].

3. The Process Capability Profile based Definition Method

3.1 The Method Development

The method was developed through the systematic making of research activities and application to pilot organizations. To access the applicability of generated concepts were temperately applied to the pilot organization of partial effects found in this activity. This is the way, method of process development capability profile based definition were defined as the following steps.

- To illustrate a small enterprise finding out the related variables.
- Map the practices based on the information of CMMI-DEV related to the certain variables [16].
- Define the steps for the definition of a Process Capability Profile (PCP).
- Apply the concepts of previous steps in Small Enterprise.
- Assess the outcomes and adjust the Process capability Profile based Definition Method.
- Review and document the method.

Step 1: The set of features have identified and applied in the software of small enterprise is the goal of the method whereas the value discipline, growth stage and business model are the three major features in the small enterprises even there are several feature available.
Step 2: The managed (level2) and defined (level3) maturity level in CMMI-DEV with its process ranged it characterization gets mapped based on the selected features. Hence, the mapped characterization are compared with nine PCPs are evaluated in the small enterprises from Florianopolis by MARES [17].
Step3: Based on step2 and bibliographic research, the execution process of initial (level1) version gets developed abut profile capability process works based on definition method.
Step4: The defined process of software applicable has considered as an initial test is a goal of assessing the definition method.
Step5: To assess the small enterprise, detected adjustment has provided as a usage from profile capability process based on definition method.

3.2 The Method

The usage context of the method is shown in figure1.

1. Select the general characteristics
2. Identify the type of activity
3. Identify Business Model
4. Identify initial Profile
5. Adjust levels of profile capability
6. Adjust the profile practices
7. Make the PCP Report

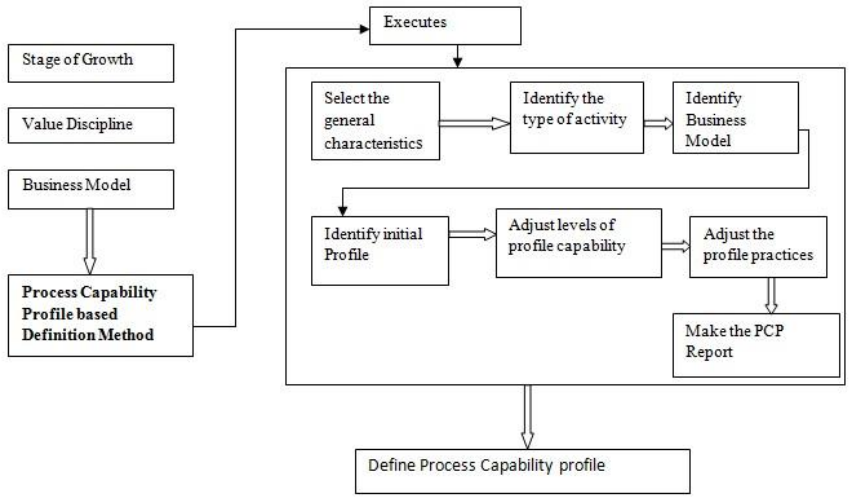

Figure 1 The Usage Context of the method

3.2.1 Select the general characteristics

This activity focuses to select, in the PCP-DEF document, the common characteristics associated to the growth stage and the value discipline detected for the organization. In this activity, the PCP-DEF user should initially select the first sublevel that represents the growth stage identified for the assessed organization. The next sublevel is related to the value discipline.

3.2.2 Identify type of activity

This activity is used to identify the type of activity the organization develops. The organizations were classified in two great areas of operation that cover the several business models: intensive product operation and intensive service operation. In this case it is considered product when its use can be separated from the production. In the case of a service, this can be made and consumed at the same time and place. A service can be associated to the use of a product.

3.2.3 Identify business model

This activity aims to select the business model identified for the assessed enterprise. In several situations the organizations can adopt, strategically, more than one business model to develop their activities, but for the PCP-DEF there should be only one selected model that represents the main strategy of the organization. In case the organization has more than one business model with the same importance, it will be able to explore the PCP-DEF mind map more than once and assess the capability profile combination identified. To conclude this activity it is necessary to accomplish sublevels 4 and 5. The general classification of the business model of the organization must be selected from sublevel 4(SL4). If the approach for SPI does not have a technique to define the business model, the method suggests a support questionnaire.

3.2.4 Identify initial profile

This activity aims to select the initial PCP to be used by the SPI approach. At this moment, according to the information and the steps followed until this activity it is derived a capability profile of initial processes that indicates the processes that can be treated as more relevant to the assessed organization. The PCP selected in this activity will be adjusted in accordance to criteria established in the next activity.

3.2.5 Adjust levels of profile capability

This activity aims to adjust the levels of capability of each process of the initial PCP to suit it to the level that the organization requires in relation to the selected model. This activity is mandatory in two situations: 1. The organization requires an official assessment, therefore it will have the initial PCP adjusted to reflect the mandatory levels to obtain the assessment; 2. Other situation, for these adjustments, would be in an organization that in some processes already has a level of capability greater than that demanded form the method.

3.2.6 Adjust levels of profile capability

This activity aims to analyze in details the processes that constitute the PCP to verify the importance of each specific practice of this process for the organization. Based on the identified processes, the activity performs an analysis of the persistent and habitual practices through a document named Adjustment Guide. These adjustments are performed still based on information collected by the SPI

approach and on the experience of the executing team. In order to support the adjustments in PCP , the technique of mapping the process perspectives for the organization is performed, when the financial perspectives, processes, clients, learning and growth and quality are assessed aiming to collect the presumed goals for each perspective. This mapping is important because typically, the VSEs do not own explicit knowledge upon their enterprise's goals. In sublevel 8 (SL 8) the adjustments in the project planning are presented.

3.2.7 Make the PCP report

Although the approach used to present the PCP-DEF in this section had been a summarized description, the method was detailed through activities using for this purpose a process representation, allowing the method to be executed thoroughly.

4. CMMI based Process

In variation of software product size the impact of CMMI based process maturity level is recommended to classify the sizes of software in an appropriate manner. The size of the software in predicting effort is measured the most well-known factor of the software product[17].Boehm in [18] has discusses the size of the software product is categorized as very large, large, medium, intermediate and small shown in table.1

Table.1 software product sizes[17]

Project Classification	Size (KLOC)
Small (S)	2
Intermediate (I)	8
Medium (M)	32
Large (L)	128
Very Large (VL)	512

PMAT scale factor on effort of software development is used to obtain the effort of different levels of maturity process for standard size projects classified above.

4.1 Effort Estimation

The basic idea in our research method is quantifying the impact of PMAT versus other factors that affect the software development effort. To find out, first we segregate the effect of PMAT from other factors as various kinds of enhancement are carried out simultaneously in the organization, project managers have no idea to describe the amount of improvement with the presence of other factors increased from process maturity [19]. In this context, COCOMO II model is employed in order to estimate the effort of software development.Table.2 and figure.2 describes the nominal values for all scale factors in all rating levels. The set of scale factors and effort multipliers to isolate their possible effects based on effort of software development to their minimal values. As an example, for a minimal PMAT rating and a standard large size project, by substituting values in equations 1 and 2, we get:

$$PMnominal = 2.94x128^{0.91+0.01x18.10} = 582.21PM$$

Table 2. Nominal values for all scale factors in all rating levels (except CMMI-based PAMT).

Scale (SF)	CMMI Level 1 (Lower)	CMMI Level 1(upper)	CMMI (Level 2)	CMMI Level 3	CMMI Level 4	CMMI Level 5
	Very Low	Low	Nominal	High	Very High	Extra High
Precedentedness (PREC)	3.72	3.72	3.72	3.72	3.72	3.72
Development Flexibility (FLEX)	3.04	3.04	3.04	3.04	3.04	3.04
Risk Resolution (RESL)	4.24	4.24	4.24	4.24	4.24	4.24
Team Cohesion (TEAM)	3.29	3.29	3.29	3.29	3.29	3.29
New Process Maturity(PMAT)	7.55	5.71	3.81	2.08	1.03	0
Summation of All SF	21.84	20	18.1	16.37	15.32	14.29

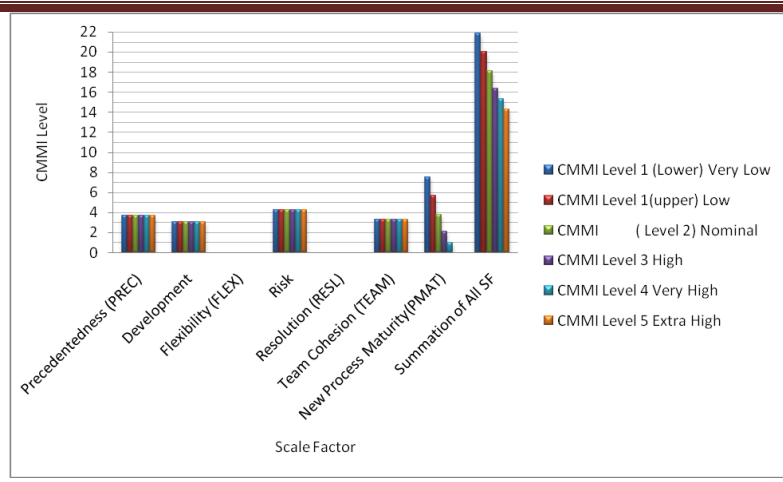

Figure.2 All rating levels (except CMMI-based PAMT)

4.3 Productivity Rate

In order to test our hypothesis which is increasing the level of CMMI-based process maturity boosts the productivity rate, equation 1 is applied for each estimated effort.

$$productivity = \frac{Size}{Effort} \quad -(1)$$

Where *Size* denotes the standard size , which is measured in this formula by thousand lines of codes (KLOC), and *Effort* denotes the effort estimated in each PMAT level for all standard sizes.

As an example for the efficiency, for nominal PMAT assessment and standard large size project, the equation 3 will be applied to the Effort produced in the previous section.

$$productivity = \frac{128}{581.21} = 218.72$$

5. Results and Discussions

5.1 Effort

After applying the method, COCOMO II has assessed the effort for all standard project sizes in each PMAT rating. Table 3 and figure.3 illustrates the resulted effort, Table 4 and figure.4 illustrates the percentage change in effort in each process maturity (PMAT) level for all standard size projects.

Table 3. Estimated effort in all CMMI-based PMAT ratings for all standard sizes.

Project Classification	Size	Very Low	Low	Nominal	High	Very High	Extra High
Small	2	6.45	6.38	6.3	6.22	6.17	6.13
Intermediate	8	30.75	29.57	28.46	27.46	26.88	26.24
Medium	32	147.88	138.78	128.98	121.48	117.16	113.07
Large	128	701.65	641.73	585.21	538.09	511.37	486.44
Very Large	512	3353.48	2989.66	2655.58	2383.98	2232.76	2093.86

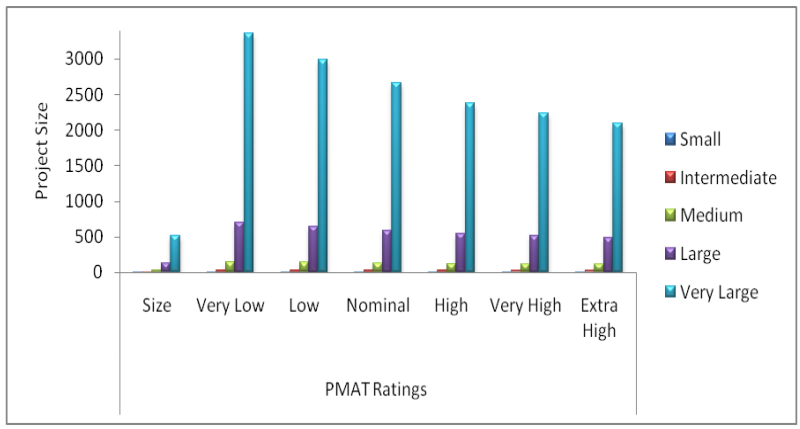

Figure.3 Effort(PM) based on PMAT rating rating and project size

Table 4. Percent change of effort in all CMMI-based PMAT ratings for all standard sizes.

	Average % Change in Effort						
Project Classification	**Size**	**Very Low**	**Low**	**Nominal**	**High**	**Very High**	**Extra High**
Small	2	2.64	1.36	0	-1.22	-1.22	-2.65
Intermediate	8	8.12	4.05	0	-3.57	-5.67	-7.67
Medium	34	13.86	6.85	0	-5.86	-9.22	-12.39
Large	129	19.22	9.68	0	-8.06	-12.66	-16.89
Very Large	515	26.3	12.6	0	-10.25	-15.95	-21.17

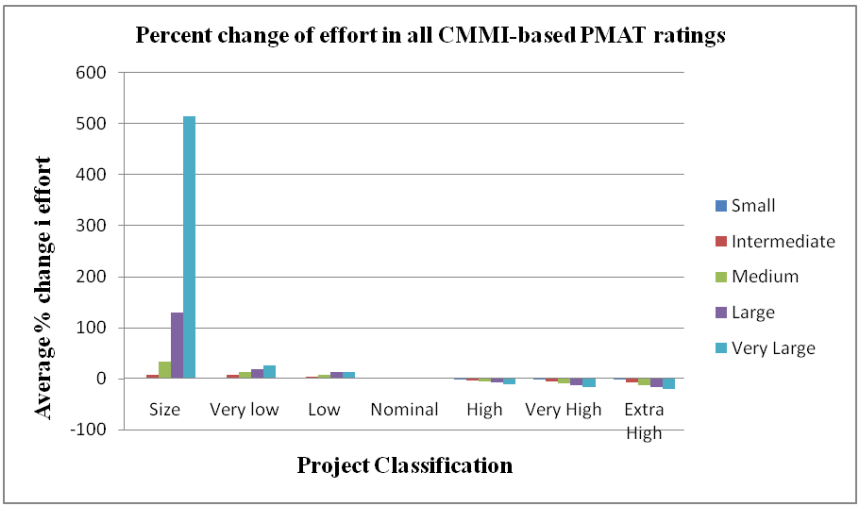

Figure.4 Average % change in effort

6. Conclusion:

The definition method with profile capability process presented in this work has matched based on software organization particular business model which assist SMEs to develop its software process and mentioned the effort of the method. The model offers group of process, which describes the typical problems for process improvement in SMEs, the process, are selected based on the existing software process with weakness. Hence, this process treated as renewable units which is adopted by organization to accomplish the chosen maturity levels of CMMI. The proposed model consist of three stags namely planning, analyzing and implementation. We expect to have a strong correlation among the reported process maturity to process capability profile based on persistent and habitual practices suggesting continued and sustained process improvement initiatives subsequent to the appraisal. This could be further validated using the trend emerging from the standard metrics reported from the organization

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