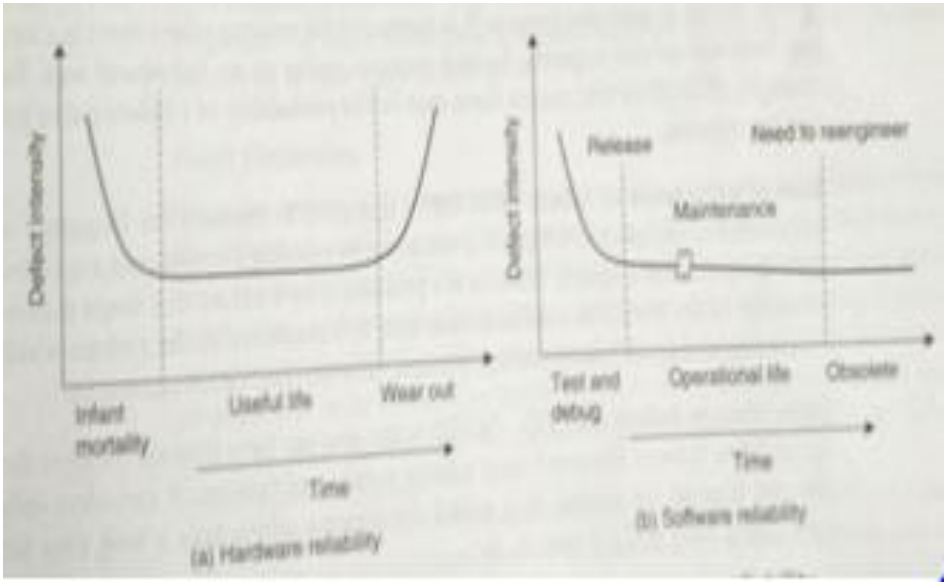
SOFTWARE ENGINEERING UNIT-IV PART-1

Software Reliability And Quality Management: Software Reliability, Statistical Testing, Software Quality, Software Quality Management System, ISO 9000, SEI Capability Maturity Model.

SOFTWARE RELIABILITY

Reliability is one of the important aspects of software operation. The primary concern of customers and the responsibility of development organization is to have a reliable system. Software testing methods are performed to detect and debug software defects so that a program can work without failures. Also, quality standards like ISO and the SEI _CMM provide guidelines and procedures to software development organization for systematic software development to produce quality software products.

Reliability is an important factor in all kinds of software application. The criticality of reliability can be observed in the most serious areas such as life safety critical systems, where the human life depends on it. If such system fails in performing the specific tasks, then there happens a lot of losses and damages.



RELIABILITY METRICS

An unreliable system is caused by the occurrence of failures. Some failures are more dangerous than others i.e. some failures have little consequences while other failures have very serious affects. The impact of the occurrence of failure is observed through reliability specifications. Reliability specification is in the range of data input, conditions and constraints, location in the program, and certain test criteria. Based on reliability specification, the following categories of failures are observed in the system.

Transient:- such failures occur for certain inputs.

Permanent:- Permanent failures occur for all inputs.

Recoverable:- When a recoverable failure occurs, the system can recover with or without operator intervention (i.e., without shutdown or restart, etc.).

Unrecoverable:- Unrecoverable failures need operator intervention to recover data from them.

Computing:- Such failures corrupt the system state or data.

Non-computing:- Non-computing failures occur but do not corrupt data or system state.

Reliability is used to address defect finding and fixing. The reliability of a system is unpredictable in the interval of the specified time. Due to uncertainty of defect occurrence, reliability is measured through probabilistic theory. In the following paragraphs, we will discuss various reliability metrics.

Probability Of Failure On Demand (POFOD) :- POFOD measures the likelihood of system failure in a service request. It is measured for systems where there is a long gap between service requests. Service requests occur in an infrequent way. For example, POFOD of 0.01 means three may be the probability of 1 failure out of 100 service requests.

Rate Of Occurrence Of Failure (ROCOF):- It is used to measure the frequency of occurrence of unexpected failures. It is measured by running a system over a specified time duration. For example, 0.001 is the probability of 1 failure in a single continuous run of the system in a defined time unit. It is measured in the system which runs continuously, such as operating systems, railways reservation system, etc.

Mean Time To Failure (MTTF):- MTTF is the average time interval between the consecutive failures observed over a large number of failures. It considers only the run time of the system. It is useful for systems which take a long time for processing, such as CAD system, etc.

Mean Time To Repair (MTTR):- MTTR is the average time taken to repair defects ain a system. Time is considered for detecting and fixing defects over a specified time interval.

Mean Time Between Failures (MTBF):-MTBF is measured by combining MTTR and MTTE. That is,

MTBF=MTTR+MTTF

If a failure occurs over specified time duration, then it measures the occurrence of the next failure over the next duration. For example, if MTBF is 24 hours, it means that the next failure may occur in the next 24 hours.

System availability:- It is the likelihood that the system will available for use over a given time duration. System availability measurement excludes MTTR and MTTF. The measurement of important for systems like server machines, telecommunication system, etc.

STATISTICAL TESTING

Statistical Testing makes use of statistical methods to determine the reliability of the program. Statistical testing focuses on how faulty programs can affect its operating conditions.

How to perform ST?

- Software is tested with the test data that statistically models the working environment.
- Failures are collated and analyzed.
- From the computed data, an estimate of program's failure rate is calculated.
- A Statistical method for testing the possible paths is computed by building an algebraic function.
- Statistical testing is a bootless activity as the intent is NOT to find defects.

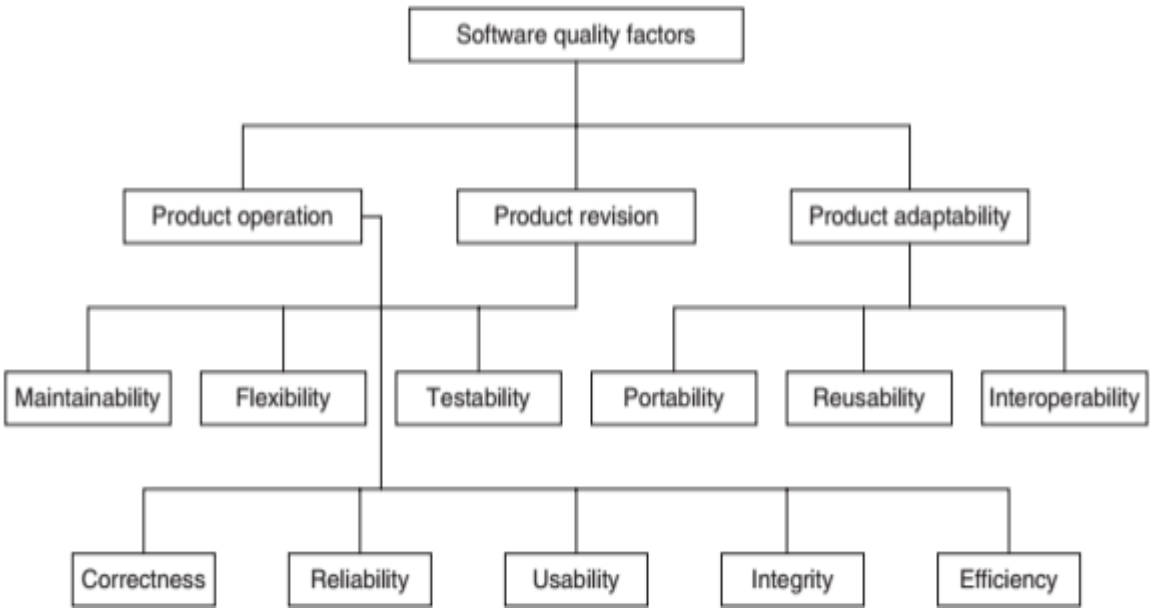
SOFTWARE QUALITY

A good quality software product satisfies the customer needs, is constructed as per standard and norms, has good internal design and developed within optimized cost and schedule. The quality of a software product is defined in terms of its characteristics or attributes. A product can be of good quality or bad quality. Weaker values of attributes define a bad quality product whereas higher values of attributes define a good quality product.

Software Quality Factors

The quality of software is measured through well defined quality factors. There are two ways to measure software quality. One way is direct measurement, which is performed through software testing for example the number of defects detected and corrected in a program, number of faults observed in source codes and design etc.

Direct measurement mainly focuses on satisfying the functional requirements. Indirect measurement is specially the quantification of non functional requirements.



- **Product Operational Factors** – Correctness, reliability, usability, integrity, and efficiency
- **Product Revision Factors-** Maintainability, flexibility and testability
- **Product Adaptability Factors** – Portability, reusability and interoperability. Product operational factors focus on the use and working of a software product.
- **Correctness:** Correctness is the primary quality of software without which other factors such as efficiency and usability are trivial.
- **Reliability:** Reliability is the extent to which a program performs its intended functions satisfactorily with required precision without failure in a specified duration.
- **Usability:** Usability is the extent of effort required to learn, operate and use a product. Usability also covers suitability, learnability and adaptability of the software.
- **Integrity:** Integrity is the extent of effort to control illegal access to data and program by unauthorized people.
- **Efficiency:** Efficiency is the volume of computing resources. (Eg: processor time , memory space , bandwidth in communication devices etc.) and the code required to perform software functions.
- **Maintainability:** Maintainability is the ease to locate and correct errors. Maintainability of software is measured through mean time to change.
- **Flexibility:** Flexibility is the cost required is modify on operational program. Flexibility can be achieved through simplicity of programs and their interfaces.
- **Testability:** Testability is the effort required to test a program to ensure that it performs its intended function. Complexity of the source code affects testability of the software.
- **Portability:** Portability is the effort required for transferring software products to various hardware and software environments. Objects-oriented programs support better portability than machine and assembly language programs
- **Reusability:** Reusability is the use of existing software or its parts. Reusability is the extent to which software or its parts can be reused in the development of some other software.
- **Interoperability:** Interoperability is the effort required to couple one system to another. Strong coupling and loose coupling are the approaches used in operability.

Verification & Validation

Verification is the process of evaluating work products in the software development phases to assess whether the work product meet the specifications as intended for the purpose. **Validation** is the process of evaluating software during or at the end of the development process to determine whether it satisfies the specified stated requirements.

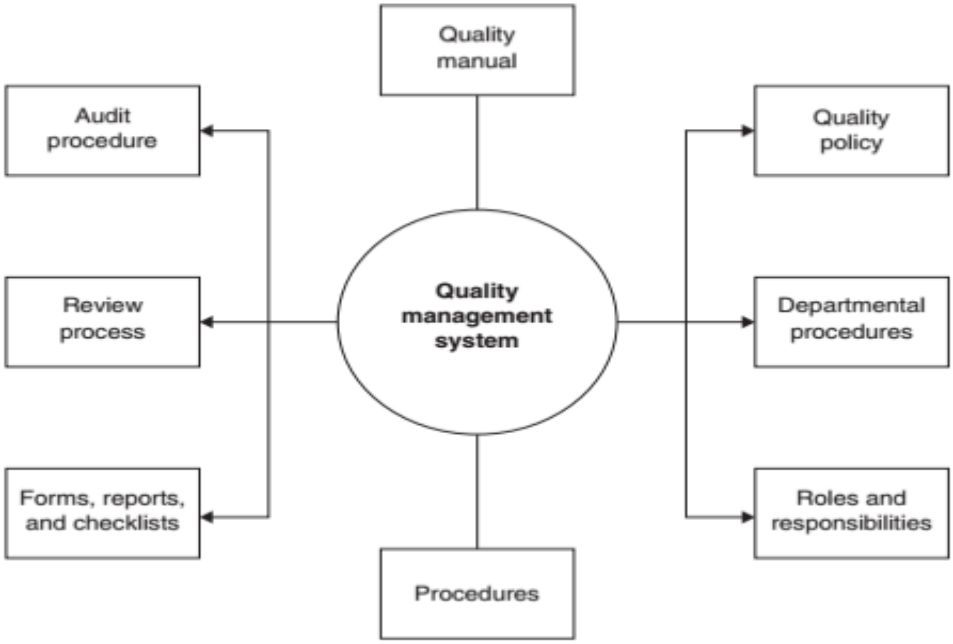
SOFTWARE QUALITY MANAGEMENT SYSTEM

Producing high quality product is the primary goal of an organization .Organization applies high quality policies to produce good products. Each organization has its own quality management system that focuses on ensuring optimum quality.

QMS is a set of procedures/processes which are carried out to ensure that the product delivered by the organization has the desired quality .Sometimes quality system is also used in place of QMS.

The success of QMS depends on employees' skills and proper support from the top management of the organization.

The quality system includes various things such as quality policy, quality manual, departmental responsibilities, roles, procedures, standards and guidelines, reports, forms, templates and checklists.



Auditing Procedures and Review of The Quality System –

- The quality manual states the vision and mission of the organization committing itself to quality.
- Quality Policy document states the intentions and directions of work flow towards quality.
- Quality Group has several sub teams for performing specific tasks of their departments.
- In QMS each individual has specific role and responsibilities .Individuals are well trained in performing their roles .There are certain procedures followed by organizations like CMM,ISO .Inspection and testing methods are applied at each phase of software development .

ISO QUALITY STANDARD

International Organization for Standardization (ISO) is a non profit and worldwide federation of national standards bodies from several countries. ISO provides state of the art specifications for products, services, and good practices, helping to make industry more

efficient and effective. It was established to promote the development of standardization and related activities in the world with a view to facilitating the international trade and developing cooperation in the spheres of intellectual, scientific, technological, and economic activity.

An ISO standard is developed by a group of experts within technical committees. A technical committee is made up of representatives of industry, NGOs, governments, and other stakeholders.

ISO 9000 STANDARD

It is a set of international standards for quality management and quality assurance .Standards were developed to help companies effectively document the elements they need to maintain an efficient quality system.

Initial ISO 9000 standards were published in 1987 as ISO 9000:1987
Revised in 1994 as ISO 9000:1994

It had three standards.
ISO 9001:1994
ISO 9002:1994
ISO 9003:1994

Later ISO 9002:1994 &ISO 9003:1994 was merged into ISO 9001:1994 .Some clauses were eliminated from 9002,9003.
In the year 2000, ISO: 1994 was revised and rewritten as ISO 9000:2000.

There were several minor revisions made in the ISO 9000 series. ISO 9001:2008 is the latest ISO standard which is most widely used by the software companies. Revised 9001:2008 series of standards forms a coherent set of quality management system. Standards facilitating mutual understanding in national and international trades

It is based on 8 quality management principles:
1.Customer Focus –As organizations depend on their customers, they should understand current and future customers .
2.Leadership- It establishes unity of purpose and direction of the organization .Organizations should create and maintain an internal environment in which people can become fully involved in achieving the organizations objectives .
3.Involvement of People – People at all levels are the assets of an organization and their full involvement enables their abilities to be used for organization ‘s objectives .
4.Process Approach –The desired result is achieved more efficiently when activities and related resources are managed as a process .

5. System Approach To Management –Identifying, understanding and managing interrelated processes as a system contributes to the organization‘s effectiveness and efficiency in achieving its objectives.

6. Continual Improvement –It is the overall performance. It should be a permanent objective of the organization.

7.Factual Approach to Decision Making -Effective decisions are based on the analysis of data and information .

8.Mutually Beneficial Supplier Relationships-Organizations and suppliers are independent and mutually beneficial relationship enhances the ability of both to create value .

ISO 9000 CERTIFICATION PROCESS

Initially an organization has to decide about getting the ISO certification because it will involve in the formal process of development .Organizations willing to achieve ISO certification go through the following ISO 9000 certification steps and apply to the ISO 9000 registrar .

- **Proposal Stage-** The organization prepares a proposal in the format and according to the guidelines provided by the ISO to apply to the registrar for ISO certification.
- **Pre assessment Stage –** At this stage registrar and the people responsible make a rough assessment of the organization.
- **Document Review and Adequacy Audit –**The registrar reviews the proposal and its related documents submitted by the organization and suggest improving the documents if there is any flow in the proposal. An audit confirms that the organization has made the planned arrangement for the ISO certification and it will make follow the process based quality management system approach.
- **Compliance Audit –** This is the verification process to check whether the organization has realized the suggestions provided by the registrar during the document review stage.
- **Registration** –The organization receives the ISO certification from the ISO registrar after completing all the previous stages.
- **Continued Surveillance :** The ISO registrar and his team regularly monitor the organization to ensure that the organization is following the ISO standards for software development .

ADVANTAGES OF ISO 9000:

1. Increased Marketability
2. Reduced operational expenditures
3. Improved internal communication
4. Improvd customer service
5. Reduction of product liability risks
6. Attractiveness to investors

DISADVANTAGES OF ISO 9000:

1. Owners and managers do not have an adequate understanding of ISO 9000.
2. Most of companies have less funding available, therefore companies are finding difficulties to adopt ISO system.
3. ISO 9000 registration need heavy document workload.
4. ISO 9000 registration process require long time.

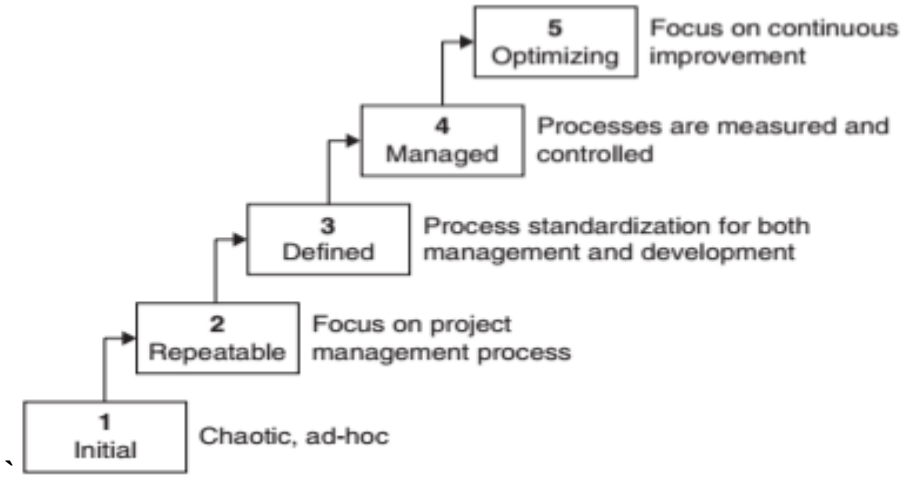
SEI CAPABILITY MATURITY MODEL.

SEI Capability Maturity Model is an industry standard model for defining and measuring the maturity of the development process and for providing strategy for improving the software process towards achieving high quality products. It was established by Software Engineering Institute (SEI) in 1986 at Carnegie Mellon University (CMU) at California, USA under the direction of US Department of Defence.

The purpose of the SEI is to help organizations improve their software engineering capabilities and to develop or acquire the right software, defect free, within budget and on-time, every time.

CMM model is different from software development life cycle models .The CMM is involved in the process management process to improve the software process whereas life cycle models are used for the software development process.

- **Initial Level-** At initial level software process is characterized as adhoc, inconsistent, and occasionally even chaotic. There are no defined processes and standard practices. Processes are unpredictable.
- **Repeatable Level-** In this software development successes are repeatable i.e. process discipline is in place to repeat earlier success on projects with similar applications. Here basic and consistent project management processes are established to track cost, schedule and development. However the discipline and process while established vary from project to project.
- **Defined Level-** Now the organization has standardized process for both management and developed activities. These processes are well documented, standardized and integrated into a standard software process for entire organization.
- **Managed Level-** Here precise measurements are used to effectively control the software development effort. Both the software process and products are quantitatively understood and controlled. Here processes are predictable to determine the performance.
- **Optimized Level-** The key characteristic of optimized level is continuous and proactive process improvement. That is continuous improvement is institutionalized in the development process by enabling quantitative analysis of the process and by piloting innovative ideas and technologies. Here processes are concerned with addressing the common causes of process variation and changing the process to improve the process performance to achieve the established quantitative process improvement objectives.



The CMM provides a way to develop and refine an organization's process. A maturity model can be used a benchmark for assessing different organizations for equivalent comparison. It describes the maturity of the company in the above stated levels based upon the project the company is dealing with and the clients. Within each of these maturity levels, there are different key process areas(KPAs) which characterize that level. The KPAs for each level are listed in below table.

An organization willing to achieve a level has to demonstrate all the KPAs in the corresponding level of CMM. There are some overlapping KPAs, such as software product engineering is addressed at defined as well as managed level

CMM level	Focus	KPAs
1. Initial	Competent people and heroics	Not applicable
2. Repeatable	Disciplined process	Requirement management Project planning and tracking Subcontractor management Software quality assurance Configuration management
3. Defined	Process standardization	Organization process focus Organization process definition Training program Software product engineering Integrated software development Inter-group coordination Peer reviews
4. Managed	Measurable and controlled processes for quality	Quantitative process management Quality management
5. Optimized	Continuous process improvement	Defect prevention Technology change management Process change management