Tailoring KPA(Key Process Area) of CMM (Capability Maturity Model) to Accede with RUP (Rational Unified Process)

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Abstract - This paper proposes to tailor RUP so as to comply with CMM Levels 2, 3, 4 & 5. Aim of this paper is to present whether RUP satisfies each key process (KP) in their respective key process area (KPA). CMM consists of many KPA’s and each KPA consists of KP comprising of some goals. In this paper we are explaining each CMM goal and we are showing whether RUP satisfies each goal or not. This is shown by each KPA goals of CMM being satisfied by RUP. After which it can be concluded which KPA goals are satisfied by RUP and which are not. RUP can be applied in that KPA’s whose goals are satisfied by RUP and an alternative has to be find out by organization’s for KPA’s which are not satisfied by RUP. If RUP satisfies every KPA goal of CMM, then it can be used in organizations in place of CMM hence covering planning, managing, engineering and maintenance practices of software development while achieving goals like cost, schedule, functionality and product quality.

Index Terms - Rational Unified Process, RUP, Capability Maturity Mode, CMM, Key Process Area; KPA, Key Process; KP, Unified Modeling Language, UML.

I. INTRODUCTION

Software process is required for developing an software conforming to some established model that guarantees good quality software. But till date no such process is defined which is stable and standardized. Researchers and Practitioners are trying to develop a process or refining the processes which can meet stakeholders requirement. Earlier processes were not confronted with the security issues which has now threaten the developer. Security is now the preliminary thing which stakeholders want in their software.

The model to which the process are majorly conformed is CMM. Capability Maturity Model (CMM) is developed by Software Engineering Institute (SEI) with assistance of Corporation. CMM is a framework that describe the key elements of an effective software process[1]. CMM first version was released on 1991 and latest version is CMMI (Capability Maturity Level Integration) Version 1.3 CMM covers many Key Practice Area (KPA) and in this area the key practices covers engineering, planning, managing software development and maintenance.

A. Overview Of Capability Maturity Model

The CMM establishes a yardstick against which it is possible to judge, in a repeatable way, the maturity of an organization’s software process and compare it to the state of the practice of the (SEI) in association with MITRE Corporation. It was primarily made for the usage of U.S federal government to evaluate software providers efficiency and know that they can handle large projects or not. CMM is used by organizations to improve their software process by managing their budget improving quality and functionality. Figure 1 shows structure of CMM[3].
CMM consists of five maturity levels. Each possessing certain key practice areas (KPA) and key practices (KP). KPA identifies the related activities which will be covered in each maturity level. Any model complying to CMM must satisfy all key practices of CMM. Figure 2. CMM levels with their respective KPA.

- **Repeatable**: In this level experience and observation of previous project is used for similar type of project for tracking cost, schedule and functionality. The policies for managing software process is also considered.

- **Defined**: Software development process is now standard and consistent as software engineering and management process are established and repeatable. Now tracking of cost, schedule and functionality can be done accurately with quality tracking. Well defined outputs, standard and procedure for performing the task.

- **Managed**: Quantitative quality goals are set for software product and process by the organization. Process trends and product quality can be predicted applying quantitative bound. Quantitative knowledge of software quality can be obtained at this level.

- **Optimizing**: Prevention of the defects occurring in the project are focused, strengths and weakness of project are identified for continuous process improvement to improve process capability and performance.

There are five maturity levels in CMM consisting of certain key process areas (described in detail in section 2). Each key process areas define interrelated software practices which are used to attain certain prespecified goal necessary for setting up process capability at that maturity level.

Key process area goals are satisfied through key practices which describes “What” and not “How”. Project scope, its boundaries and its intent is defined in its goal that shows which key practices of each key process area has to satisfied. All levels except level 1 has certain key process area comprising key processes. Any organization willing to attain certain level has to satisfy all the key practices of that level to make process effective, repeating and lasting.

- **Initial**: There is no predefined software process which organization follows. Process may vary according to software requirements. The development of software process depends initially on individual work efforts and skills The procedure can be repeated.
B. Overview of Rational Unified Process

RUP is a software engineering process widely used by software developers. It is an iterative software development process framework based on UML created by the Rational Software Corporation, a division of IBM since 2003[2]. UML (Unified Modeling Language) is a standardized general purpose modeling language in field of software engineering[3]. Rational Unified Process (RUP) is a software engineering approach to the assignment of tasks and responsibilities within a development organization. Its goal is to deliver the software on time with assured quality and within affordable cost. RUP is modified and customized in accordance with project but it does not deal with issues like how to provide security to a developing software. RUP deals with “HOW” and not with “WHAT” i.e. it shows how to do and not what to do. The security is limited to only initial phases of development during the identification and documentation of supplementary requirements. But only in the initial phase the threats cannot be identified completely. No security plans exists thereafter for finding malicious objects within a software. RUP is an iterative software engineering process, though it is not a well defined process model instead it is an adaptable process framework which can be tailored or customized by an organization according to different application. RUP is a disciplined, iterative approach used to assign task and responsibilities to software development team. Uses UML (Unified Modeling Language) for visualizing model. It comprises of six best practices which are: develop iteratively, manage requirements, employ a component based architecture, model software visually, continuously verify quality and control changes. Four Phases of RUP are Inception Phase in this initial cost, budget and success factor is forecasted. Use case model, project plan and initial risk assessment is generated. Elaboration Phase this phase focuses on risk items and architecture of project. Construction Phase objective is to develop components and other features of the project results in deliverable output. Transition Phase in this the software transits from producers to end users. End user training, maintenance and testing is done. There are nine disciplines within each iteration which describes unit of work assigned to a role. Six engineering disciplines are- Business Modeling is used for enterprise process analysis, improving process efficiency and quality. Requirements deals with functional, quality and performance requirement which collectively defines what system should do Analysis And Design Transforms requirement to system design using use cases and models defined by UML (Unified Modeling Language) defines object characterized by its class to develop comprehensive architecture adapting design of system for performance. Implementation Classes and objects are implemented in terms of executables, source files and others. Components are tested and integrated to produce executable system. Test and Deployment where test verify the implementation correctness. Any defects encountered is either fixed or elicited. Deployment refers to custom install and end user can access the system. Three supporting disciplines Generally are – Configuration and Change Management discipline deal with identifying and managing configuration item and control changes demanded and change version Project Management discipline focuses on monitoring project by planning, staffing and risk management. Metrics and progress of iterative projects are also monitored. Environment discipline aims to configure the process and provides tools and Supporting processes to software development as shown in Fig. 3. [4]
In this paper we are trying to make RUP compatible to CMM so that it can comply with all CMM levels 1, 2, 3, 4 & 5 that is initial, repeatable, defined, managed, and optimizing respectively. Also in this paper RUP shortcomings are elicited so that RUP can be used for delivering a complete software. This paper will present what are the key areas that should be covered by RUP to conform to CMM. What measures are required for enhancing RUP so that in an organization it can be used conforming CMM Level 2,3,4 & 5. RUP can be tailored as per organization needs. CMM is a framework and not a model it is used to develop and refine software development process. Whereas RUP is a process framework which is used for assigning task and responsibilities within organization. The six best practices described in RUP are: develop iteratively, manage requirements, use components, model visually verify quality, control changes used in designing software.

Sections covered by this paper are as follow:
Section 2 overview the extension required in RUP to comply with CMM level 2, 3, 4 & 5. Section 3 concludes paper.

I. Extension Required in RUP to Comply With CMM Level 2, 3, 4 & 5.

In this Section we will discuss whether organization who want to reach CMM level can use RUP instead or not. What are the key practices that RUP must satisfy so that it can be used in place for each one get chance to add their requests. of CMM. A CMM key practice is considered to be satisfied if there is a set of activities, artifacts, workers, or workflows in RUP to implement it [5]. This sections describe all the key practices of CMM level 2, 3, 4 & 5 and also whether RUP satisfy all key process area of CMM or not. And if not then organizations have to achieve them by some alternatives. Level 1 that is Initial level does not have any key process area so it is not considered for RUP extension.

A. Level 2- Repeatable Process

a. KPA 1: Requirement Management (RM) –
It focuses on building shared understanding between customer and program of what are customer’s requirement and that are essential for the developing software are agreed upon. Planning and management of software is done accordingly.

b. KPA 2: Software Project Planning (PP) – It involves establishing task, resource allocation and schedule for performing and managing software project’s activities.

- Goal 1: Software estimates are documented for use in planning and tracking the software project.

RUP defines this in Project Management Workflow it involves planning, staffing, executing, managing project and managing risk to ensure synchronized and consistent software development.

- Goal 2: Software project activities and commitments are planned and documented.

RUP artifacts satisfying this are – Software Development Plan (SDP) gathers all information required to manage and control project. Business Case provides information whether the project is worth investing or not. Risk Management Plan deals with how to manage project risks. Status Assessment its objective is to ensure all parties expectation to be consistent and synchronized. Iteration Assessment it it evaluates the iteration result to find to which extend criteria met and changes to be done. Development Case discusses infrastructure plan and tool.
• Goal 3 : Affected groups and individuals agree to their commitments related to the software project.

RUP artifact Product Acceptance Plan describes customer evaluation of deliverable artifact to determine they meet predefined set of acceptance criteria. Project Measurement it is project repository of metrics data. Work Order in this planning is turned to action.

Project Manager is responsible to keep project team focused on right goal and also ensures project artifact integrity and quality. Project Reviewer evaluates project planning and assessment artifacts.

c. KPA 3 : Software Project Tracking & Oversight (PT) – It involves software tracking, reviewing and providing adequate visibility into actual progress to manage and to take considerable action when the path diverges against the software plan.

• Goal 1 : Actual results and performances are tracked against the software plans.

Project plan and state evaluation is required in RUP for matching the result to actual plan. Project Management Workflow is used to Monitor and Control project, Project Planning Review and at the end of each phase formal reviews are taken. Stage end is known by achieving RUP milestone.

• Goal 2 : Changes to software commitments are agreed to by the affected groups and individuals.

This goal is satisfied by artifacts and activity of RUP, artifact Iteration Plan it is a time sequenced set of Activities associated with assigned resources, contains task dependency for every iteration. Risk List it identifies risk to the project. Associated with mitigation or contingency actions. Project Measurement is used for storing the accomplished data.

Project Manager is responsible to keep project team focused on right goal and also ensures project artifact integrity and quality with accomplishment of project.

d. KPA 4 : Software Sub Contractor Management (SCM) - Its purpose is to select and manage qualified software sub contractors. SCM task is to setting commitments with sub contractors, tracking and reviewing its performance and obtaining results. Prime Contractor is assigned which works with sub contractor to manage its product and process interfaces.

• Goal 1 : The prime contractor selects qualified software sub contractors.

• Goal 2 : The prime contractor and the commitments to each other.

• Goal 3 : The prime contractor and the software sub contractor maintain ongoing communications.

• Goal 4 : The prime contractor tracks the software sub contractor's actual results and performance against its commitments.

There is no artifact or workflow in RUP supporting this KPA.

e. KPA 5 : Software Quality Assurance (SQM) – Its purpose is to review, audit and manage the Software products to verify that they comply with the plan procedures and standards. It ensures proper application of quality control within the application. It has four goals.

• Goal 1 : Software quality assurance activities are planned.

RUP achieves this goal through Quality Assurance Plan. It gives a clear view for how to assure product, artifact and process quality.

• Goal 2 : Adherence of software product and Activities to the applicable standards, Procedures and requirements is verified objectively.

Developing plan is covered in Develop Quality Assurance Plan activity of RUP which create project documented plan for quality assurance.

• Goal 3 : Affected groups and individuals are informed of software quality assurance activities and results.

For achieving this goal RUP recommends Software Engineering Process Authority (SEPA) to have Engineering Process Authority (SEPA) to have and ensuring proper planning and conduct to review events. As described in Review and Audit section of Quality Assurance Plan.

• Goal 4 : Noncompliance issue that cannot be resolved within the software project are addressed by senior management.

RUP neither provide clear view of how to tackle problems arising from review or audit nor states how to convey the result to Software Engineering Group or to the workers.

Quality Manager is responsible for process assurance and audits the application of practice.
f. KPA 6 : Software Configuration Management (CM)
It involves identifying specific configuration for the software and maintaining the integrity and traceability of the software project throughout software life cycle and keep control on project deliverable versions. Its goals are.
- Goal 1 : Software configuration activities are planned.
RUP artifact Configuration Management Plan deals with configuration and Change Control Management activities performed during project lifecycle. It covers activity schedule, assigned responsibilities and resources required.
- Goal 2: Selected software work products are identified, controlled and available.
RUP artifact Configuration Management Monitors project asset and software development policies controls the changes.
- Goal 3 : Changes to identified software work.
RUP activity Establish Change Control Process ensures that changes made to the system are assessed and applied in a consistent controlled manner.
- Goal 4 : Affected groups and individuals are informed of the status and content of software baselines.
RUP workflow Manage Change Request ensure that stakeholders are informed for the changes and state of product. Configuration or Change Control Board (CCB) oversees that change process consists of representative from customer, developer and user. Configuration Manager is responsible for ensuring Change Management (CM) development facilitates product review, change and defect tracking, develop CM plans and report progress based on change request.

B. Level 3 – Defined

a. KPA 1 : Organization Process Focus (OPF) –
It involves developing and maintaining software processes and coordinating the activities to assess, develop, maintain and improve the organization’s overall software process capability.
- Goal 1 : Software process development and improvement activities are coordinated across the organization.
RUP artifact Development – Organization Assessment and activity Assess Current organization describes the current status of the software organization in terms of current process, tools, peoples' competencies, peoples' attitudes, customers, competitors, technical trends, problems, and improvement areas.
  - Goal 2 : The strength and processes used are identified relative to a process standard.
According to [5] RUP does not describe how the improvements identified at the process evaluation are implemented neither does it include information about how to elaborate or review plans, as is proposed in CMM.
  - Goal 3: Organization level process development and improvement activities are planned.
RUP artifact Software Development Plan gathers all the information required to manage the project and is maintained throughout the project.
  - Process Manager is responsible for software process development and continuously improving the process during the development effort.

b. KPA 2:Organization Process Definition(PD) –
The purpose of Organization Process Definition is to develop and maintain a usable set of software process assets that improve process performance across the projects and provide a basis for cumulative, long-term benefits to the organization. Involves developing and maintaining the organization's standard software process, along with related process assets. Assets are used for developing, implementing and maintaining the projects’ defined software processes.
  - Goal 1 : A standard software process for the organization is developed and maintained.
RUP artifact Development Case describes the development process that has been chosen to follow in project.
  - Goal 2 : Information related to the use of the organization's standard software process by the software projects is collected, reviewed, and made available.
Through the RUP artifact Software Development Plan all the required information is gathered to manage and maintain project and activity Monitor Project Status capture current status of the project and evaluate status against plans.
  The Process Engineer is responsible for the software development and improvement process.
c. KPA 3: Training Program (TP) – Its purpose is to develop the skills and knowledge of individuals so they can perform their roles effectively and efficiently. Each software project evaluates its current and future skill needs and determines how these skills will be obtained. Training is provided by organization.
- Goal 1: Training activities are planned.
- Goal 2: Training for developing the skills and knowledge needed to perform software management and technical roles is provided.
- Goal 3: Individuals in the software engineering group and software related groups receive the training necessary to perform their roles.

This KPA is not supported by RUP.

d. KPA 4: Integrated Software Management (ISM) – Its purpose is to integrate the software engineering and management activities into a coherent, defined software process that is tailored from the organization’s standard software process and related process assets, which are defined in Organization Process Definition. The tailored development process to program specific requirements and is used for planning, estimating resources and cost and manage risks.
- Goal 1: The project’s defined software process is a tailored version of the organization’s standard software process.

RUP artifact Development Case describes the development process chosen. Environment Workflow describes how for a specific project, organization software process to be tailored.
- Goal 2: The project is planned and managed according to the project’s defined software process.

RUP activity Monitor Project Status capture current status of the project and evaluate status against plans and activity Develop Measurement Plan define management goals, in terms of quality, progress and improvement.

\[ \text{terms of quality, progress and improvement.} \]

- Goal 2: Software work products are kept consistent with each other.

Software engineering activities are described by RUP nine workflows as mentioned in section 3. It covers all the aspects of software product engineering.

f. KPA 6: Intergroup Coordination (IC)- The purpose of Intergroup Coordination is to establish a means for the software engineering group to participate actively with the other engineering so the project is better able to satisfy the customer's needs effectively and efficiently. Its purpose is to control and coordinate software engineering group's interaction with other groups.
- Goal 1: The customer's requirements are agreed to by all affected groups.
- Goal 2: The commitments between the engineering groups are agreed by the affected groups.
- Goal 3: The engineering groups identify, track, and resolve intergroup issues.

RUP describes interaction among workers of different and activities executed. RUP does not give a clear vision of how the commitments and activities at system level are coordinated.

g. KPA 7: Peer Reviews (PR) - The purpose of Peer Reviews is to remove defects from the software work products early and efficiently. An important corollary effect is to develop a better understanding of the software work products and of defects that might be prevented. Specific software work product areas are evaluated for identifying defects and changes needed.
- Goal 1: Peer review activities are planned. This is achieved through Review and Audit Plan of artifact quality and assurance plan.
- Goal 2: Defects in the software work products are identified and removed. This is achieved through Review record which is done at the end of each review comprising of used artifact result review, defects identified, resources used, scheduling, cost etc.

C. Level 4 – Managed

a. KPA: Quantitative Process Management (QP) Its purpose is to control the process performance
technical activities to be done in process development.

- Goal 1: The software engineering tasks Process performance represents the actual results achieved from following a process. Quantitative Process Management adds a comprehensive measurement program to the practices of Organization process Definition, Integrated Software Management, Intergroup Coordination, and Peer Reviews[6].

- Goal 1: The quantitative process management activities are planned.

RUP artifact Measurement Plan defines measurement goal and metrics used for monitoring progress of the project through Monitor Project Status.

- Goal 2: The process performance of the project’s defined software process is controlled quantitatively.

RUP any workflow does not satisfy this goal. But Test Manager is responsible for identifying necessary resources, human, hardware and software.

- Goal 3: The process capability of the organization’s standard software process is known in quantitative terms.

RUP artifact Project Measurement is a repository of metric data and contains most current project, resources, process and product measurement at the primitive and derived level. Activity Create Baseline ensures all developed artifacts are captured and archived.

b. KPA 2: Software Quality Management (QM) - Its purpose is to develop a quantitative understanding of the quality of the project’s software product and achieve specific quality goals.

- Goal 1: The project’s software quality management activities are planned.

In RUP mapping of Quality Assurance Plan section to artifacts Project Management, Review and Audit Plan and Documentation ensures management, planning and documentation of software quality.

- Goal 2: Measurable goals for software product quality and their priorities are defined.

RUP concept Measuring Product Quality identifies the measure and determine if desired level of quality has been achieved. Negotiate Work Product advocate for an appropriate solution to be auctioned in an acceptable time frame that does not adversely affect required quality but RUP does not specify about goal priorities.

- Goal 3: Actual progress toward achieving the quality goals for the software products is quantified and managed.

of the software project quantitatively. Software RUP artifact Assess and advocate quality monitor the progress and support appropriate completion of changes for improving software quality. The activity Develop measurement plan define management plan in terms of quality, progress and improvement. Project Manager allocates resources, determines priority and keeps team focused on right goal. He also ensures quality and integrity of project.

D. Level 5 – Optimizing

a. KPA 1: Defect Prevention (DP) – Its purpose is to identify the cause of defects and prevent them from recurring. It prevents the occurrence of defects in future on the basis of defects encountered earlier and taking its remedial action.

- Goal 1: Defects prevention activities are planned.

RUP does not specify any form of defect prevention and removal techniques[7].

- Goal 2: Common causes of defects are sought out and identified.

Artifact Change Request (CRs) is used to document and track defects. The Testers uses CRs to identify and describe defects found in testing. The main source of defect is the result of executing the tests – integration, system and performance[8]. Activity Fix Defect is used to find the common occurrence of defects.

- Goal 3: Common causes of defects are prioritized and systematically eliminated.

RUP does not specify any form of defect prioritization and defect removal techniques.

b. KPA 2: Technology Change Management (TCM) - Its purpose is to identify new technologies (i.e. tools, methods, and processes) and track them into the organization in an orderly manner. It focuses to improve software quality, increase productivity and decrease product development time.

- Goal 1: Incorporation of technology changes are planned.

- Goal 2: New technologies are evaluated to determine their effect on quality and productivity.

- Goal 3: Appropriate new technologies are transferred into normal practice across the organization.
RUP does not specify anything about Technology Change Management instead it specifies about Tools select and acquire tool, setup tool, develop and verify.

c. KPA 3 : Process Change Management (PCM) – Its purpose is to continually improve the software process used in the organization with the intent of improving software quality, increasing productivity and decreasing the cycle time for product development. It deals with incremental improvement of Defect Prevention and Technology Change Management.

- Goal 1 : Continuous process improvement is planned.
- Goal 2 : Participation in the organization’s software process improvement activities is organization wide.
- Goal 3 : The organization’s standard software process and the project’s defined software processes are improved continuously.

Although the RUP recognizes the possible need for Process Improvement Plan, it is currently outside of the scope of the process and no explicit guidance is provided for their creation or for their contents[9].

II. SUMMARY AND CONCLUSION

In this paper the KPA goals satisfied by RUP and goals not satisfied by RUP phases, workflows, artifacts, roles are identified. Organization can tailor RUP according to their requirements and search an alternative for uplifting the shortcoming encountered, so as to comply with CMM level 2, 3, 4 and 5. RUP does not support the following KPA’s –

For achieving CMM level 3 the organization should find path for providing training program to members and finding means to improve the process such as improvement plans and review procures.

For achieving CMM level 4 organization should deploy an alternative for controlling software process quantitatively.

For achieving CMM level 5 defect prevention and their prioritize activities should be planned at organization level.

Measures has to be taken by organizations to meet the following goals not attain by RUP.

REFERENCES
[13] Chang Ge “Modifying RUP (Rational Unified Process) to Comply with CMM(Capability Maturity Model) Levels 2&3”