

Software Process Improvement in Agile Software Development by Mapping KPAs in CMMI

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ABSTRACT

Quality software product development is a challenging yet important asset for most software organizations, especially small medium sized companies. In small and medium sized companies development activities should be into line with Software Process Improvement (SPI) practices. Most organizations are adopting agile approach for developing software products. Different maturity models have been used for accessing maturity of process among which CMMI is widely used. However, it is considered difficult to implement it for small sized companies. This paper presents an integrated framework for improving agile practices by linking them with specific key process areas in CMMI framework for process improvement.

Keywords: *Software Process Improvement (SPI), CMMI, Agile software Development*

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1. INTRODUCTION

The aim of software process improvement is to produce high quality software product by improving development practices. SPI incorporates the assessment and improvement of the software development process [1]. The existing SPI models are designed for traditional software development practices. Evidently, the underlying differences of the traditional and agile software development approaches require new SPI mechanism from the perspective of agile software development. Nowadays, most organizations are directing towards agile software development. Agile practices have changed the nature of cooperation and communication, and offer rapid software development incrementally and increases customer value. Today's competitive software market demands rapid product delivery, quality products and customer satisfaction to achieve better place in market [2]. Agile approach is based on rapidity to respond to changes. In view of agile mindset, new encounters and prospects for conducting SPI are also emerging. Integrating CMMI for software process improvement to the agile methods is a challenging concern. According to some stated reports on respective approaches, both agile approaches CMMI and have inadequacies on certain key process areas which cause failure in achieving the anticipated resulting product. On contrary to that, few reviews have stated collaborating agile and CMMI to overcome deficiencies of two approaches to ensure complementary for each other [3].

To improve software quality, different software organizations are implementing variety of maturity models. Over the past few years, Capability Maturity Model Integration (CMMI) [4] have been extensively used for evaluating the maturity of development process used. Companies exalting to improve their processes and practices centered on CMMI have now grasped that agile methodologies can provide improvements as well. In contrast to that, agile process has been a subject of critique due to lack of discipline and claimed for being appropriate only for some specific projects (e.g. small applications and teams) [5,6]. As organizations may be indecisive between their previous plan-driven and new agile approaches, assessing development practices using CMMI framework could support in building trust for agile methods and offer safer ground for starting agile-based improvements.

This paper proposes an approach for assimilating agile methods with some Key Process Areas (KPA) aligning them in CMMI framework to evaluate process capability and organizational maturity. CMMI is used as a maturity evaluation framework in software process improvement. Research shows that by combining the key process areas and some agile methodologies in the CMMI levels can result better if implemented in a pipeline. By combining both techniques a remarkable improvement has been seen in the results. All the existing research shows the benefits and opportunities related to the collaboration of CMMI and agile methodologies. The existing researches focus on two prominent areas, firstly introducing the CMMI to the organizations working with agile methodologies, secondly to add agile methodologies in the matured processes. The companies under consideration are those following either agile or CMMI into their underlying process.

2. BACKGROUND

Considering particular context, the illustration of SPI programs varies considering the precedence of key parameters. Reviewing the contemporary practices and their approach is very helpful in evaluating alternative approach to develop SPI framework that is simple and effective. In the following subtopics, main process improvement enactment strategies with related approach is studied.

A. *CMMI*

CMM model is comprised of five maturity levels, each practicing number of key process areas (KPAs) to be exalted to next advanced maturity level [7]. CMM model further extended to CMMI by assimilating other capability models. In spite of the fact that CMMI has been extensively used as maturity assessment framework over the past few years, still some problems exits concerning its implementation for small sized cooperation [8, 9].

B. Practices in Agile

An agile method is a development methodology introduced to the market by software development community. Agile development focuses on customer satisfaction through rapid delivery of artifacts, iterative development and adaptive changes. Traditional plan-driven practices of software development and agile development methods are considered opposite to each other [10, 11]. The most extensively used approaches for agile development are Extreme Programming (XP) and Scrum. Long term process improvement is the main concern and drawback of agile practices. Agility is the ability to react to the changes in a continuously changing business trend, as described by Highsmith [12].

C. Aligning CMMI and Agile

At present, no practical methods exist for assessing and evaluating maturity of agile software development. The method of Boehm and Turner [6] presented a way for evaluating the agile software project. However, the presented model emphasis on evaluating the plan driven and agile risks instead of concentrating on weaknesses and strengths of the used approaches. So, it cannot provide enough data on what needs to be enhanced and upgraded. Currently, to find an effective approach of assimilating the CMMI with agile methods by mapping key process areas of agile practices in CMMI model. Consequently, some encouraging attainments have been initiated [13, 14].

These findings have provided an improved prospect for organizations which find it difficult to regulate standard Software Process Improvement (SPI) practices due to economy issues and essential skills. The results of evaluation represents that agile and CMMI can work effectively in certain areas [14]. This research states, how organizations following goal oriented traditional methodology which can use agile methods. The results indicate that, there is an association between the activities but further analysis is required to fully map KPAs of all CMMI maturity levels.

3. RELATED WORK

Implementing CMMI and agile approach is considered as an unsuited pile of practices to be used together. Recently, the research development is to find an effective approach of implementing both CMMI and Agile to cooperate each other to establish an integrated model. The succeeding summary of previous conducted research work presented in section 2 elaborates the findings and approaches along with the limitations.

Pikkarainen and Mäntyniemi [14] proposed a maturity framework based on CMMI for evaluating practices in agile development. The study does not present a complete model but some basic association between the practices, it just concentrates on the evaluation and assessment aspect and does not provides guidelines for software process improvement

practice. It is a fragmented method of CMMI model for evaluating organizations and implementing agile methodology. K. Miler and J. Lukasiewicz et al. presented Cloud Service (CS) model for representing particular practices of the 2nd and the 3rd level of maturity in the CMMI. A reference model CMMI (V 1.2) is proposed with the key activities defined by the Scrum methodology [15]. This research reflects that Scrum relates some practices of level two and three but does not ensure that all maturity level process practices are fully mapped in detail.

Sofia et al. [16] presented mapping of scrum activities to maturity model of CMMI to bring rapidity to a traditional goal oriented approach. The approach focused on evaluating project management areas of scrum by aligning it to CMMI project management key process areas. The main emphasis of this research is to put key process areas of CMMI and scrum methodology on the same level of project management. Except project management other key process areas (KPA) were not under consideration. Khan and Qaisar [17] presented an approach for small and medium organizations to implement practices in agile and incline to the maturity of CMM based organization. Proficiency in agile helps developers to attain maturity level staged in CMM model [17]. This paper has not presented clear association between agile and CMMI practices and strategies regarding implementation of these practices is also not mentioned.

Lina and Dan [18] presented that by using CMMI and agile in pipeline increases the efficiency of medium and small sized companies. The presented approach defines the project management framework that correlates scrum and CMMI. The results show that management processes in software can be improved by implementing the scrum under the key process areas of CMMI [18]. However, this research focuses only on the management feature of software development without considering the KPA in CMMI level 2 or 3.

A report focusing the implementation of CMMI and scrum on level 5 has been reported by Jakobsen [19]. The presented report suggests that in comparison with the traditional models improved competence should be included in the software development [19]. The Agile and CMMI incorporation was stated with regard to help companies using agile procedures. The main aim of this report is to introduce the scrum practices and other agile practices specifically in the mature companies, focusing to maximize the effectiveness of software development. However, the Process improvement for the early stages in agile development is not addressed. A comprehensive model proposed by Diaz et al. [20] analyzes the relation between scrum and CMMI practices [20]. The main focus of the research is on the CMMI level 2 process areas.

Kähkönen and Abrahamsson [21] discussed the ideas about the relationship between the CMMI and the Extreme Programming (XP). The results show that CMMI level 2 KPA can be achieved by integrating the XP practices. The underlying research provides no evidence

about the maturity of organizations depending on these activities about it and just focuses on the application of CMMI for evaluating the XP practices.

4. INTEGRATED FRAMEWORK OF AGILE AND CMMI

The proposed unified framework can be used as a path for software process improvement for organizations with low maturity. The aim of Agile ISO Maturity Model (AIMM) model is to enhance and improve the agile development methodology. Integrated framework by mapping agile practices and CMMI processes increase flexibility of product oriented approach and upgrades SPI to improve practice capability. This abstract view of model indicates how development method used in agile mature from ad-hoc level to constantly refining level based on the agile principles and key process areas. This model presents that how each level specified goal will help organizations to make emphasis on making improvement in their process activities. The approach will concentrate on the most proficient method to hold learning and encounter by focusing on programming improvement exercises.

A. Study Framework

To exploit the benefits and prospects of merging agile approaches and practices an approach is defined by integrating different models as a unified model with comprehensive analysis of association between the key process areas and practices of agile method and CMMI. In this research an integrated maturity framework which syndicates agile methods with key process areas (KPAs) of CMMI maturity model is presented enhance software process improvement practices and to improve development process maturity for attaining better place in competitive software market. The framework uses CMMI framework [19] representation with agile methods. In the presented model, explicit practices of each key process area (KPA) are mapped to agile methods practices. . To keep the illustration simple and practical the AIMM relates the agile development procedures to CMMI maturity levels. The AIMM model is centered on agile software methods and principles.

B. Mapping CMMI KPAs to Agile Process

To ensure that CMMI model can withstand in agile environment, we directed an implementation to map key process areas in CMMI with agile practices and attained project explicit method that fulfills the CMMI maturity requirements besides satisfying agile manifesto as shown in Table 1.

a) Level 1: Initial (Not defined goals or procedures to follow)

The software development process is not clearly defined at this stage and not essentially repeatable. Development environment for better product development and procedures are not defined. Level 1 organization does not provide definite agile development process. The

main difficulties at this stage are communication gap, product quality, time and budget schedule maintenance and overtime. The end product developed relies on process followed and team capability.

b) Level 2: Repeatable (Project planning and team organization)

Level 2 signifies a more organized approach towards software development than level 1. Companies with CMMI maturity level 2 are more proficient and face fewer difficulties as compared to level 1 counterpart. Interaction and coding problems and staff maintenance remain major concerns in this level.

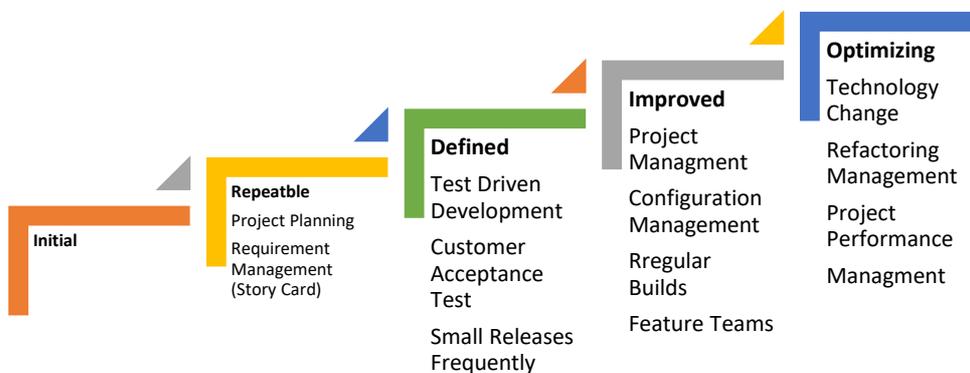


Fig. 1. Agile Integrated Maturity Model

The objectives of level 2 are:

- Project scheduling
- Develop agile requirements engineering
- Increase coordination between customer and developer

At this level organizations are more focused towards planning and scheduling and make sure that story cards for requirements are inscribed by the on-site end user or customer. Level 2 in general denotes that an organization has devoted resources to the planning and story cards (requirements engineering) practices as a whole. The AIMM at maturity stage 2 objects to assist developers and users to recognize and improve difficulties regarding, requirements gathering, planning and onsite customer by considering previous project experiences. Fig. 1 demonstrates KPAs and evaluation questionnaires for maturity assessment at level 2.

Table 1. Mapping of CMMI and Agile Practices

CMMI KPAs	Agile	Mapping CMMI and Agile practices
Maturity Level 2		
REQ Management	Project Backlog	User stories, Kickoff meeting, Backlog refinement
Project Planning	Sprint Planning	Stories, Sprint Planning, Standardization of model
Project Monitoring and Control	Daily gatherings	Project dashboards, Burn down charts, Sprint closure meetings
Configuration Management	Configuration tools	Configuration tools
Maturity Level 3		
Integrated Project Management	Constant Integration	-
Risk Management	Risk Management	Maintain Project Risk Register
Requirement Development	User stories	Use case documentation
Verification	Pair Programming	Peer review, Code review, Peer Testing
Validation	Automated Testing	QTP
Organization Training	Agile clubs, Agile coaches	Continuous agile training program, Training
Maturity Level 4		
Quantitative Plan Management	-	Key process areas measurement related to sprints
Organization Process Performance	-	Periodic Release of performance baselines for agile
Maturity Level 5		
Causal Analysis and Resolution	Project Backlog	Defect Analysis, defect prevention action
Organization Improvement Management	-	Organization level process improvement

5. EVALUATING MODEL

To find the accuracy of proposed model, evaluation is a vital process to ensure feasibility, comprehensiveness and competence. The major assessment is to evaluate the adherence of KPAs of agile with process areas and practices with CMMI maturity model. Two agile practices have also been compared in Table 2 in order to have an idea of the suitability of each of those under certain circumstances. As specified in study framework in related work, the presented model was evaluated with a survey based on skilled professionals.

Table 2. Comparison of Two Agile Practices

Metric	Goal and objective	Ratios	Target	Clues	Condition	Target	Nov-14	Dec-14	Jan-14
Velocity Measurement Ratio	Tracks Sprint velocity ratio	$\text{Velocity Ratio} = (\text{Existing Sprint Velocity per hour}) - (\text{Baselined Velocity for the project per hour}) / (\text{Baselined Velocity for the project per hour})$	$0 \leq$	> 0 : Constructive Velocity progress trend = 0 : Velocity as per baseline < 0 : Velocity not as per anticipations; take remedial action	\leq	0	-0.056	-0.200	0.200
Story Acceptance Ratio	Evaluate the value of the deliverables per Sprint	$\text{Story Approval Ratio} = (\text{No. of Stories accepted}) / (\text{Total no of Stories in Sprint})$	$>= 90\%$	= 100% -> Very worthy quality > 90% and < 100%: Quality meets potentials < 90%: Take action	$>$	90%	94%	95%	92%

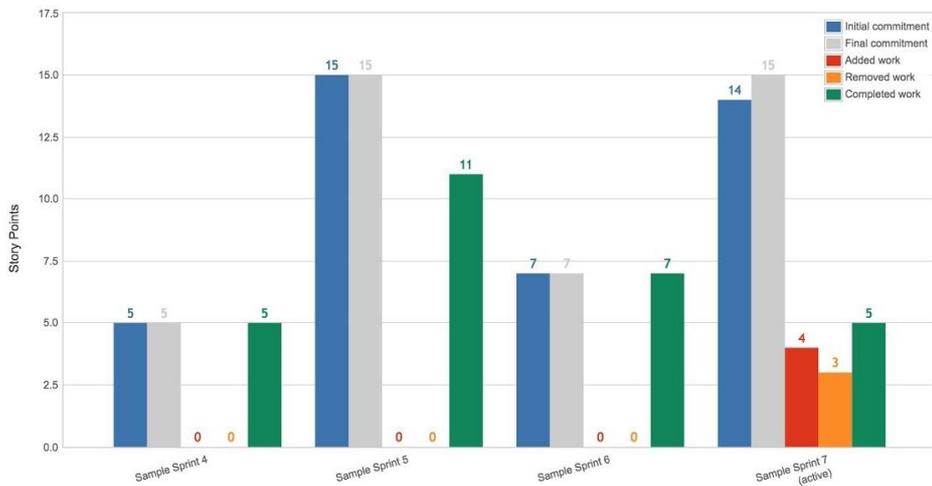


Fig. 2. Completion Velocity Chart

Table 3. General Idea of Analyzing the Questionnaire

Answers	Total Answers	Total Questions	Total no of (n/a) response	KPA percentage
Yes	4			
Moderately	3	9	1	84.44%
No	1			
N/A	1			

The questionnaire was distributed to a group of experts (business professionals) in mapping CMMI process areas and agile, with different levels of maturity in software process improvement (SPI). In total, five professionals from different organizations were the part of evaluation. One related to industry and the others in research and development experienced persons. Their key recommendations provide depiction of the levels, results of the process areas, to map with other models. Reflections were used to polish the proposed model.

AIMM assessment questionnaires responses are: Yes, Moderately, No, Not Appropriate (NA). In our method, response moderately documents the supposition that part of the procedure has been done or if achieved then not completely described NA is selected when it is not possible to implement the practice. If it is yes, then the practice is fully applied and well implemented. If No, then it's not talked at all. In AIMM evaluation, improvement is identified if the response of the questionnaires is Moderately, No or N/A. Using prescribed criteria ratio, each KPAs can be estimated. The analyzed ratio of KPA's is presented in Table 3.

Fig. 2 depicts the mission achievement (production rate of development). As compared to traditional plan driven approach of estimating each task and then pursuing scheduled versus actual performance, the presented procedure tracks incompetency in meeting individual commitment. The former measures deviation in the value of overall system goals.

6. CONCLUSIONS AND FUTURE WORK

Aligning software process improvement activity (SPI) with the development practices is reflected essential. Considering contemporary approaches for SPI in current business situation is merging agile approaches and CMMI maturity model. The key concern is to map specified process areas of CMMI with agile development for SPI coping with existing development challenges. The future steps in this research is to combine other maturity models to develop complex hybrid model depicting and mapping key process areas of different models.

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