A HYBRID APPROACH FOR MAPPING SCRUM TO CAPABILITY MATURITY MODEL INTEGRATION KEY PROCESS AREAS FOR WEB ENVIRONMENT APPLICATIONS

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ABSTRACT: Project planning and management of any software are two crucial and complex processes considering multiple key factors. Software development organizations usually use Capability Maturity Model Integration and agile methodologies to improve software process and development of web projects. In present study, mapping of Scrum to Capability Maturity Model Integration key process areas was proposed for managing requirements and project planning activities. Requirement management and project planning key process areas were targeted for mapping. Mapping of Scrum and Capability Maturity Model Integration facilitated effective handling of web projects. It aided achievement of organizational goals that could further lead to research for maturing an organization's software processes. Proposed Capability Maturity Model Integration and Scrum mapping covered 100% requirement management goals and 72% of project planning goals.

INTRODUCTION

In past years, web engineering appears as a distinct field of software engineering. Web-based project development is quite different from classical software development due to its quick adaptability, complex navigational structure, and agility, reduced time to market, interface requirements and customer involvement during the development process. The core objective of every software development organization is to manage and plan project activities to deliver useful products within short time (Torrecilla-Salinas *et al.*, 2015).

Capability Maturity Model Integration (CMMI) is a reference model and process improvement approach that helps the organization to access the maturity of its software process. More than five thousand small and medium size organizations throughout the world are using CMMI to mature their development processes (Lina and Dan, 2012, Silva *et al.*, 2015). CMMI framework consists of five levels that describe a broad range of best practices and engineering activities throughout the product life cycle (Lina and Dan, 2012). Capability Maturity Model Integration for Development (CMMI-DEV) (Garzás and Paulk, 2013) is advancement in CMMI framework, used by organizations to develop quality software and assess their maturity level. CMMI-DEV uses staged representation (Tariq *et al.*, 2014, Team, 2011).

Agile methodologies (Torrecilla-Salinas *et al.*, 2015) are found more effective and suitable for small and medium size organizations developing software especially web development environments. Popular agile methodologies are Extreme Programming (XP)

(Torrecilla-Salinas *et al.*, 2016), Scrum (Darwish and Megahed, 2016), Feature Driven Development (FDD) (Lina and Dan, 2012), Dynamic System Development Method (DSDM) (Chagas *et al.*, 2014), Adaptive Software Development (ASD) (Torrecilla-Salinas *et al.*, 2016) and Lean Software Development (LD) (Torrecilla-Salinas *et al.*, 2015). Web engineering includes its own specific tools and techniques to develop the software system across the World Wide Web (Torrecilla-Salinas *et al.*, 2016). Scrum is popular and is best suited for web development due to its adaptability and extension (Darwish and Megahed, 2016). Scrum provides a skeleton or set of practices and predefined roles to effectively manage web development projects (Torrecilla-Salinas *et al.*, 2015). Combining CMMI with Scrum to manage the web projects promises to be a good approach (Torrecilla-Salinas *et al.*, 2016).

The main objective of this research is to review CMMI, Scrum and web development approaches and to propose an agile approach with the mapping of Scrum practices to the CMMI Requirement Management (REQM) and Project Planning (PP) Key Process Areas (KPAs). Combining Scrum with CMMI is a good combination to improve the development processes (Fontana *et al.*, 2015; Torrecilla-Salinas *et al.*, 2015; Torrecilla-Salinas *et al.*, 2014; Tuan and Thang, 2013; Łukasiewicz and Miler, 2012). Both Agile and CMMI include valid set of principles therefore usage of agile methods to achieve CMMI goals give the organization a capability to quickly respond to changes and deliver quality software (Torrecilla-Salinas *et al.*, 2016). A set of Scrum practices (user story, sprint planning, release planning, product backlog, retrospective & daily sprint

meetings work breakdown structure, pre-game and post-game development phases, master phase and project execution phase) are mapped on selected CMMI level 2 goals (PP, REQM) and relevant conclusions are extracted.

MATERIALS AND METHODS

A model was proposed that consisted of mapping the PP and REQM KPAs of CMMI for Scrum. A research model and design of the proposed mapping approach is given in fig-1.

A literature survey was conducted to identify that Scrum and CMMI were compatible at level 2. Relevant published literature was selected for inclusion in the review based on the following terms: "agile, scrum, CMMI, maturity, model, agility". REQM KPA was chosen for mapping keeping in view the continuously changing requirements of the Web Projects. The PP KPA was chosen for mapping with Scrum practices. Each Scrum practice was mapped to each specific goal of both KPAs.

A selection criterion was proposed for Scrum to cover a specific goal. Three ratings were specified i.e. unsatisfied, satisfied, and partially satisfied. Rating criteria decision was made on the basis of evidences. For example, in the case of risk identification goal of PP phase, if some evidence of the goals were fulfilled by Scrum e.g. risk identification done during meetings were reviewed but if no systematic parameters existed to categorize or eliminate those risks, then categorized as partially satisfied. Proposed approach to map REQM's specific goals and Scrum practices is presented (table-1).
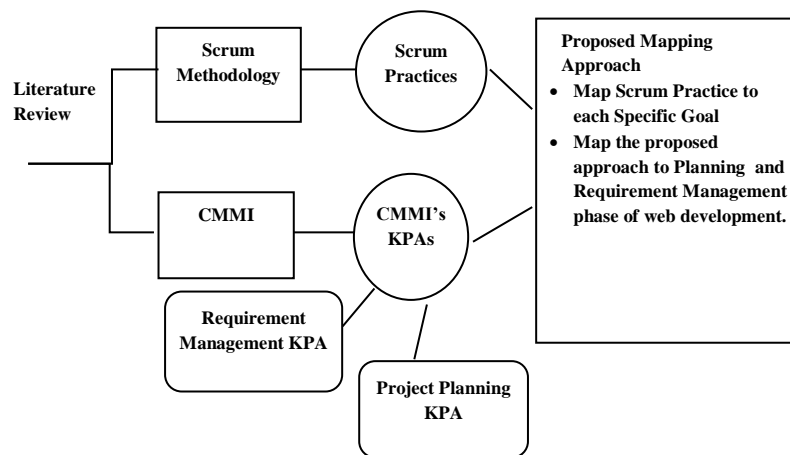

Figure-1: Research design of the proposed approach

Table-1: Proposed approach to map REQM's specific goals and scrum practices.

REQM's specific Goals / practices of CMMI		Mapping of Scrum Practices	Rating
S.P 1.1	Requirements Understanding	Scrum provides the right involvement of stakeholders for initial understanding of requirements. Feature for writing a user story is also provided for clear understanding of requirements.	S
S.P 1.2	Obtain Commitment to Requirements	Phases of sprint planning and release planning in Scrum manage a collective commitment for the requirements. Scrum master deals with necessary actions and process for commitment.	S
S.P 1.3	Requirements Change Management	In Scrum, product owner can change user stories. Scrum provides product backlog to manage next sprint. Changes are discussed during sprint planning meetings among the product owner and team members.	S
S.P 1.4	Maintain Bidirectional Traceability of Requirements	Scrum provides basic hierarchy for traceability of requirements and new stories provided by the user. Requirement prioritizing and dependencies can be managed using daily sprint meeting.	S
S.P 1.5	Ensuring Alignment of Plans and Work Product with Specified Requirements	In Scrum, backlog ensures the right plans and requirement management. Sprint backlog assures work has been implemented as committed.	S

PP KPA of CMMI with its specific goals was mapped in a similar manner with Scrum practices (table-2). PP helped to manage product development related activities, establish and maintain plans. PP KPA consisted of three specific goals i.e. to establish estimates, develop a project plan and to obtain commitment to plan. These specific goals consisted of 14 specific practices (table-2).

Table-2: Proposed approach to map PP's specific goals and scrum practices.

PP's specific Goals and practices of CMMI		Mapping of Scrum Practices	Rating
S.P 1.1	Estimation of the Scope of the Project	The top-level work break down structure (WBS) is handled by Scrum pre-game phase to estimate the scope of the project. Sprint backlog ensures the WBS for pre-defined constraints and allocation of resources.	S
S.P 1.2	Establish Estimations for Work Product and Task Attributes	Release planning in Scrum ensures the estimation of user stories. Sprint planning deals with the estimation of tasks. Uncertainty and complexity estimation are based on expert judgment.	S
S.P 1.3	Defining a Project Life cycle	Pre- game development and post-game phases of Scrum deal with constraints and defined processes for a project life cycle.	S
S.P 1.4	Estimate Efforts and Costs	In Scrum initial estimation is done by pre-game phase while second estimation is ensured at the starting of sprint backlog. Story points, velocity and sprint buffers are used for estimation. Scrum does not provide any process to estimate and calculate cost.	PS
S.P 2.1	Ensuring Budget and Schedule	Scrum framework does not provide any categorical orientation about establishing budget. Project budget can be derived from estimation of efforts. The project scheduling is managed by Scrum pre-defined plan sprints and release sprints.	PS
S.P 2.2	Identification of Project Risk	The release planning phase of Scrum, retrospectives and reviews meetings continuously deal with risk identification. Risks are written on boards and flip charts. However, risk assessment, categorization and prioritizing are done in an informal manner.	P S
S.P 2.3	Plan for Data Management	Formal data management is not done in Scrum framework. Scrum involves continuous involvement of customers so all the data is stored in public folder which can cause privacy issues.	U
S.P 2.4	Planning for Project Resources	In Scrum pre-game phase, tools and other resources needed for project are defined and project team is also ensured for commitment. Master phase of Scrum manages all the necessary resources needed for a project.	S
S.P 2.5	Plan for Required Knowledge and Skills	Knowledge needed and skills required are defined and mentioned at the beginning of the project. Any remaining issues regarded as resolved during daily and retrospective meetings.	S
S.P 2.6	Plan Stakeholders Involvement	Roles, responsibilities and stakeholders are fully defined and managed by Scrum's Project Execution phase. Scrum master deals and manage all the activities, rules and stakeholders involvement.	S
S.P 2.7	Establish Project Plan	High level project plan is made in the form of vision document, product backlog, release planning and Scrum's sprints planning.	S
S.P 3.1	Review Plans that Effect the Project	Retrospective and daily meetings in Scrum deal with the reviews. CMMI itself does not mention reviews but Scrum resolves this issue.	S
S.P 3.2	Reconcile Work and Resources	Reconciliation of work is managed very well in Scrum. Sprint planning, meetings with product owner and the team ensure all the activities needed.	S
S.P 3.3	Obtain Plan Commitment	The iterative nature of Scrum guarantees the planning at beginning of each sprint. Whole commitment process is managed during sprint planning meetings.	S

RESULTS AND DISCUSSION

The results of the detailed comparison of different development models conducted are presented (table-3). It was evident from the analysis that CMMI and Scrum were compatible and approaches proposed by combination were beneficial.

There was a lack of detailed mapping approach to manage requirements and plan the project for web

development. An approach that could map Scrum methodology to each generic and specific goal of Requirement Management and PP KPA of CMMI was much needed. Web development projects, due to an agile nature could use Scrum methodology. With the help of a combined approach, an organization could run the project using agile methodology while maintaining the maturity (Torrecilla-Salinas *et al.*, 2015).

The continuous involvement of stakeholders and variable requirements were crucial for web-based projects. Agility of the Scrum methodology helped to manage requirements very well when used in combination with other approaches. The proposed model served as a framework that could be evaluated by web development organizations for performance and results. To investigate the proposed approach a survey was

conducted that consisted of structured questionnaires. Questionnaire consisted of ten questions extracted from above approach. Target was different software houses of Pakistan where teams were working on web development projects. Responses were collected and quantitative measurements for results were calculated.

The results proved that Scrum was a better approach to manage web development projects. It suited best to the specific character of web projects for managing requirements (covered 100% goals) as well as it covered more than half of PP goals (10 goals out of 14 goals were fully satisfied, 03 were partially satisfied and 1 was unsatisfied) of CMMI for web development. Degree / rate of specific goals covered by mapping CMMI and Scrum was calculated (Equation 1).

**Table-3: Comparison of CMMI, Scrum and Web Development.**

Factors		Development Models			
		CMMI		Scrum Methodology	Web Development
		Continuous Representation	Staged Representation		
Model Type		Reference Model with Compatibility Levels	Reference Model with Maturity Levels	Incremental/Iterative Model	Incremental/Iterative Model
Key components		KPAs	Maturity Levels	Sprints	Requirements
Process Levels	Level 0	Incomplete	-	-	-
	Level 1	Performed	Initial	Pre-game/ Planning phase	Planning
	Level 2	Managed	Managed	Game/ Development phase	Design/ Implementation
	Level 3	Defined	Defined	Post-game phase	Testing
	Level 4	-	Quantitatively Managed	-	Maintenance
	Level 5	-	Optimizing	-	-

$$S_{KPA} = \frac{X_{s.p}}{\sum_{S.p=1}^{n} X_{s.p}} \times 100\% \quad (1)$$

Where, S_{KPA} represents the selected KPA for rating. While, $X_{s.p}$ represents the specific goal selected for calculate rating.

The coverage rate of CMMI and Scrum mapping were calculated. CMMI and Scrum mapping covered 100% of REQM goals and 72% goals of PP. Details of

the results for PP KPA are given in Fig-2. The results proved that Scrum is a better approach to manage web development projects. It suited best to the specific character of web projects for managing requirements as well as it covered more than half of PP goals of CMMI for web development. Fig-3 shows the general comparison of both KPAs.
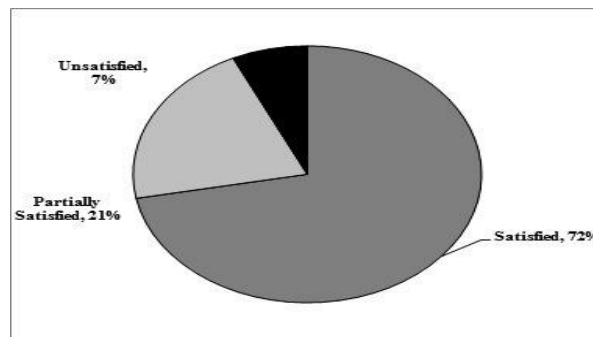
Figure-2: General Rating of Coverage of PP
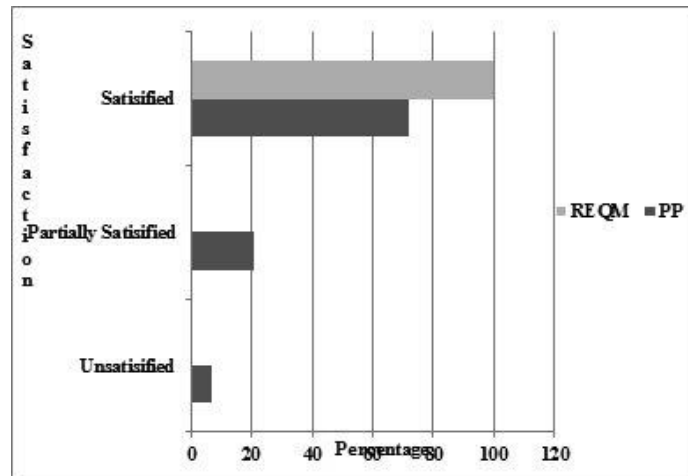
Figure-3: General Graph of Comparison of REQM and PP.

A number of systematic reviews, including works by Darwish and Megahed (2016), Silva *et al.* (2015) and Chagas *et al.* (2014) suggested the compatibility of CMMI and SCRUM. The proposed mapping approach was compared with a number of research works conducted by well-known researchers. Scope, method, type of work, targeted areas and recommendations were considered while making comparisons with the existing research. Fontana *et al.* (2015) conducted an empirical research and suggested a framework for maturing the development processes targeting CMMI, Scrum and web development. But there existed a gap for combining CMMI's principles with an agile methodology for web development. Torrecilla-Salinas *et al.* (2014) proposed the mapping of Scrum and CMMI for web development but no detailed approach was given. Mapping proposed in this paper is detailed and overcame the lacking. Diaz *et al.,* (2009) studied CMMI goals and scrum principles. Their findings were similar to those of the analysis and mapping proposed in this paper. They reported the compatibility of CMMI and scrum and the work covered CMMI level 2. Marçal *et al.* (2008) mapped Scrum principles and CMMI key process areas but their work was limited to older version of CMMI and web development was also not specifically targeted. The proposed mapping in this paper involved latest version of CMMI.

Lina and Dan (2012) mapped Scrum and CMMI for software development for small and medium sized organizations but they did not specifically focus on web development. Gillani *et al.* (2014) and Garzás and Paulk (2013) implemented case studies for software process improvement targeting web development using Scrum and CMMI. Their findings were similar to the findings of proposed research and mapping of Scrum and CMMI improved the software processes specifically for web development. Hayat and Qureshi (2015) measured the effects of infusion of CMMI quality standards with Scrum for general software process improvement validated their findings using a survey. Their proposed infusion didn't specifically target web development but the proposed mapping approach in this paper not only targeted web development but was also validated it using a survey.

Miller and Haddad (2012) conducted an investigation to check the compatibility of Scrum and CMMI. They found compatibility both at levels 2 and 3. Their findings also strengthened the mapping proposed in this research.

Conclusion: In this research, a detailed mapping of REQM and PP was proposed that could further lead to design of a consistent framework. Proposed approach would facilitate even a small size organization to use CMMI model to demonstrate a certain maturity level to its client.

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