Module 13

Software Reliability and Quality Management

Lesson 35

SEI CMM

Specific Instructional Objectives

At the end of this lesson the student would be able to:

- Identify the different levels of SEI Capability Maturity Model.
- Explain the key process areas of a software organization provided by SEI CMM model.
- Differentiate between ISO 9000 certification and SEI CMM.
- Explain the type of systems to which the SEI CMM model of quality management is applicable.
- Explain what personal software process is.
- Explain what six sigma is.

SEI Capability Maturity Model

SEI Capability Maturity Model (SEI CMM) helped organizations to improve the quality of the software they develop and therefore adoption of SEI CMM model has significant business benefits.

SEI CMM can be used two ways: capability evaluation and software process assessment. Capability evaluation and software process assessment differ in motivation, objective, and the final use of the result. Capability evaluation provides a way to assess the software process capability of an organization. The results of capability evaluation indicates the likely contractor performance if the contractor is awarded a work. Therefore, the results of software process capability assessment can be used to select a contractor. On the other hand, software process assessment is used by an organization with the objective to improve its process capability. Thus, this type of assessment is for purely internal use.

SEI CMM classifies software development industries into the following five maturity levels. The different levels of SEI CMM have been designed so that it is easy for an organization to slowly build its quality system starting from scratch.

Level 1: Initial. A software development organization at this level is characterized by ad hoc activities. Very few or no processes are defined and followed. Since software production processes are not defined, different engineers follow their own process and as a result development efforts become chaotic. Therefore, it is also called chaotic level. The success of projects depends on individual efforts and heroics. When engineers leave, the successors have great difficulty in understanding the process followed and the work completed. Since formal project management practices are not followed, under time pressure short cuts are tried out leading to low quality.

Level 2: Repeatable. At this level, the basic project management practices such as tracking cost and schedule are established. Size and cost estimation techniques like function point analysis, COCOMO, etc. are used. The necessary process discipline is in place to repeat earlier success on projects with similar applications. Please remember that opportunity to repeat a process exists only when a company produces a family of products.

Level 3: Defined. At this level the processes for both management and development activities are defined and documented. There is a common organization-wide understanding of activities, roles, and responsibilities. The processes though defined, the process and product qualities are not measured. ISO 9000 aims at achieving this level.

Level 4: Managed. At this level, the focus is on software metrics. Two types of metrics are collected. Product metrics measure the characteristics of the product being developed, such as its size, reliability, time complexity, understandability, etc. Process metrics reflect the effectiveness of the process being used, such as average defect correction time, productivity, average number of defects found per hour inspection, average number of failures detected during testing per LOC, etc. Quantitative quality goals are set for the products. The software process and product quality are measured and quantitative quality requirements for the product are met. Various tools like Pareto charts, fishbone diagrams, etc. are used to measure the product and process quality. The process metrics are used to check if a project performed satisfactorily. Thus, the results of process measurements are used to evaluate project performance rather than improve the process.

Level 5: Optimizing. At this stage, process and product metrics are collected. Process and product measurement data are analyzed for continuous process improvement. For example, if from an analysis of the process measurement results, it was found that the code reviews were not very effective and a large number of errors were detected only during the unit testing, then the process may be fine tuned to make the review more effective. Also, the lessons learned from specific projects are incorporated in to the process. Continuous process improvement is achieved both by carefully analyzing the quantitative feedback from the process measurements and also from application of innovative ideas and technologies. Such an organization identifies the best software engineering practices and innovations which may be tools, methods, or processes. These best practices are transferred throughout the organization.

Key process areas (KPA) of a software organization

Except for SEI CMM level 1, each maturity level is characterized by several Key Process Areas (KPAs) that includes the areas an organization should focus to improve its software process to the next level. The focus of each level and the corresponding key process areas are shown in the fig. 13.5.

CMM Level	Focus	Key Process Ares
1. Initial	Competent people	
2. Repeatable	Project management	Software project planning Software configuration management
3. Defined	Definition of processes	Process definition Training program Peer reviews
4. Managed	Product and process quality	Quantitative process metrics Software quality management
5. Optimizing	Continuous process improvement	Defect prevention Process change management Technology change management

Fig. 13.5: The focus of each SEI CMM level and the corresponding key process areas

SEI CMM provides a list of key areas on which to focus to take an organization from one level of maturity to the next. Thus, it provides a way for gradual quality improvement over several stages. Each stage has been carefully designed such that one stage enhances the capability already built up. For example, it considers that trying to implement a defined process (SEI CMM level 3) before a repeatable process (SEI CMM level 2) would be counterproductive as it becomes difficult to follow the defined process due to schedule and budget pressures.

ISO 9000 certification vs. SEI/CMM

For quality appraisal of a software development organization, the characteristics of ISO 9000 certification and the SEI CMM differ in some respects. The differences are as follows:

- ISO 9000 is awarded by an international standards body. Therefore, ISO 9000 certification can be quoted by an organization in official documents, communication with external parties, and the tender quotations. However, SEI CMM assessment is purely for internal use.

- SEI CMM was developed specifically for software industry and therefore addresses many issues which are specific to software industry alone.

- SEI CMM goes beyond quality assurance and prepares an organization to ultimately achieve Total Quality Management (TQM). In fact, ISO 9001 aims at level 3 of SEI CMM model.

- SEI CMM model provides a list of key process areas (KPAs) on which an organization at any maturity level needs to concentrate to take it from one maturity level to the next. Thus, it provides a way for achieving gradual quality improvement.

Applicability of SEI CMM to organizations

Highly systematic and measured approach to software development suits large organizations dealing with negotiated software, safety-critical software, etc. For those large organizations, SEI CMM model is perfectly applicable. But small organizations typically handle applications such as Internet, e-commerce, and are without an established product range, revenue base, and experience on past projects, etc. For such organizations, a CMM-based appraisal is probably excessive. These organizations need to operate more efficiently at the lower levels of maturity. For example, they need to practice effective project management, reviews, configuration management, etc.

Personal software process

Personal Software Process (PSP) is a scaled down version of the industrial software process. PSP is suitable for individual use. It is important to note that SEI CMM does not tell software developers how to analyze, design, code, test, or document software products, but assumes that engineers use effective personal practices. PSP recognizes that the process for individual use is different from that necessary for a team.

The quality and productivity of an engineer is to a great extent dependent on his process. PSP is a framework that helps engineers to measure and improve the way they work. It helps in developing personal skills and methods by estimating and planning, by showing how to track performance against plans, and provides a defined process which can be tuned by individuals.

Time measurement. PSP advocates that engineers should rack the way they spend time. Because, boring activities seem longer than actual and interesting activities seem short. Therefore, the actual time spent on a task should be measured with the help of a stop-clock to get an objective picture of the time spent. For example, he may stop the clock when attending a telephone call, taking a coffee break etc. An engineer should measure the time he spends for designing, writing code, testing, etc.

PSP Planning. Individuals must plan their project. They must estimate the maximum, minimum, and the average LOC required for the product. They should use their productivity in minutes/LOC to calculate the maximum, minimum, and the average development time. They must record the plan data in a project plan summary.

The PSP is schematically shown in fig. 13.6. While carrying out the different phases, they must record the log data using time measurement. During post-mortem, they can compare the log data with their project plan to achieve better planning in the future projects, to improve their process, etc.

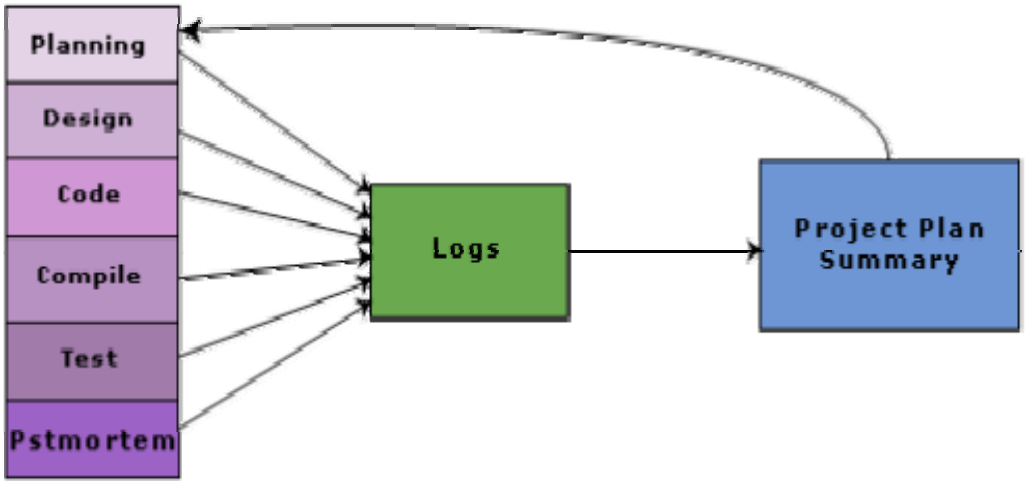

Fig. 13.6: Schematic representation of PSP

The PSP levels are summarized in fig. 13.7. PSP2 introduces defect management via the use of checklists for code and design reviews. The checklists are developed from gathering and analyzing defect data earlier projects.

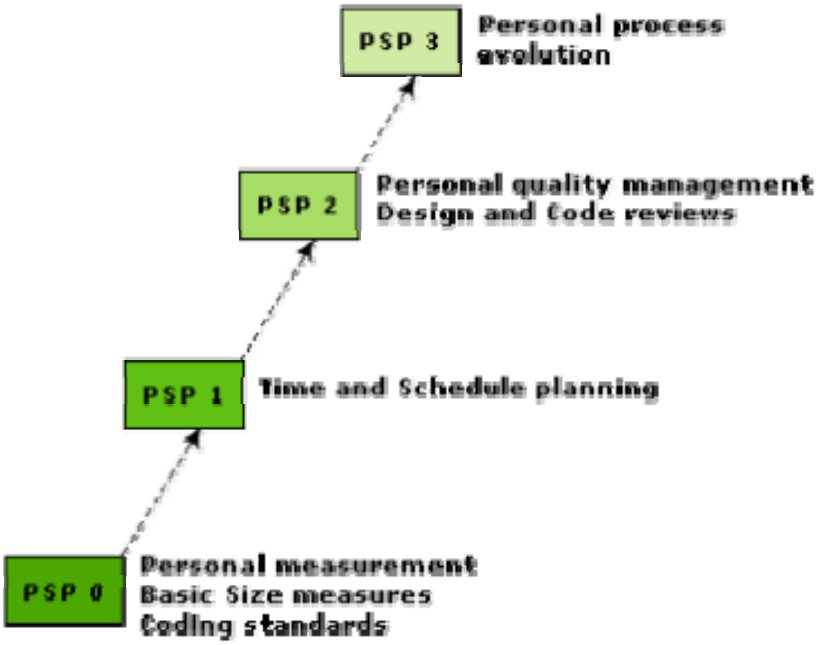

Fig. 13.7: Levels of PSP

Six sigma

The purpose of Six Sigma is to improve processes to do things better, faster, and at lower cost. It can be used to improve every facet of business, from production, to human resources, to order entry, to technical support. Six Sigma can be used for any activity that is concerned with cost, timeliness, and quality of results. Therefore, it is applicable to virtually every industry.

Six Sigma at many organizations simply means striving for near perfection. Six Sigma is a disciplined, data-driven approach to eliminate defects in any process – from manufacturing to transactional and product to service.

The statistical representation of Six Sigma describes quantitatively how a process is performing. To achieve Six Sigma, a process must not produce more than 3.4 defects per million opportunities. A Six Sigma defect is defined as any system behavior that is not as per customer specifications. Total number of Six Sigma opportunities is then the total number of chances for a defect. Process sigma can easily be calculated using a Six Sigma calculator.

The fundamental objective of the Six Sigma methodology is the implementation of a measurement-based strategy that focuses on process improvement and variation reduction through the application of Six Sigma improvement projects. This is accomplished through the use of two Six Sigma

sub-methodologies: DMAIC and DMADV. The Six Sigma DMAIC process (define, measure, analyze, improve, control) is an improvement system for existing processes failing below specification and looking for incremental improvement. The Six Sigma DMADV process (define, measure, analyze, design, verify) is an improvement system used to develop new processes or products at Six Sigma quality levels. It can also be employed if a current process requires more than just incremental improvement. Both Six Sigma processes are executed by Six Sigma Green Belts and Six Sigma Black Belts, and are overseen by Six Sigma Master Black Belts.

Many frameworks exist for implementing the Six Sigma methodology. Six Sigma Consultants all over the world have also developed proprietary methodologies for implementing Six Sigma quality, based on the similar change management philosophies and applications of tools.

The following questions have been designed to test the objectives identified for this module:

1. Explain the relative advantages of repeatable and non-repeatable software development organization.

2. How can the reliability of a software product be increased.

3. Identify the factors which make the measurement of software reliability much harder problem than the measurement of hardware reliability.

4. Discuss how the reliability changes over the life time of a software product and a hardware product.

5. Define six metrics to measure software reliability. Do you consider these metrics entirely satisfactory to provide measure of the reliability of a system? Justify your answer.

6. Explain using one simple sentence each what you understand by the following reliability measures:

    - A POFOD of 0.001
    - A ROCOF of 0.002
    - MTBF of 200 units
    - Availability of 0.998

7. Differentiate among the characteristics of different types of failures of software products.

8. In the context of reliability growth modeling, compare the characteristics between Jelinski and Moranda Model, and Littlewood and Verall's Model.

9. What is the main objective of statistical testing and also identify the three specific steps of statistical testing.

10. Compare the relative advantages and disadvantages of statistical testing.

11. What does the quality parameter "fitness of purpose" mean in the context of software products? Why is this not a satisfactory criterion for determining the quality of software products?

12. What according to you is a quality software product?

13. If an organization does not document its quality system, what problems would it face?

14. In a software development organization, identify the persons responsible for carrying out the quality assurance activities. Explain the principal tasks they perform to meet this responsibility.

15. In a software development organization whose responsibility is to ensure that the products are of high quality? Explain the principal tasks they perform to meet this responsibility.

16. What do you understand by Total Quality Management (TQM)? What are the advantages of TQM? Does ISO 9000 standard aim for TQM?

17. What are the principal activities of a modern quality system?

18. What is meant by ISO 9000 certification?

19. Discuss the types of organizations to which different types of ISO standards are applicable.

20. Compare the characteristics of software products and other types of products.

21. Why is it important for a software development organization to obtain ISO 9001 certification.

22. List five salient requirements that a software development organization must comply with before it can be awarded the ISO 9001 certificate.

23. What are the salient features of ISO 9001 certification?

24. What are the shortcomings of ISO 9000 certification process?

25. What is the main purpose of SEI Capability Maturity Model (SEI CMM)? How can SEI CMM model be used to improve the quality of software products?

26. Explain five different levels of SEI CMM model.

27. What do you understand by repeatable software development? Organizations assessed at which level SEI CMM maturity to achieve repeatable software development?

28. Suppose an organization mentions in its job advertisement that it has been assessed at level 3 of SEI CMM, what can you infer the about the current quality practices at the organization? What does this organization have to do to reach SEI CMM level 4?

29. What is the difference between process metrics and product metrics? Give four examples of each.

30. Suppose you want to buy a certain software product and you have kept a purchase precondition that the vendor must install the software, train your manpower on that, and maintain the product for at least one year, only then you would release the payment. Also, you do not foresee any maintenance requirement for the product once it works satisfactorily. Now, you receive bids from three vendors. Two of the vendors quote Rs. 3 Lakhs and Rs. 4 Lakhs whereas the third vendor quotes Rs. 10 Lakhs saying that the prices would be high because they would be following a good development process as they have been assessed at the Level 5 of SEI CMM. Discuss how would you decide whom to award the contract.

31. What do you understand by Key Process Area (KPA), in the context of SEI CMM? Would there be any problem if an organization tries to implement higher level SEI CMM KPAs before achieving lower level KPAs? Justify your answer using suitable examples.

32. Compare the relative advantages and disadvantages of ISO 9001 certification and the SEI CMM-based quality assessment.

33. What do you mean by Personal Software Process (PSP)?

34. What is the Six Sigma quality initiative? To which category of industries is it applicable? Explain the Six Sigma technique adopted by software organization with respect to the goal, the procedure, and the outcome.

Mark all options which are true.

1. Repeatable software development implies which of the following?

□ software development process is person-dependent
□ software development process is person-independent
□ either software development process is person-dependent or person-independent
□ neither software development process is person-dependent nor person-independent

2. A type of failures that occurs for all input values while invoking a function of the system is

□ transient failure
□ permanent failure
□ recoverable failure
□ unrecoverable failure

3. The reliability growth modeling can be used

□ to improve the reliability of a software product as errors are detected and repaired
□ to predict when a particular level of reliability is likely to be attained
□ to determine when to stop testing to attain a given reliability level
□ all of the above

4. Statistical testing is based on first determining

□ operation profile
□ user profile
□ product profile
□ development process profile

5. The quality system activities encompass

□ auditing of projects
□ review of the quality system
□ development of standards, procedures, and guidelines, etc.
□ all of the above

6. The basic premise of modern quality assurance is

□ continuous process improvement

□ thorough product testing
□ if an organization's processes are good and are followed rigorously then the products are bound to be of good quality
□ collection of process metrics

7. Continuous process improvement is achieved through which stages of a quality system?

□ quality control
□ quality assurance
□ total quality management
□ none of the above

8. Which ISO 9000 standard can be applied to organizations engaged in design, development, production, and servicing of goods etc.?

□ ISO 9001
□ ISO 9002
□ ISO 9003
□ none of the above

9. Salient feature/features of ISO 9001 certification is/are

□ all documents concerned with the development of a software product should be properly managed, authorized, and controlled
□ proper plans should be prepared and then progress against these plans should be monitored
□ the product should be tested against specification
□ all of the above

10. In which level of SEI Capability Maturity Model the processes for both management and development activities are defined and documented?

□ initial level
□ defined level
□ repeatable level
□ managed level

11. In which level of SEI Capability Maturity Model both product and process metrics are defined?

□ initial level
□ defined level
□ repeatable level
□ optimizing level

12. Continuous process improvement is achieved in which level of SEI Capability Maturity Model?

□ initial level
□ defined level
□ repeatable level
□ optimizing level
□ managed level

13. Personal Software Process (PSP) is targeted for

□ individual use
□ team use
□ individual use as well as team use
□ none of the above

14. The purpose of Six Sigma is

□ to improve development processes to do things better
□ to improve development processes
□ to make development processes cost effective
□ all of the above

Mark the following as either True or False. Justify your answer.

1. Reliability of a software product is observer-independent.

2. The reliability of a software product increases almost linearly, each time a defect gets detected and fixed.

3. Reliability of a software product depends upon the product's execution profile.

4. Reliability behavior for hardware and software are almost same.

5. The reliability with time of a particular software product always increases.

6. As testing continues, the rate of growth of reliability slows down representing a diminishing return of reliability growth with testing effort.

7. The term "fitness of purpose" is appropriate for defining a quality software product.

8. Modern quality assurance paradigms are centered around carrying out through product testing.

9. One of the major criteria for obtaining ISO 9001 certification for a software development organization is to possess well-documented software production process.

10. One of the uses of receiving ISO 9001 certification by a software organization is that it can improve its sales efforts by advertising its products as conforming to ISO 9001 certification.

11. ISO 9000 gives specific guidelines for defining an appropriate process for the development of a particular product in an organization.