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Software process improvement models and their comparison

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Abstract: Software Process Improvement (SPI) involved the practical actions to improve the processes in the organizations to make their business goals more effective. The main objective of SPI is to set methods in such a way that it improves the software development process. To implement the methods of software process improvement, there are some methods which help in understanding those methods. These models are known as Software Process Improvement Model. This paper includes study of some important software process improvement models and a comparative analysis is done between these models. Some limitations of these SPI models are also discussed in this paper.

Keywords: Software Process, Software Process Improvement, SPI models.

I. INTRODUCTION

To begin with the improvement of software process, we have to understand what exactly the term "software process" means. A process is a chain of activity or procedures taken in order to achieve a specific conclusion. In case of software, a process is defined as a series of actions or steps in order to achieve a software product or another process. Since, it is necessary to achieve a good quality software product in order to satisfy the customer's requirement and making a software product effective to use, we have to improve the process to make it more effective and easy to use. An approach which is needed to improve the software process is called software process improvement.

A collection of associated movement that results in a software product is called software process. Based on the selection and perception made by people, software processes are complicated, rational and innovative process. [1] There are four main activities in different software processes that are basic to software engineering which are software specification, software design and implementation, software validation and software evolution.

Software process improvement involved the actions which are practical in nature for the improvement of processes in the organization in order to ensure that they meet business goals more effectively. It is concerned with describing the correct processes and consistently follows them. Software process improvement involves training to all staff on the new processes; refine them, and continuously improved them. [2] The main aim of software process improvement (SPI) is to put procedures to improve the development process which includes management of projects, obtaining and managing requirements, work plan, decision making, measuring capabilities, risks-handling etc. It is important for the organizations to identify the main reasons behind their failed and accomplished projects and take measures or necessary actions to make corrections wherever needed. [3] Organizations have to be ready to generate quality software and services that meet requirements on schedule and within budget, to be in competition. Thus, to improve the quality of a software product and performance of project, organizations are executing software process improvement approach. These are the actions which are taken to change

the technique of an organization so that they accomplish more effectively their business objectives.

Software process improvement is one of the important methods to solve the crisis of software. It is based on the assumption that "developing software in a more anticipated ways outturn into approving quality software within time and cost schedules."[5] Therefore it is needed to implement the changes in the software process within the organization to attain particular objectives such as increasing development speed, attaining higher quality product or reducing costs.
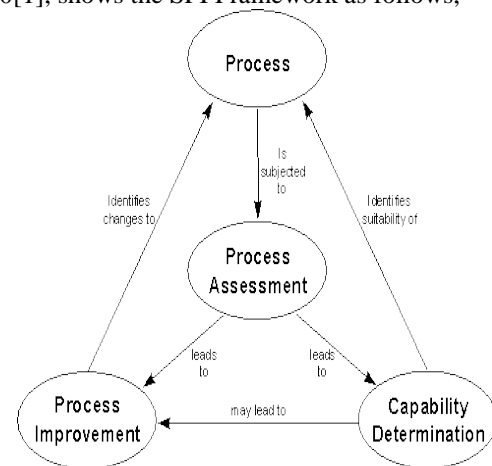
Fig. 1.0[1], shows the SPI Framework as follows,

Fig.1.0. SPI Framework [1]

There are main advantages of software process improvement which are as follows:
- Quality improved
- Productivity increases
- Low quality cost reduced
- Satisfaction of customer increases
- Consistency is improved in budget and schedule delivery
- Cost of software development reduced
- Team spirit improves. [2]

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II. HISTORICAL BACKGROUND

A time comes when dilemma takes place in software engineering around 1965-1985. The failure of a project was increased and the main cause of this crisis of software is the overall complexity of the software process. There are several ways by which crisis showing it as follows:
* Project was running above budget
* Project was running above time
* Low- quality software
* Requirement are not met
* Project was troublesome and there is difficulty in a code to maintain.[4]

We need an approach which helps in overcome this crisis. Thus, the Shewhart Cycle provides the basis for improvement of software process. The Shewhart Improvement Cycle was developed by Walter Shewhart, a physicist, worked at AT&T's Bell Laboratory in statistical process control in the 1930s. This idea was further adapted by W. Edward Deming and implemented in Japanese industry after World War II. As shown in fig. 2.0 [6], it defines four steps for a general improvement process [Deming82]. [6]

1. Plan
   Specify the problem
   Set up aim of improvement
2. Do
   Determine possible causes of problem
   Set up baselines
   Test change
3. Check
   Set data
   Measure data
4. Act
   Implement change in system
   Determine effectiveness.

Fig.2.0.The Shewhart Improvement Cycle [6]

III. SOFTWARE PROCESS IMPROVEMENT MODELS

To implement the software process improvement, researchers proposed some models which helps in understanding the methods which includes in the improvement of software. The models which help in the improvement of software process are known as software process improvement models.

A. *Six Sigma*

Six sigma methodologies were invented by Quality Engineer, Bill Smith at Motorola in 1986. This idea came when the CEO of Motorola, Bob Galvin was trying to improve the manufacturing process. They found that their quality was not good enough and hence, adopted the six sigma strategy to improve the quality. [7] Further, Jack Welch made it fundamental to his business approach at General Electric in 1995. [8]

Based on statistical analytic techniques, in order to enhance the organizational performance and to improve the quality, Six Sigma is a structured quantitative method. It was originally invented with the aim of reducing defects but later on it focuses on strategy execution and became a management system to run the business. [7]

Its definition is extended to three levels:

* **As a metric:** it mainly focuses on reducing defects when it comes to describe as a metric. We say a process is achieved Six Sigma if the quality is 3.4 DPMO (Defects per Million Opportunities). It shows that how well the product is functioning.
* **As a methodology:** it just not deals with reducing defects but rather to improve the process. Mainly two models i.e. DMAIC and DMADV were widely used.
* **As a management system:** as it is discussed earlier that six sigma approaches later focuses on strategy execution, it combines the metrics and methodologies for executing it. It provides a top-down solution to help the organization and aims to continuous improving product quality.[7]

Advantages and disadvantages of six sigma

Advantages: There are following advantages of six sigma:-
* Six-Sigma is customer-driven.it primarily focuses on maximizing the customer satisfaction [9].
* It is proactive rather than reactive because it determines that how we can make improvements before any failure or defects occurs in a product [9].
* Reduced defects [11].
* Increased profits and cost reduction [11].
* Improved quality [11].
* It basically focuses on the process improvement rather than final outcome [11].

Disadvantages: There are following disadvantages of six sigma:-
* Six Sigma critics often criticized, discussed and question about the adoption of Six Sigma. According to them, it takes a lot of time in those domain which are unprofitable in measuring 3.4 defects per million. Instead, they opined that quality standards should be according to specific tasks [11].
* There are lots to real-time barriers when we convert the theoretical concepts into practical applications which need to be resolved [11].
* It is difficult to implement as it requires the total co-operation and participation of the company. In large-companies, getting the entire staff on the same process can be a bit difficult [10].
* The extreme focus on the satisfaction of the customer can damage the company [12].
* It creates a stiff, procedural process and the cost of achieving its goals can harm profits [12].

B. *IDEAL Model*

The IDEAL model is developed by Software Engineering Institute (SEI) of Carnegie Mellon University in 1996 for software process improvement. It is an approach to continuous improvement which includes some phases to build a successful improvement strategy. [4 5] This model consists of five phases i.e. initiating, diagnosing, establishing, acting and leveraging phase.
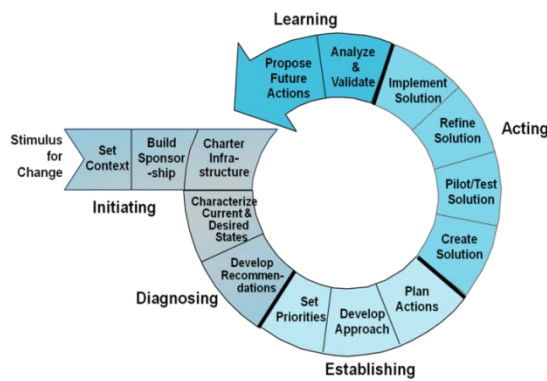
Fig.3.0 The IDEAL Model [4]

All these phases are described as follows:-
A. *Initiating phase: -* It is the starting point. In this phase, establishment of initial improvement infrastructure is done, the roles and responsibilities of infrastructure are specified, and the initial resources are appointed. The general objectives of SPI model are also specified in this initiating phase.
B. *Diagnosing phase: -* This phase starts the continuous software process improvement path and lays groundwork for the later phases. In this phase, lessons are learned from the past improvements efforts, and according to the organization's view, strategic business plans and SPI action plan is initiated.
C. *Establishing phase: -* During the establishing phase, issues are prioritized which are decide by organization to include in their improvement activities and also the solutions regarding those issues are developed. The general goals which are defined in initiating phase are used to develop measurable goals and these measurable goals are included in the final version of the SPI action plan.
D. *Acting phase: -* In the acting phase, the solutions to improvements are created, controlled and arranged to see whether it is going in a right direction or not, refined and then implement these solutions. This phase is all about doing the work required to achieve the desired goals.
E. *Leveraging phase: -* The main goal of the leveraging phase is to make the next pass through the IDEAL model more adequate. Solutions are made, and lessons are learned from the past and by adopting these ways we can improve in the future.[15]

Advantages: - IDEAL model provides a disciplined strategy and for the improvement process and establishes a long-term improvement strategy. It is the effective approach to software process improvement methods. [4]
Disadvantages: - Since, it is a continuous improvement model. No recovery phase exits in this model and hence either it will be successful or fail all at once. [4]
C. *SPICE Model*
ISO/IEC validated a project under the working title SPICE (Software Process Improvement and capability determination) in January 1993. It includes the participation of dominant world experts in the field of software engineering. The main aim of this project was to determine a standard for determining the ability of its continual improvement and software production process. Standard ISO/IEC 15504 or SPICE provides a framework for the determination of software processes. This framework can be used by organizations involved in devising, executing,

monitoring, controlling and improving the attainment, supply, development, operation, measurement and support of software. [16]
SPICE has a process model architecture which is two dimensional structures: the process dimension and the capability dimension. The process dimension includes the main processes and the base practices under the process categories. These process categories are as follows:
➢**Customers-Suppliers (CUS):** It consists of 8 CUS processes. These are the group of processes which directly affect the customers, transition of the software to the customer, and support development.
➢**Engineering (ENG):** It consists of 7 ENG processes. It defines straightaway, executes or maintains a system and software product, also maintains its user documentation.
➢**Project (PRO):** It consists of 8 PRO processes. It consist a group of processes that helps in building the project, combine, and manages its resources to produce a product or provide a service that satisfies the requirement of customer.
➢**Supports (SUP):** It consists of 5 SUP processes. It supports and prepares the performance of the processes in a project.
➢**Organizations (ORG):** It consists of 7 ORG processes. These processes build the business goals of the organization. It develops a process, project, and resources to achieve the desired business goals.[16]
In capability dimensions, each process capability is expressed in terms of capability levels. The capability level is collection of common features that work together to provide a major improvement in the ability to perform a process. There are 6 capability levels:
➢**Level 0:** *Not-Performed:* It expresses the general failure to perform the ground practices in the processes. The work product or output cannot be easily identified.
➢**Level 1:** *Performed-Informally:* It allocates resources, assigns roles, process documentation, supply tools, and provides training and process planning.
➢**Level 2:** *Planned-and-Tracked:* In this, the performances are well planned and tracked.
➢**Level 3:** *Well-Defined:* This level is planned and managed using an organization wide standards process.
➢**Level 4:** *Quantitatively-Controlled:* Performance is actively managed and quality of the work products is known.
➢**Level 5:** *Continuously-Improving:* It includes the ability to build the process effectiveness goals, improve the standard process. Reducing the cause of defects and continuously improve the defined process.[16]

Advantages- According to the business needs, when compared to a step-by-step evolutionary approach, organization can focus on the appropriate process areas for development. [17].
D. *CMM Model*
Capability Maturity Model (CMM) for software was developed in 1991 by Software Engineering Institute (SEI) at Carnegie Melon University. As it helps the organization and gives a brief description of how they can improve the process to develop software. It proves to be a major milestone in the software process management. There are five maturity levels of the software CMM- Initial, Repeatable, Defined, Managed and Optimized. These levels are defined as follows:
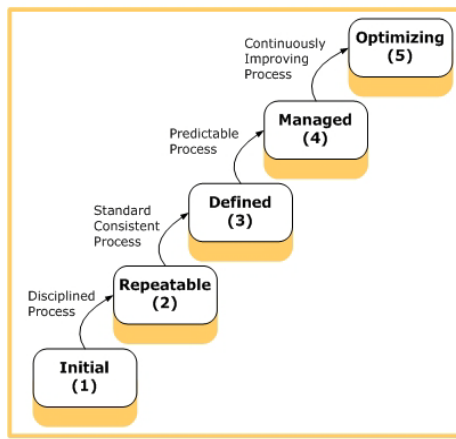
Fig.4.0 The Five Levels of Process Maturity Levels [4]

At the Initial level, it is ad-hoc in nature. At this stage, processes are not defined or documented. At the repeatable level, basic management actions are generating such as to track cost, functionality and schedule. At the Defined level, the procedures are well-defined and documented. But quantitative measures are not done at this level. At the Managed level, measurements of product and process metrics are done and collected. At the optimized level, the focus is on continuous process improvement. The strengths and weakness are identified and defects are removed. [13]

Advantages- There are following advantages:-

- Consistent and cost-saving.
- Improve the process effectively.
  Disadvantages- There are following disadvantages:-
- It cannot be used as an emergency method of recovering from a difficult state.
- It describes what should be done to improve the process rather than how to do it.[4]

E. *ISO Model*

ISO stands for *International Organization for Standardization.* The term was chosen because it means "equal" in Greek, so the association wanted to express the idea of equality. [13] It is a standard for quality management system. Its certification is important to improve the organization. Standard assure some appropriate properties of products and services such as quality. [4].

The reasons why we use the ISO certification are as follows:-

- This ensures the customer confidence.
- It suggests corrective measures for improvements and focus on the weakness.
- Makes projects more focused, capable, and cost-effective.
- It articulates the need for desired documentation. [13].
  Advantages: Some of the benefits include:-
- Customer Satisfaction improves.
- Gives better product and services.
- Greater assurance of quality.
- Costs are reduced.
- Productivity improves. [13]
  Disadvantages: Some of the limitations include:-
- Absence of commitment by top managers.
- High cost in implementation and maintenance of ISO is also a big challenge.

- Also, there is a lack of knowledge on the importance of ISO in some organizations and therefore cannot implement it.
- The process to implement ISO registration process takes more time to complete. [14].

IV. COMPARATIVE ANALYSIS

A. *Comparison between CMM, ISO and Six Sigma [4]*

S. No.	CMM	ISO	SIX SIGMA
1	It is a goal for process improvement.	It is a quality management system which includes specialized quality standards.	It is a metric and methodology for process improvement.
2	It is about software development.	It works for hardware and software both.	It works as a management system for the improvement of process in an organization.
3	It describes how "mature" a software organization is.	It describes the quality of a product.	It shows how well the product is performing by removing defects.
4	It has an absence of standard-metrics.	It focus on the product quality	It focus on customer.
5	It is a process improvement approach which has 5 maturity levels.	ISO is the international developer of standards. It does not have a specific structure or levels.	It is a structured quantitative method aiming in reducing defects.

B. *Comparison between CMM and SPICE Model* [18].

S. No.	CMM	SPICE MODEL
1	It has a goal to improve the whole process capability in an organization.	It has a goal to improve the capability in each process.
2	It evaluates the capability of software process according to the data collection and analysis.	It evaluates the properties based on each process by analysis and data collection.
3	It has 5 maturity levels.	It has 6 capability levels.
4	It is more suitable for software process improvement.	It works on measuring and contrasting the capability of software process.

V. CONCLUSION

This paper includes the study of software process improvement and its models. We learn how we can improve the process by using different models. Some benefits and limitations of some important models are also discussed in this paper. Comparison between the models is done. These models help us to understand how the process of software improvement is done step by step and also helps us in understanding the concept of software process improvement.

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