

Role of Capability Maturity Model Integration (CMMI) in Software Process Improvement

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ABSTRACT

Software development process have been improving continuously and process improvement is growing concern for successful delivery of the product. Productivity, efficiency, quality and fit for purpose are major factors considered in software development. Different models based on CMMI, that software companies are using to improve the software process improvement activities are discussed in this article. Software companies are resistant to adopt improved models and methods due to various reasons such as complex structures. Project managers can understand and control the quality of the software and very closely by implementing CMMI model. In order to increase the maturity of the software development process, this study defines the major process areas for software projects and offers implementation strategies in the form of key activities.

Keywords:- CMMI, software process improvement, process area, project management

INTRODUCTION

Software development process requires regular improvement to build a quality product. Many software companies now a days wants to improve their software development process to improve software quality, productivity and reduce development time in order to increase competitiveness and revenue [1].

Software development process tasks are treated as a single measurable, controllable and improved process to address the software related tasks [2]. Improvement of software development process helps to maintain balance between time, cost and quality of software. However, most of the companies fail to identify the key factor affecting the performance of the development process. A wide variety of methods, such as, configuration management, defect prevention, function point analysis, quality function deployment, software quality assurance (SQA), software-reliability engineering,

and total quality management, usually puts project managers in dilemma to choose the proper method in proper time [1].

The motivation of software process improvement is a result of a competitive market, customer's demand well performing software product and to make substantial profit margin. Process improvement approach is not applied without studying the current performance and status of the development process. Once performance and status of the software development process is studied, either process improvement approach is applied or development process is changed.

Most often, improvement approach is applied rather than changing the existing process till it is possible to improve. "The selection and successful implementation of improvements depend on many variables, such as the current process maturity, skill base, organization, and business issues

such as cost, risk, and implementation speed” [3].

CMMI is used for software process improvement. It offers a useful framework for direction that incorporates CMMI models, training, and evaluation techniques. The many interests of an organization are focused on by CMMI, including development, services, and acquisition. Multiple process areas are covered by the practices in CMMI. Project management is a common major process area of CMMI, and its goal is to recommend project management techniques, the management process, and the final product throughout the project life cycle. The main goal of CMMI is the

achievement of business objectives through a mature process. As a result, benefits include process adherence, cost of quality, performance improvement, increased business efficiency, increased productivity, accelerated schedules, customer satisfaction, and return on investments [4].

Software project processes are represented as five-level system as shown in figure 1. Software development process improvement identifies whether the development process is under statistical control or not, if yes, it performs well, otherwise it is not possible until it comes under statistical control.

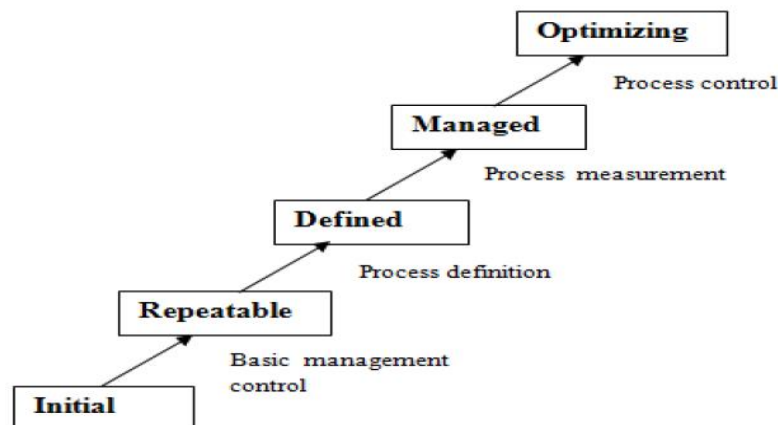


Fig.1:-CMMI Maturity Levels [2]

Maturity levels and capability levels are two varieties of levels supported in CMMI. Maturity levels give a staging of processes for improvement across an organization from maturity level one to maturity level five [5].

Every level could be cluster of process areas (i.e. practices that once enforced satisfies a set of goals resulting an improvement in a specific area in an organization. e.g. project planning). Capability levels enable organizations to focus its process improvement efforts by process area from capability level 0 to capability level 3 [6].

RESEARCH METHODOLOGY

The study is more concerned with the understanding of CMMI in software development process improvement. Models, training, and evaluation techniques are all part of the CMMI framework, which offers an efficient direction.

The use of CMMI to achieving business objectives through an established process is the focus of the work. An interpretive research approach was followed to conduct this study. If a research is carried out being based on the assumption that humans learn about the reality from meaning they assign

to social phenomena such as language, consciousness, shared experiences, publications, tools and other artifacts [7]. Interpretive research is predicated on the idea that social reality is not static or objective but is instead affected by individual experiences and social situations. The interpretive research process can be interpreted as a hermeneutic circle. Different stages of the hermeneutic circle are shown in figure 2. At first phase of hermeneutic circle researcher makes the pre understanding about the research problem. The second

phase which is called absorption phase is concerned about gaining the more knowledge from different resources to expand the interpretation potential. The third phase is concerned with theory building on the basis of interpretations, explanation attempts, and perception of missing knowledge areas. Finally new theories and results acquired from the study are documented as a report [8]. In this study, hermeneutic approach is used to explore the improvement of software development model using CMMI.

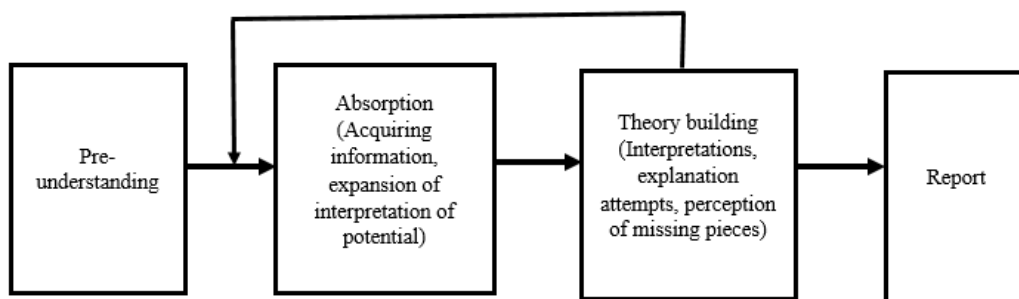


Fig.2:-Hermeneutic circle [8]

CAPABILITY MATURITY MODEL INTEGRATION (CMMI)

The Capability Maturity Model (CMM) was originally developed and published in 1988 by Watts Humphrey at Software Engineering Institute (SEI). Primary aim of the CMM is to assist United States (US) department of Defense in software related activities. A year earlier, SEI released a framework briefly describing the process

maturity. Capability Maturity Model Integration (CMMI) is the successor of CMM model. According to SEI [9], CMMI aids in the integration of formerly distinct organizational tasks, establishes goals and priorities for process improvement, offers direction for high-quality processes, and serves as a benchmark for evaluating current processes.

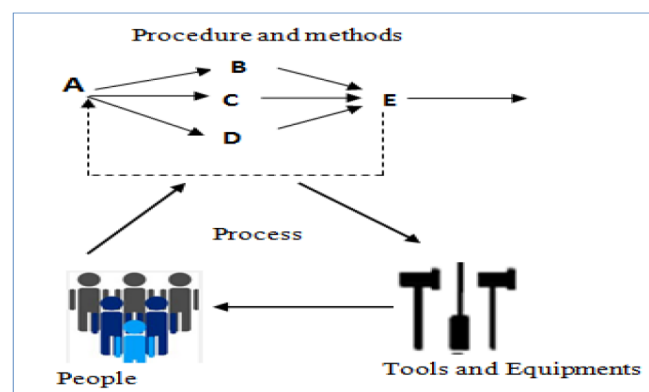


Fig.3:-Critical dimensions for software process improvement [10]

Among several dimensions that an organization can focus for software process improvement, typically three critical dimensions are focused. Such critical dimensions are; procedure and methods, people and tools and equipment's. Critical dimensions that an organization focuses are shown in figure 3.

The CMMI model provides two methods (1) continuous representation and (2) staged representation of the software process improvement. These methods are also called model representations [10]. Continuous representation and staged representation approached are associated with capability levels and maturity levels of CMMI respectively. Using the continuous representation enables you to achieve "capability levels" and using the staged representation enables you to achieve "maturity levels" [5].

SOFTWARE PROCESS IMPROVEMENT USING CMMI

CMMI research discovered three critical dimensions in development of any product and service as shown in Figure 3. In any software development process the first major dimension is the people who are the key drivers. These are the highly skilled people with high motivation and training and they know their goals and targets. The second dimension is the tools and equipment's provided by an organization. To achieve best result new technologies and setup are built.

The third dimension is methods and procedures which are followed in order to achieve organizations goals effectively and efficiently within the allocated time and budget. People cannot be good each day, it might require longer time and resources to understand new technology trends, procedures and methods may vary in different environment but if an organization has a quality process its performance will increase rapidly because

the companies who focus on process don't need to put additional effort in people, procedures and technologies they just work smartly and improve the process [4]. The main focus of CMI is to improve the quality of development process.

The advantages of using CMMI is to reduce cost, effective utilization of resources, streamline things and manage the resources to produce quality products in low cost. The CMMI model provides two methods which are continuous representation and staged representation of the software process improvement. While continuous representation employs individual process areas from any level, staged representation takes a step-by-step strategy within an organization.

A. Staged Representation

Maturity levels are used in staged representation to describe how the organization's processes now stand in relation to the model. It is less detailed than continuous representation, but it provides higher level of aspects of organization, straightforward, easily understandable label, with more direct commercial implications.

Through grouping, validated order, and relationships between organizations, the staged model offers a specified path for process improvement. Five maturity levels of CMMI are shown in figure 1. The predetermined paths are described as the stage of maturity level by the phases, which are the model representation technique. Maturity levels apply to method improvement actions taken by associated organizations across several process areas.

These levels serve as a way to enhance the processes associated with a certain group of process areas.

I. Maturity level

Maturity level indicates the level of performance expected from the

development process followed by the organization. There are five maturity levels in CMMI. Since each level serves as the "pathway" for the organization to carry

out process improvement, if level 2 is not archived, level 3 cannot be reached or begun. [4]. Table 1 shows five maturity levels together with accompanying indices.

Table 1:-CMMI maturity levels

Index	Maturity Level
1	Initial
2	Managed
3	Defined
4	Quantitatively Managed
5	Optimizing

II. Maturity levels and process area

In staged representation there is co-relation between process area and maturity level. Maturity level contains name and number of process area and process area belongs to specific maturity level. But the same

process cannot exist in multiple levels. CMMI includes 5 Maturity levels, 22 process areas [11]. Table 2 shows the relationship between process area and maturity levels.

Table 2:-Relationship between process area and maturity level.

Process Area	Maturity Level
Organizational Innovation and Deployment (OID)	5. Optimizing
Causal Analysis and Resolution (CAR)	
Organizational Process Performance (OPP)	4. Quantitatively Managed
Quantitative Project Management (QPM)	
Requirements Development (RD)	3. Defined
Technical Solution (TS)	
Project Integration (PI)	
Verification	
Validation	
Organizational Process Focus (OPF)	
Organizational Process Definition (OPD)	
OT: Organizational Training (OT)	
IPM: Integrated Project Management (IPM)	
Risk Management (RM)	
Decision Analysis and Resolution (DAR)	
Requirement Management (ReM)	2. Managed
Project Planning (PP)	
Project Monitoring and Control (PMC)	
Supplier Agreement Management (SAM)	
Measurement and Analysis (MA)	
Process and Product Quality Assurance (PPQA)	
Configuration Management (CM)	
	1. Initial

Maturity levels advance gradually in due order to achieve certain maturity level. For example to achieve CMMI level 4 , in addition to satisfy the total two process

areas of CMMI level 4, the eleven process areas of level 3 and the seven process areas of level 2 should also be satisfied.

This process implies to achieve any CMMI level.

B. Continuous Representation

In continuous representation, capability levels identifies the state of the organization's processes compared to an individual process area. Continuous representation enables a company to assess each process area separately. Continuous representation enables pinpointing problem areas, focusing on them, and tracking improvement progress on a more granular level. In individual process area,

capability levels are used to measure the improvement path from an unperformed process to an optimizing process. These levels are means for incrementally improving the process corresponding to a given process area [3].

I. Component structure model

Continuous representation combines all the process areas in order to follow compatibility and capability level of process improvement in every process area. Structural relationship between different elements is shown in figure 4.

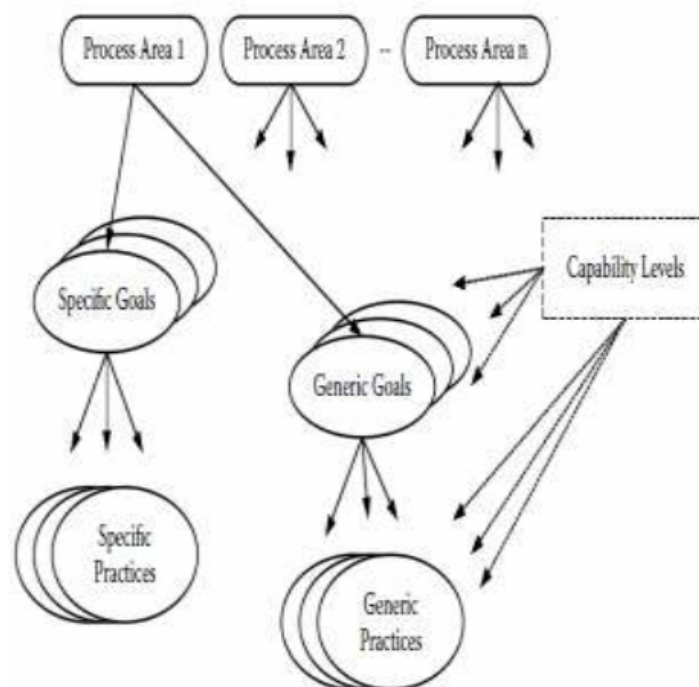


Fig.4:-CMMI model components in the continuous representation [5]

Figure shows that each special practice and each generic practice correspond to a capacity level, whereas the specific aim organizes specific practice and the generic goal organizes generic practice. The unique process area can make use of the specific objective and specific practice.

II. Capability level

CMMI contains six capability levels and are leveled from 0 to 5. Each capability model contains related specific practice

and generic practice of different process areas which helps to improve the process. Capabilities of different process are shown in table 3.

The capability level zero or 'incomplete' is a process where no generic goals are defined and which is either not performed or partially performed. Level 1 is the actual initial stage of process improvement where organizations perform something. As level one is initial stage so nothing can

be measured in terms of schedule, cost and quality. Level 2 deals with the policies and strategies of the organization. The people involved in the development process are experienced and skilled so that they can perform tasks utilizing the resources in structured manner. Tasks are performed in defined process so that project status can be monitored. At level 3, organizations set of standards, described process, tools and methods are described. At capability level

4 organizations define the process by controlling it using quantitative and statistical techniques. Life cycle of the project is managed through out by applying statistical and quantitative methods in terms of product quality, process performance and service quality. Level 5 deals on analyzing and studying the results of the entire process to find the problems in process improvement and fixes them accordingly.

Table 3:-CMMI Capability levels

Index	Capability Level
5	Optimizing
4	Quantitatively Managed
3	Defined
2	Managed
1	Performed
0	Incomplete

III. Process area capability profile

Capability profile is the relationship between process area and the capability in each level. It indicates the organizational achievement of each process area as a result profile. If the profile represents the process improvement goal of an organization, the process area capability represents the goal profile. Goal profile can track the process improvement progress rate whereas result profile can verify the management results of organization in addition to track the process improvement progress rate.

CONCLUSION

Software process improvement helps to improve the software productivity significantly. Implementation of CMMI model is one means of software process improvement. Software process improvement can be achieved by focusing on different fields such as selecting skilled employee, process standardization, adequate documentation, continuous quality measurement and their controlling,

and introducing basic project management processes. Implementation of CMMI model helps project managers to understand and control the software product quality very closely. Managerial activities refer to the manager's strategy to motivate employees to act according to the organizational strategy, procedure and goals.

Control activities refer to the defining and documenting the task assignment, defining the way of work being done, defining standards and performance guidelines, and defining the processes. The results achieved from the research study indicate that, it is one of the best options to implement CMM model to achieve higher software quality and to achieve significant improvement in productivity.

CMMI model focuses on "what to do" approach rather "how to do" approach. Team members can include "how to do" approach to carry out tasks assigned to them without modifying "what to do."

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