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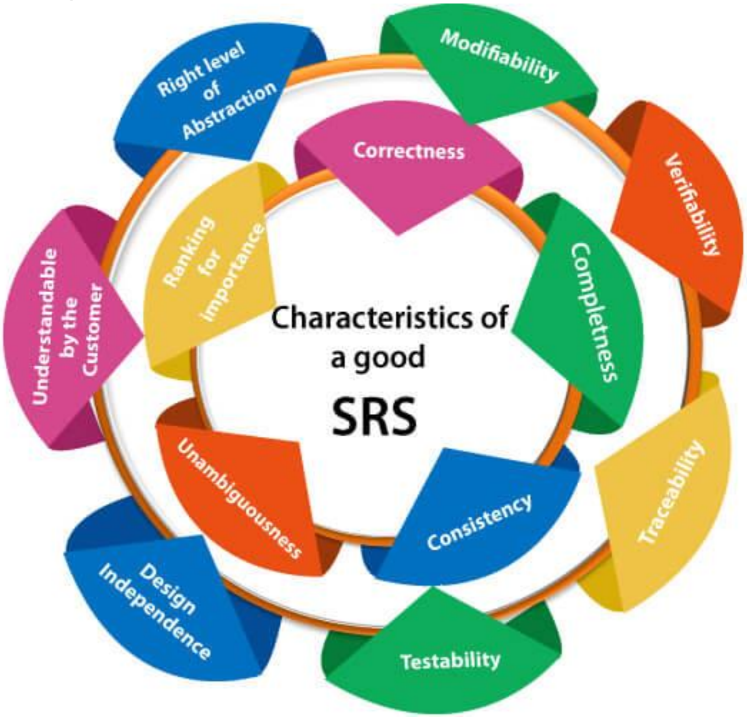
Software Requirements

The software requirements are description of features and functionalities of the target system. Requirements convey the expectations of users from the software product. The requirements can be obvious or hidden, known or unknown, expected or unexpected from client's point of view.

Software requirement specification is a kind of document which is created by a software analyst after the requirements collected from the various sources - the requirement received by the customer written in ordinary language. It is the job of the analyst to write the requirement in technical language so that they can be understood and beneficial by the development team.

The models used at this stage include ER diagrams, data flow diagrams (DFDs), function decomposition diagrams (FDDs), data dictionaries, etc.

Characteristics of good SRS



Following are the features of a good SRS document:

- Correctness
- Completeness
- Consistency

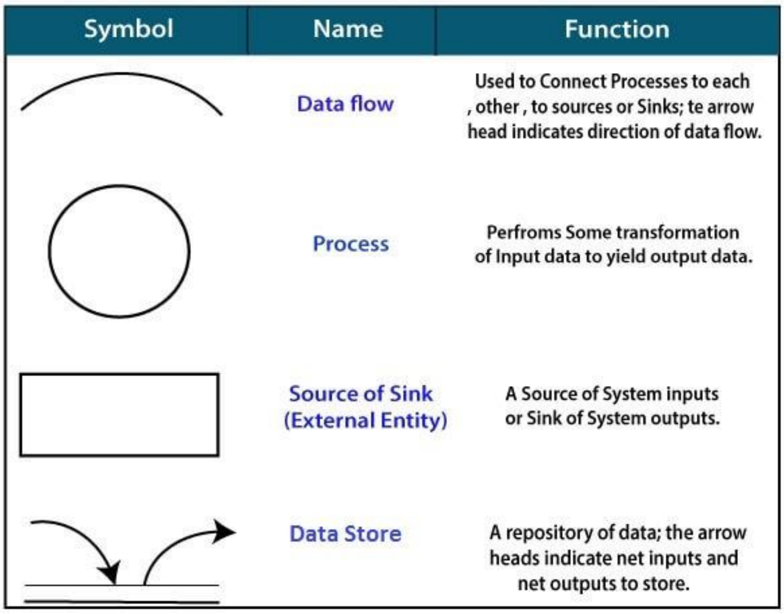
- Unambiguousness
- Ranking for importance and stability
- Modifiability
- Verifiability
- Traceability
- Design
- Testability
- Understandable by the customer
- The right level of abstraction

Data Flow Diagrams

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It can be manual, automated, or a combination of both. It shows how data enters and leaves the system, what changes the information, and where data is stored.

The objective of a DFD is to show the scope and boundaries of a system as a whole. It may be used as a communication tool between a system analyst and any person who plays a part in the order that acts as a starting point for redesigning a system. The DFD is also called as a data flow graph or bubble chart.

Standard symbols for DFDs are derived from the electric circuit diagram analysis and are shown in fig:



Symbol	Name	Function
	Data flow	Used to Connect Processes to each , other , to sources or Sinks; te arrow head indicates direction of data flow.
	Process	Perfroms Some transformation of Input data to yield output data.
	Source of Sink (External Entity)	A Source of System inputs or Sink of System outputs.
	Data Store	A repository of data; the arrow heads indicate net inputs and net outputs to store.

Symbols for Data Flow Diagrams

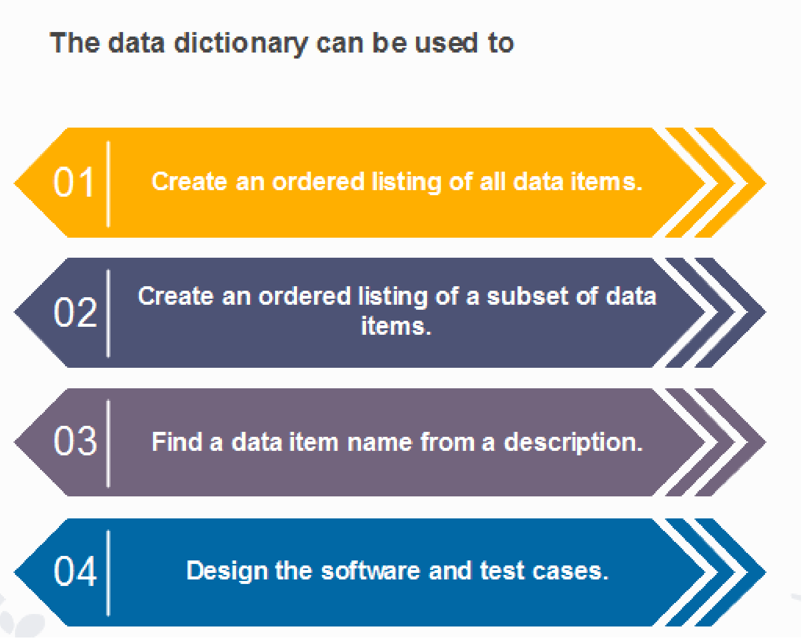
- Circle
- Data Flow
- Data Store
- Source or Sink

Data Dictionaries

A data dictionary is a file or a set of files that includes a database's metadata. The data dictionary hold records about other objects in the database, such as data ownership, data relationships to other objects, and other data. The data dictionary is an essential component of any relational database. Ironically, because of its importance, it is invisible to most database users. Typically, only database administrators interact with the data dictionary.

The data dictionary, in general, includes information about the following:

- Name of the data item
- Aliases
- Description/purpose
- Related data items
- Range of values
- Data structure definition/Forms



The data dictionary can be used to

01 Create an ordered listing of all data items.

02 Create an ordered listing of a subset of data items.

03 Find a data item name from a description.

04 Design the software and test cases.

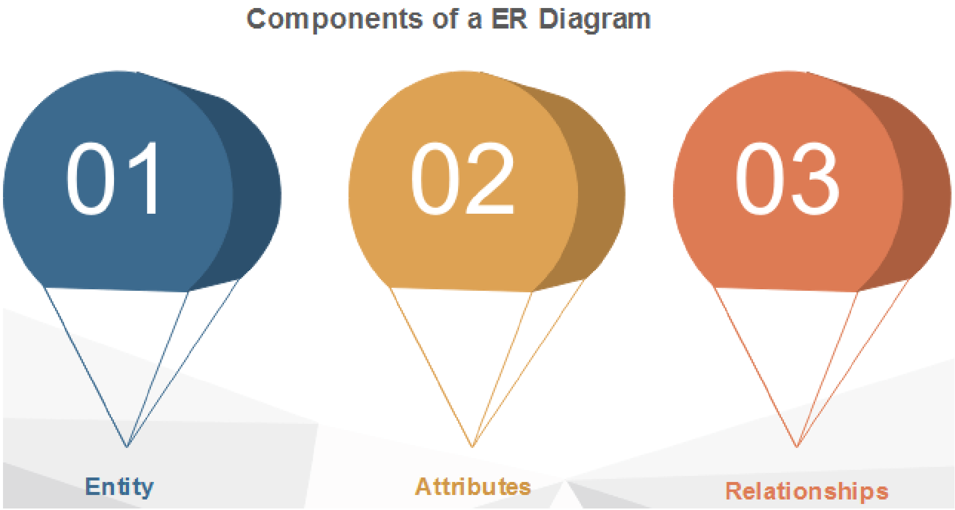
The mathematical operators used within the data dictionary are defined in the table:

Notations	Meaning
x=a+b	x includes of data elements a and b.
x=[a/b]	x includes of either data elements a or b.
x=a x	includes of optimal data elements a.
x=y[a]	x includes of y or more occurrences of data element a
x=[a]z	x includes of z or fewer occurrences of data element a
x=y[a]z	x includes of some occurrences of data element a which are between y and z.

Entity-Relationship Diagrams

ER-modelling is a data modelling method used in software engineering to produce a conceptual data model of an information system. Diagrams created using this ER-modelling method are called Entity-Relationship Diagrams or ER diagrams or ERDs.

Components of an ER Diagrams

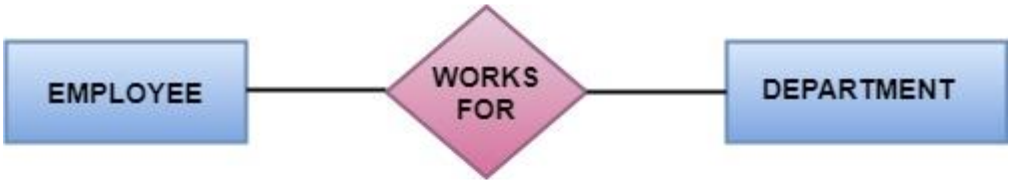


1. Entity

An entity can be a real-world object, either animate or inanimate, that can be merely identifiable. An entity is denoted as a rectangle in an ER diagram. For example, in a school database, students, teachers, classes, and courses offered can be treated as entities. All these entities have some attributes or properties that give them their identity.

Entity Set

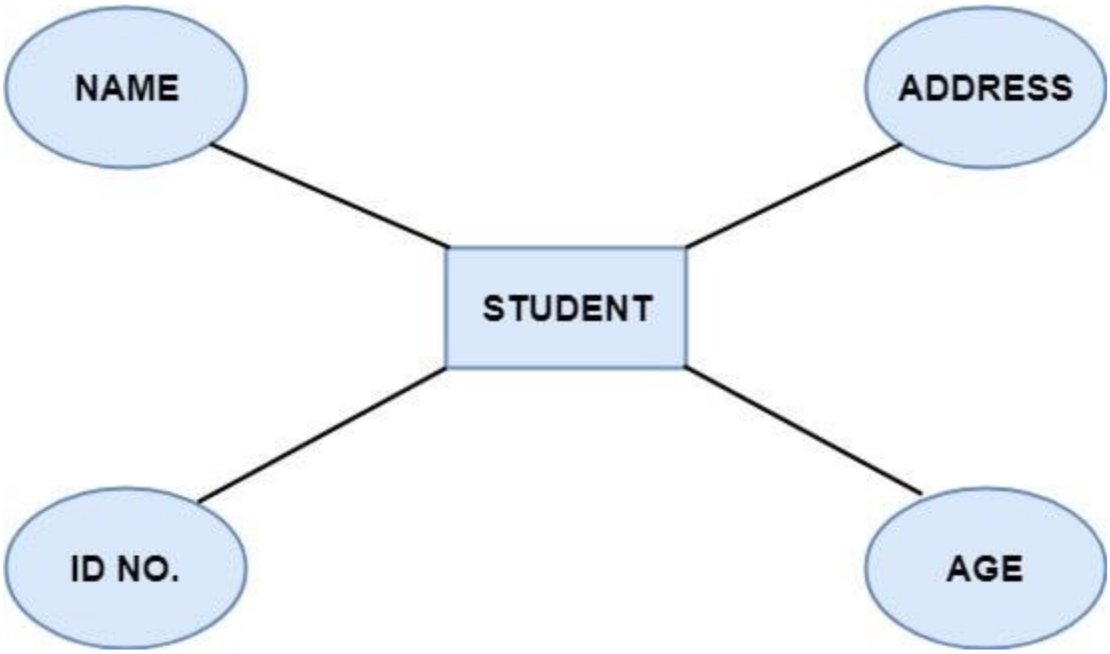
An entity set is a collection of related types of entities. An entity set may include entities with attribute sharing similar values. For example, a Student set may contain all the students of a school; likewise, a Teacher set may include all the teachers of a school from all faculties. Entity set need not be disjoint.



2. Attributes

Entities are denoted utilizing their properties, known as attributes. All attributes have values. For example, a student entity may have name, class, and age as attributes.

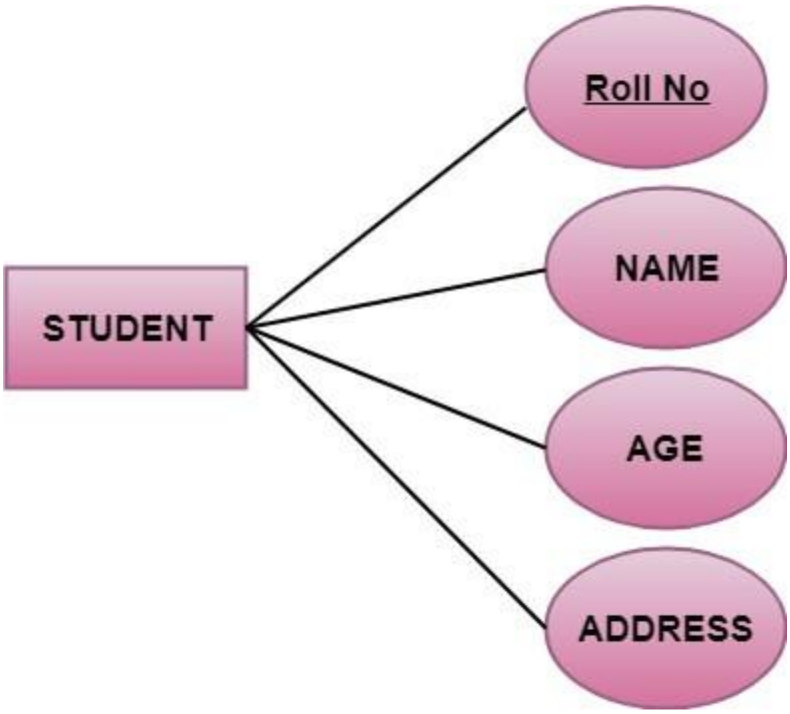
There exists a domain or range of values that can be assigned to attributes. For example, a student's name cannot be a numeric value. It has to be alphabetic. A student's age cannot be negative, etc.



There are four types of Attributes:

1. Key attribute
2. Composite attribute
3. Single-valued attribute
4. Multi-valued attribute
5. Derived attribute

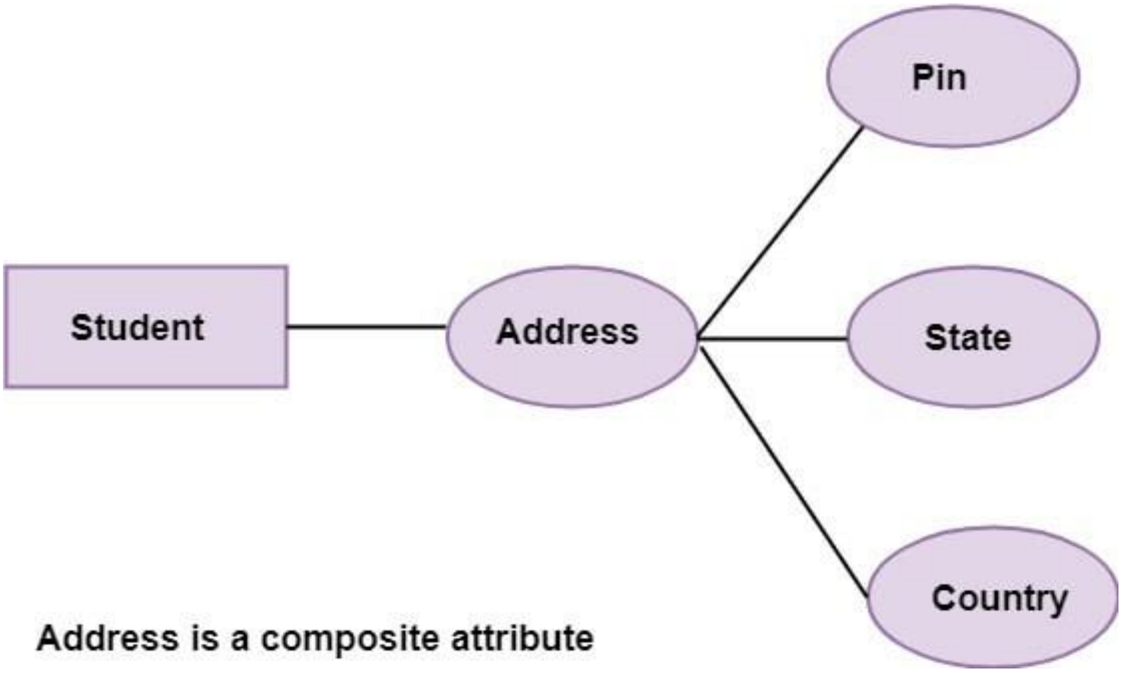
1. Key attribute: Key is an attribute or collection of attributes that uniquely identifies an entity among the entity set. For example, the roll_number of a student makes him identifiable among students.



There are mainly three types of keys:

1. **Super key:** A set of attributes that collectively identifies an entity in the entity set.
2. **Candidate key:** A minimal super key is known as a candidate key. An entity set may have more than one candidate key.
3. **Primary key:** A primary key is one of the candidate keys chosen by the database designer to uniquely identify the entity set.

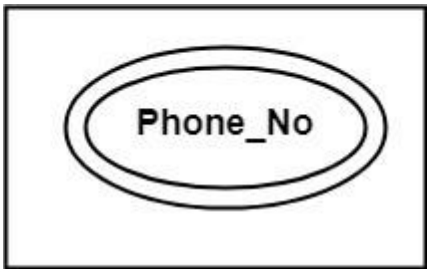
2. Composite attribute: An attribute that is a combination of other attributes is called a composite attribute. For example, In student entity, the student address is a composite attribute as an address is composed of other characteristics such as pin code, state, country.



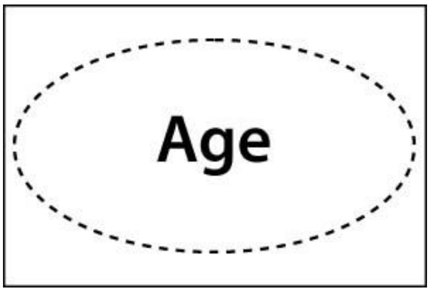
Address is a composite attribute

3. Single-valued attribute: Single-valued attribute contain a single value. For example, Social_Security_Number.

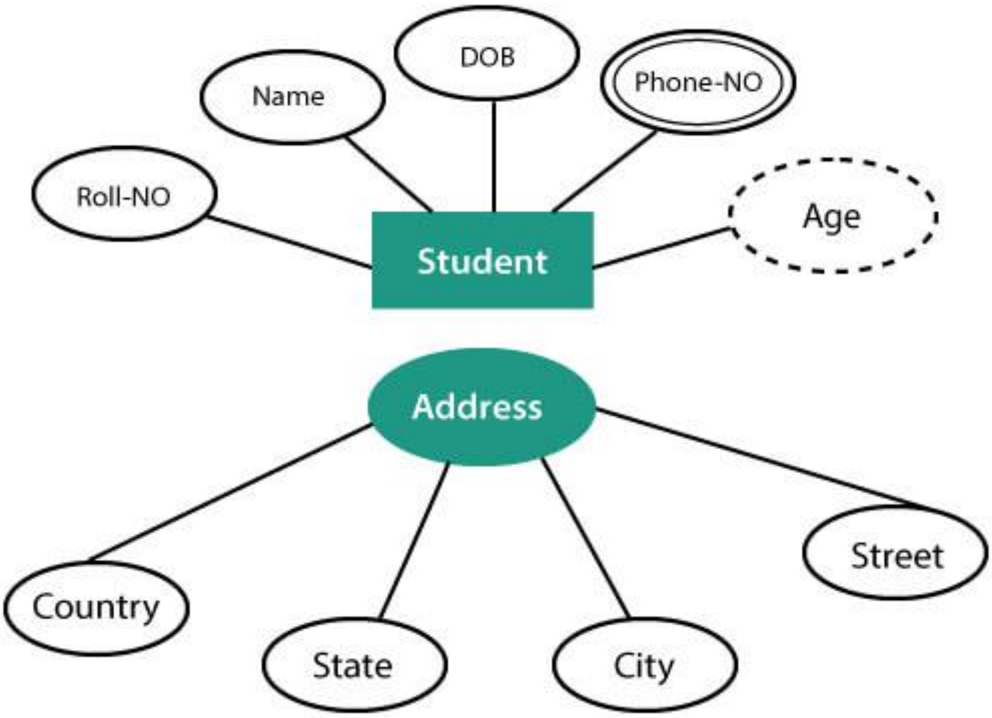
4. Multi-valued Attribute: If an attribute can have more than one value, it is known as a multi-valued attribute. Multi-valued attributes are depicted by the double ellipse. For example, a person can have more than one phone number, email-address, etc.



5. Derived attribute: Derived attributes are the attribute that does not exist in the physical database, but their values are derived from other attributes present in the database. For example, age can be derived from date_of_birth. In the ER diagram, Derived attributes are depicted by the dashed ellipse.



The Complete entity type Student with its attributes can be represented as:



3. Relationships

The association among entities is known as relationship. Relationships are represented by the diamond-shaped box. For example, an employee works_at a department, a student enrolls in a course. Here, Works_at and Enrolls are called relationships.

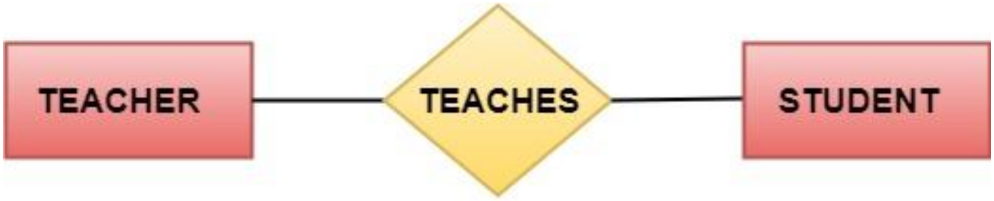


Fig: Relationships in ERD

Relationship set

A set of relationships of a similar type is known as a relationship set. Like entities, a relationship too can have attributes. These attributes are called descriptive attributes.

Degree of a relationship set

The number of participating entities in a relationship describes the degree of the relationship. The three most common relationships in E-R models are:

1. Unary (degree1)
2. Binary (degree2)
3. Ternary (degree3)

1. Unary relationship: This is also called recursive relationships. It is a relationship between the instances of one entity type. For example, one person is married to only one person.

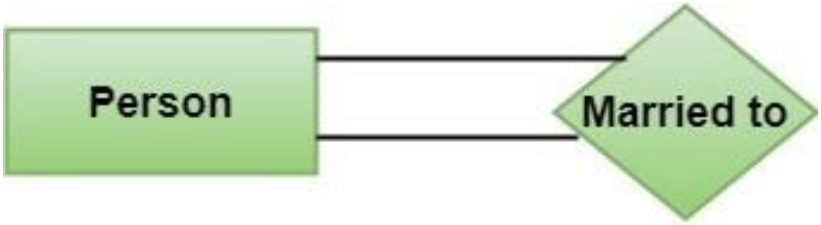


Fig: Unary Relationship

2. Binary relationship: It is a relationship between the instances of two entity types. For example, the Teacher teaches the subject.

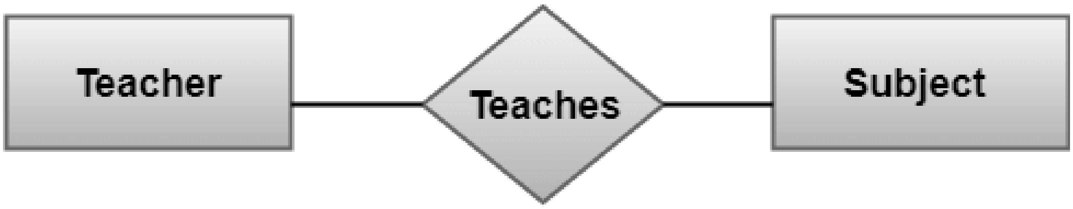


Fig: Binary Relationship

3. Ternary relationship: It is a relationship amongst instances of three entity types. In fig, the relationships "**may have**" provide the association of three entities, i.e., TEACHER, STUDENT, and SUBJECT. All three entities are many-to-many participants. There may be one or many participants in a ternary relationship.

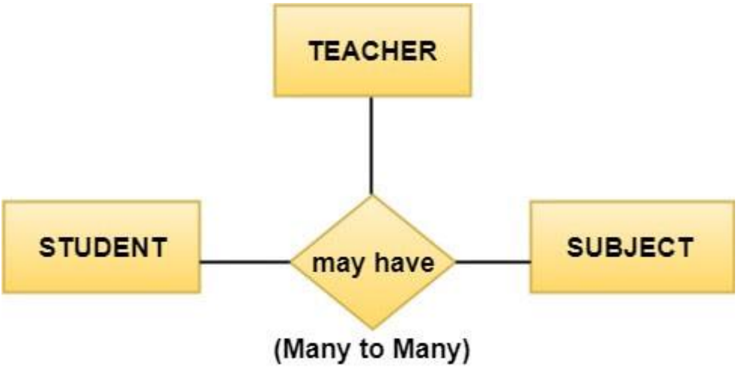


Fig: Ternary Relationship

Cardinality

Cardinality describes the number of entities in one entity set, which can be associated with the number of entities of other sets via relationship set.

Types of Cardinalities are:

- One to One
- One to many
- Many to One
- Many to Many

Software Configuration

When we develop software, the product (software) undergoes many changes in their maintenance phase; we need to handle these changes effectively.

The elements that comprise all information produced as a part of the software process are collectively called a software configuration.

As software development progresses, the number of Software Configuration elements (SCI's) grow rapidly. These are handled and controlled by SCM. This is where we require software configuration management.

SCM is the discipline which

- Identify change

- Monitor and control change
- Ensure the proper implementation of change made to the item.
- Auditing and reporting on the change made.

The objective is to maximize productivity by minimizing mistakes (errors).

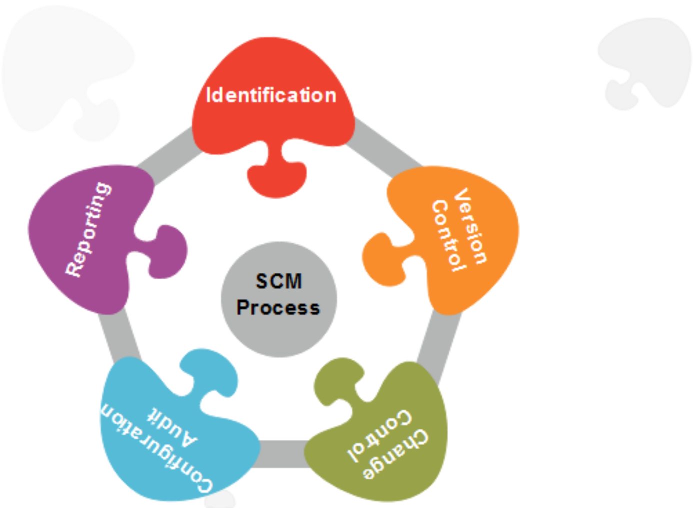
Importance of SCM

- It provides the tool to ensure that changes are being properly implemented.
- It has the capability of describing and storing the various constituent of software.
- SCM is used in keeping a system in a consistent state by automatically producing derived version upon modification of the same component.

SCM Process

It uses the tools which keep that the necessary change has been implemented adequately to the appropriate component. The SCM process defines a number of tasks:

- Identification of objects in the software configuration
- Version Control
- Change Control
- Configuration Audit
- Status Reporting



Software Configuration Management Process

Identification

- Basic Object: Unit of Text created by a software engineer during analysis, design, code, or test.
- Aggregate Object: A collection of essential objects and other aggregate objects. Design Specification is an aggregate object.

Each object has a set of distinct characteristics that identify it uniquely: a name, a description, a list of resources, and a realization.

Version Control: combines procedures and tools to handle different version of configuration objects that are generated during the software process.

Change Control: Access Control governs which software engineers have the authority to access and modify a particular configuration object.

Configuration Audit: SCM audits to verify that the software product satisfies the baselines requirements and ensures that what is built and what is delivered.

Status Reporting: Configuration Status reporting (sometimes also called status accounting) providing accurate status and current configuration data to developers, testers, end users, customers and stakeholders through admin guides, user guides, FAQs, Release Notes, Installation Guide, Configuration Guide, etc.

Software Quality

Software quality product is defined in term of its fitness of purpose. That is, a quality product does precisely what the users want it to do. For software products, the fitness of use is generally explained in terms of satisfaction of the requirements laid down in the SRS document. Although "fitness of purpose" is a satisfactory interpretation of quality for many devices such as a car, a table fan, a grinding machine, etc. for software products, "fitness of purpose" is not a wholly satisfactory definition of quality.

The modern view of a quality associated with a software product several quality methods such as the following:

- Portability: A software device is said to be portable, if it can be freely made to work in various operating system environments, in multiple machines, with other software products, etc.
- Usability: A software product has better usability if various categories of users can easily invoke the functions of the product.
- Reusability: A software product has excellent reusability if different modules of the product can quickly be reused to develop new products.
- Correctness: A software product is correct if various requirements as specified in the SRS document have been correctly implemented.
- Maintainability: A software product is maintainable if bugs can be easily corrected as and when they show up, new tasks can be easily added to the product, and the functionalities of the product can be easily modified, etc.

Software Quality Management System

A quality management system is the principal methods used by organizations to provide that the products they develop have the desired quality.

A quality system subsists of the following:

Managerial Structure and Individual Responsibilities: A quality system is the responsibility of the organization as a whole. However, every organization has a sever quality department to perform various quality system activities. The quality system of an arrangement should have the support of the top management. Without help for the quality system at a high level in a company, some members of staff will take the quality system seriously.

Quality System Activities: The quality system activities encompass the following:

- Auditing of projects
- Review of the quality system
- Development of standards, methods, and guidelines, etc.
- Production of documents for the top management summarizing the effectiveness of the quality system in the organization.

Evolution of Quality Management System

Quality systems have increasingly evolved over the last five decades. Before World War II, the usual function to produce quality products was to inspect the finished products to remove defective devices. Since that time, quality systems of organizations have undergone through four steps of evolution, as shown in the fig. The first product inspection task gave method to quality control (QC).

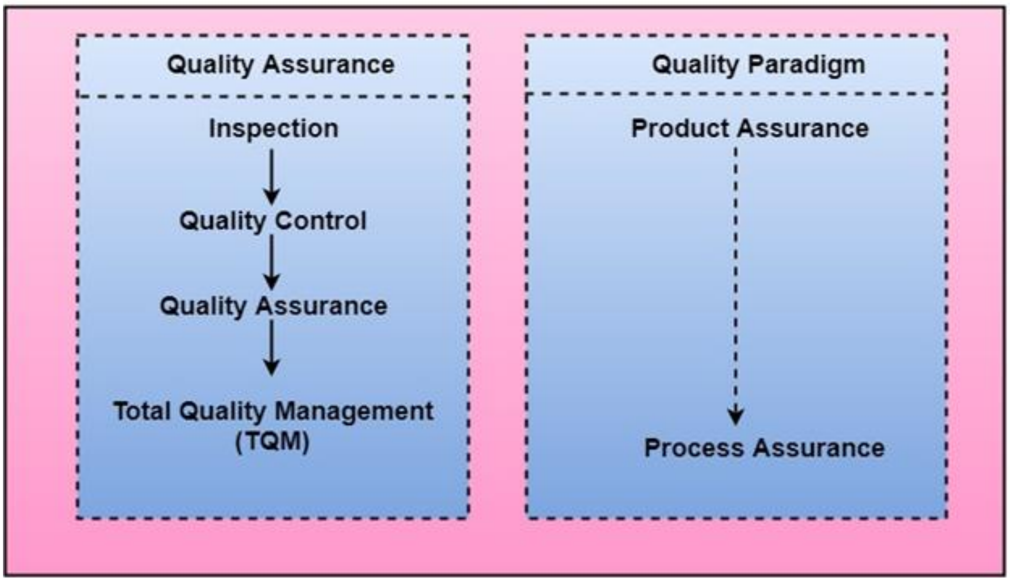
Quality control target not only on detecting the defective devices and removes them but also on determining the causes behind the defects. Thus, quality control aims at correcting the reasons for bugs and not just rejecting the products. The next breakthrough in quality methods was the development of quality assurance methods.

The primary premise of modern quality assurance is that if an organization's processes are proper and are followed rigorously, then the products are obligated to be of good quality. The new quality functions include guidance for recognizing, defining, analysing, and improving the production process.

Total quality management (TQM) advocates that the procedure followed by an organization must be continuously improved through process measurements. TQM goes stages further than quality assurance and aims at frequently process improvement. TQM goes beyond documenting steps to optimizing them through a redesign. A term linked to TQM is Business Process Reengineering (BPR).

BPR aims at reengineering the method business is carried out in an organization. From the above conversation, it can be stated that over the years, the quality paradigm has changed from product assurance to process assurance, as shown in fig.

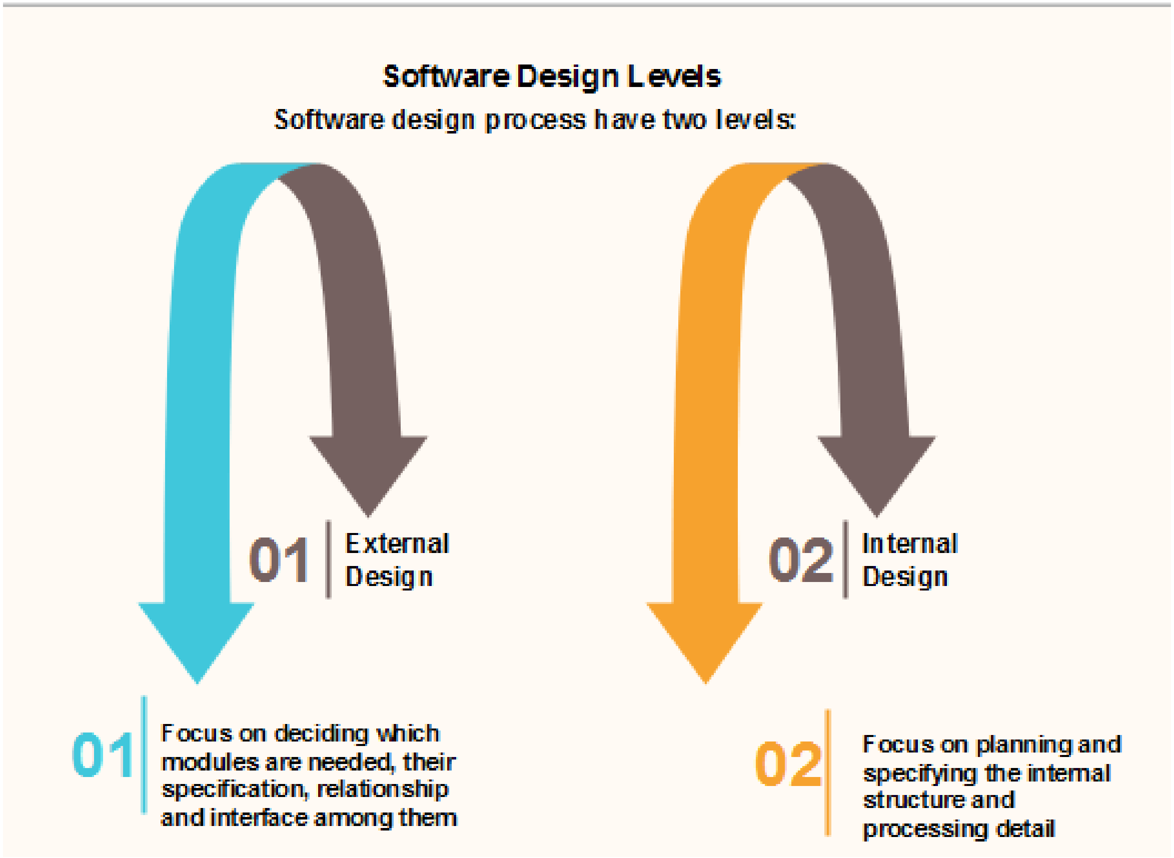
Evolution of quality system and corresponding shift in the quality paradigm



Software Design

Software design is a mechanism to transform user requirements into some suitable form, which helps the programmer in software coding and implementation. It deals with representing the client's requirement, as described in SRS (Software Requirement Specification) document, into a form, i.e., easily implementable using programming language.

The software design phase is the first step in **SDLC (Software Design Life Cycle)**, which moves the concentration from the problem domain to the solution domain. In software design, we consider the system to be a set of components or modules with clearly defined behaviours & boundaries.


Software Design Levels
Software design process have two levels:
01 External Design
02 Internal Design
01 Focus on deciding which modules are needed, their specification, relationship and interface among them
02 Focus on planning and specifying the internal structure and processing detail

Objectives of Software Design

Following are the purposes of Software design:

Correctness
Completeness
Efficiency
Flexibility
Consistency
Maintainability

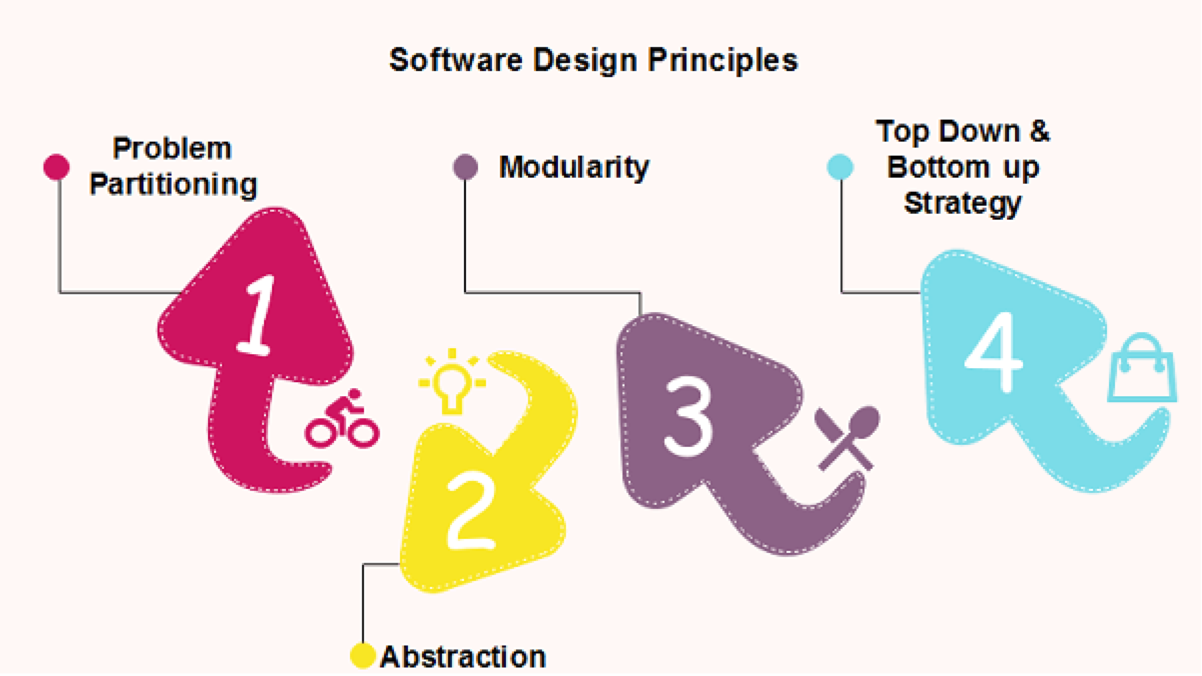
Objectives of Software Design

- Correctness
- Completeness
- Efficiency
- Flexibility
- Consistency
- Maintainability

Software Design Principles

Software design principles are concerned with providing means to handle the complexity of the design process effectively. Effectively managing the complexity will not only reduce the effort needed for design but can also reduce the scope of introducing errors during design.

Following are the principles of Software Design



Problem Partitioning

For small problem, we can handle the entire problem at once but for the significant problem, divide the problems and conquer the problem it means to divide the problem into smaller pieces so that each piece can be captured separately.

For software design, the goal is to divide the problem into manageable pieces.

Benefits of Problem Partitioning

1. Software is easy to understand
2. Software becomes simple
3. Software is easy to test
4. Software is easy to modify
5. Software is easy to maintain
6. Software is easy to expand

These pieces cannot be entirely independent of each other as they together form the system. They have to cooperate and communicate to solve the problem. This communication adds complexity.

Abstraction

An abstraction is a tool that enables a designer to consider a component at an abstract level without bothering about the internal details of the implementation. Abstraction can be used for existing element as well as the component being designed.

Here, there are two common abstraction mechanisms

1. Functional Abstraction
2. Data Abstraction

Functional Abstraction

i. A module is specified by the method it performs.

ii. The details of the algorithm to accomplish the functions are not visible to the user of the function.

Functional abstraction forms the basis for Function oriented design approaches**.**

Data Abstraction

Details of the data elements are not visible to the users of data. Data Abstraction forms the basis for **Object Oriented design approaches**.

Modularity

Modularity specifies to the division of software into separate modules which are differently named and addressed and are integrated later on in to obtain the completely functional software. It is the only property that allows a program to be intellectually manageable. Single large programs are difficult to understand and read due to a large number of reference variables, control paths, global variables, etc.

The desirable properties of a modular system are:

- Each module is a well-defined system that can be used with other applications.
- Each module has single specified objectives.
- Modules can be separately compiled and saved in the library.
- Modules should be easier to use than to build.
- Modules are simpler from outside than inside.

Advantages of Modularity

- It allows large programs to be written by several or different people
- It encourages the creation of commonly used routines to be placed in the library and used by other programs.
- It simplifies the overlay procedure of loading a large program into main storage.
- It provides more checkpoints to measure progress.
- It provides a framework for complete testing, more accessible to test
- It produced the well designed and more readable program.

Disadvantages of Modularity

- Execution time maybe, but not certainly, longer
- Storage size perhaps, but is not certainly, increased
- Compilation and loading time may be longer
- Inter-module communication problems may be increased
- More linkage required, run-time may be longer, more source lines must be written, and more documentation has to be done

Modular Design

Modular design reduces the design complexity and results in easier and faster implementation by allowing parallel development of various parts of a system.

1. Functional Independence: Functional independence is achieved by developing functions that perform only one kind of task and do not excessively interact with other modules. Independence is important because it makes implementation more accessible and faster. The independent modules are easier to maintain, test, and reduce error propagation and can be reused in other programs as well. Thus, functional independence is a good design feature which ensures software quality.

It is measured using two criteria:

- **Cohesion:** It measures the relative function strength of a module.
- **Coupling:** It measures the relative interdependence among modules.

2. Information hiding: The fundamental of Information hiding suggests that modules can be characterized by the design decisions that protect from the others, i.e., In other words, modules should be specified that data include within a module is inaccessible to other modules that do not need for such information.

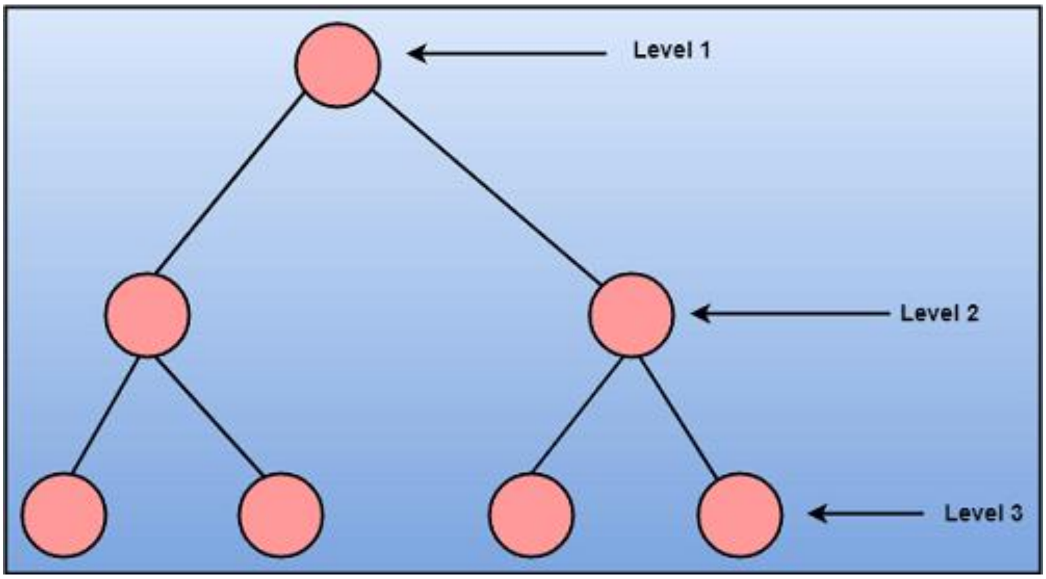
Strategy of Design

A good system design strategy is to organize the program modules in such a method that are easy to develop and latter too, change. Structured design methods help developers to deal with the size and complexity of programs. Analysts generate instructions for the developers about how code should be composed and how pieces of code should fit together to form a program.

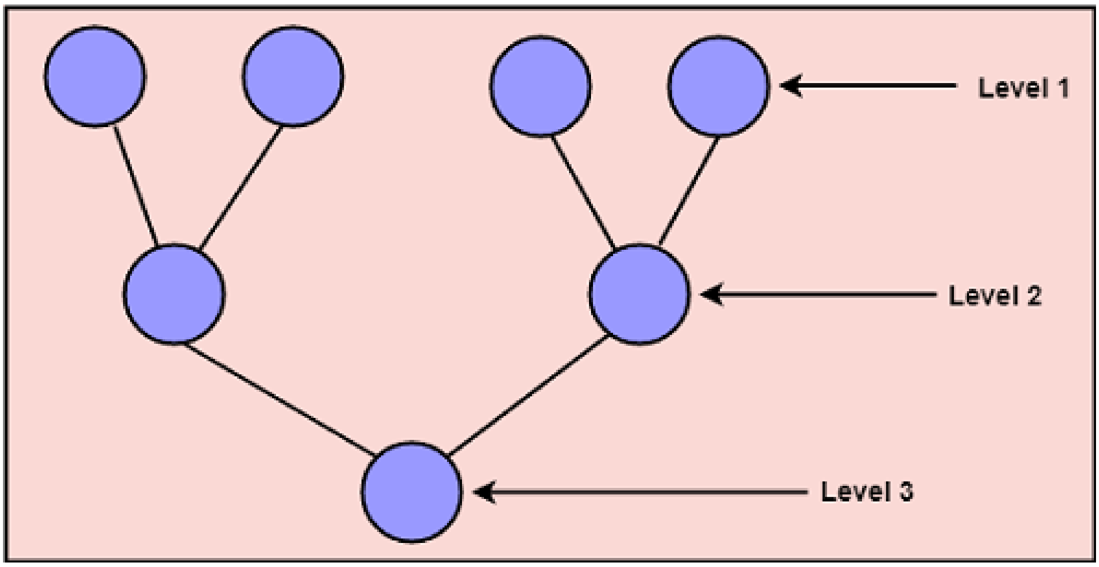
To design a system, there are two possible approaches:

1. Top-down Approach
2. Bottom-up Approach

1. Top-down Approach: This approach starts with the identification of the main components and then decomposing them into their more detailed sub-components.



2. Bottom-up Approach: A bottom-up approach begins with the lower details and moves towards up the hierarchy, as shown in fig. This approach is suitable in case of an existing system.



Software Coding

The coding is the process of transforming the design of a system into a computer language format. This coding phase of software development is concerned with software translating design specification into the source code. It is necessary to write source code & internal documentation so that conformance of the code to its specification can be easily verified.

Coding is done by the coder or programmers who are independent people than the designer. The goal is not to reduce the effort and cost of the coding phase, but to cut to the cost of a later stage. The cost of testing and maintenance can be significantly reduced with efficient coding.

Goals of Coding

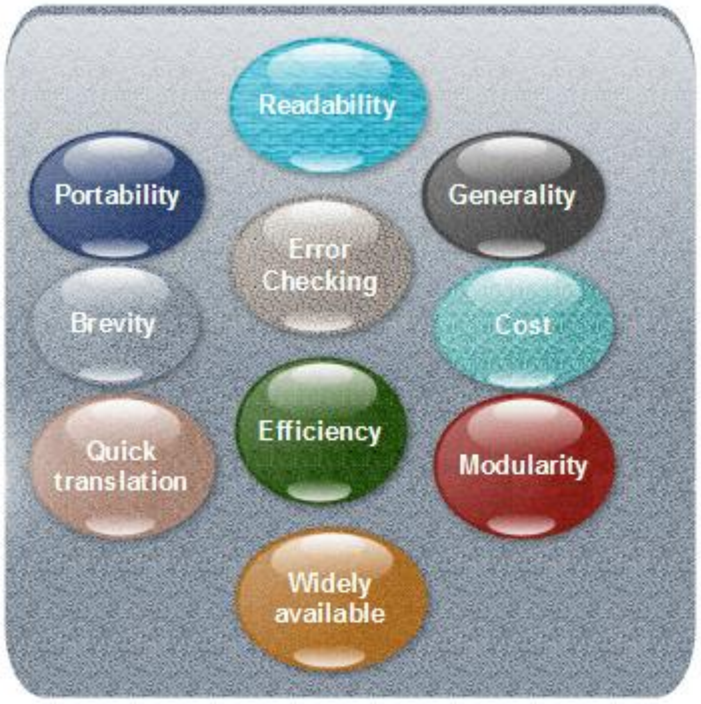
1. **To translate the design of system into a computer language format:** The coding is the process of transforming the design of a system into a computer language format, which can be executed by a computer and that perform tasks as specified by the design of operation during the design phase.
2. **To reduce the cost of later phases:** The cost of testing and maintenance can be significantly reduced with efficient coding.
3. **Making the program more readable:** Program should be easy to read and understand. It increases code understanding having readability and understantability as a clear objective of the coding activity can itself help in producing more maintainable software.

For implementing our design into code, we require a high-level functional language. A programming language should have the following characteristics:

Characteristics of Programming Language

Following are the characteristics of Programming Language:

Characteristics of Programming Language



Readability: A good high-level language will allow programs to be written in some methods that resemble a quite-English description of the underlying functions. The coding may be done in an essentially self-documenting way.

Portability: High-level languages, being virtually machine-independent, should be easy to develop portable software.

Generality: Most high-level languages allow the writing of a vast collection of programs, thus relieving the programmer of the need to develop into an expert in many diverse languages.

Brevity: Language should have the ability to implement the algorithm with less amount of code. Programs mean in high-level languages are often significantly shorter than their low-level equivalents.

Error checking: A programmer is likely to make many errors in the development of a computer program. Many high-level languages invoke a lot of bugs checking both at compile-time and run-time.

Cost: The ultimate cost of a programming language is a task of many of its characteristics.

Quick translation: It should permit quick translation.

Efficiency: It should authorize the creation of an efficient object code.

Modularity: It is desirable that programs can be developed in the language as several separately compiled modules, with the appropriate structure for ensuring self-consistency among these modules.

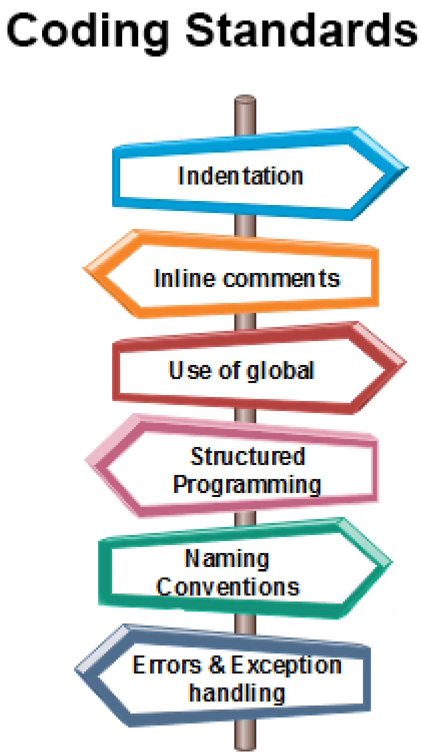
Widely available: Language should be widely available, and it should be feasible to provide translators for all the major machines and all the primary operating systems.

A coding standard lists several rules to be followed during coding, such as the way variables are to be named, the way the code is to be laid out, error return conventions, etc.

Coding Standards

General coding standards refers to how the developer writes code, so here we will discuss some essential standards regardless of the programming language being used.

The following are some representative coding standards:

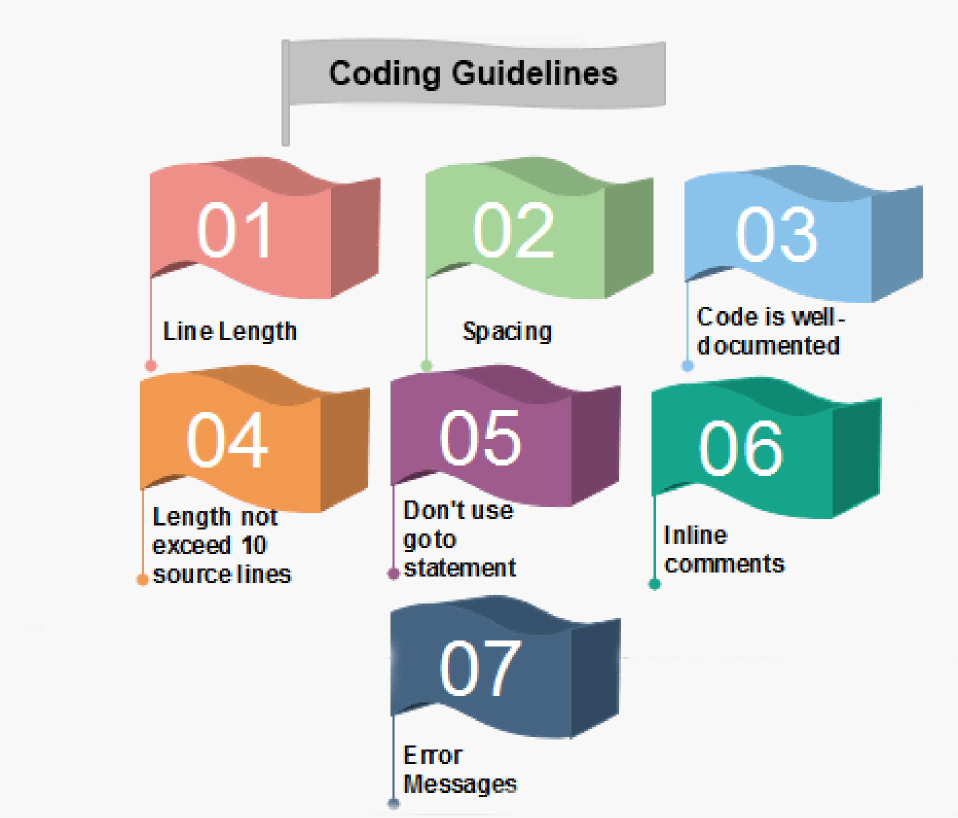


1. **Indentation:** Proper and consistent indentation is essential in producing easy to read and maintainable programs.
   Indentation should be used to:
   - Emphasize the body of a control structure such as a loop or a select statement.
   - Emphasize the body of a conditional statement
   - Emphasize a new scope block
2. **Inline comments:** Inline comments analyse the functioning of the subroutine, or key aspects of the algorithm shall be frequently used.
3. **Rules for limiting the use of global:** These rules file what types of data can be declared global and what cannot.
4. **Structured Programming:** Structured (or Modular) Programming methods shall be used. "GOTO" statements shall not be used as they lead to "spaghetti" code, which is hard to read and maintain, except as outlined line in the FORTRAN Standards and Guidelines.
5. **Naming conventions for global variables, local variables, and constant identifiers:** A possible naming convention can be that global variable names always begin with a capital letter, local variable names are made of small letters, and constant names are always capital letters.
6. **Error return conventions and exception handling system:** Different functions in a program report the way error conditions are handled should be standard within an organization. For example, different tasks while encountering an error condition should either return a 0 or 1 consistently.

Coding Guidelines

General coding guidelines provide the programmer with a set of the best methods which can be used to make programs more comfortable to read and maintain. Most of the examples use the C language syntax, but the guidelines can be tested to all languages.

The following are some representative coding guidelines recommended by many software development organizations.



1. Line Length: It is considered a good practice to keep the length of source code lines at or below 80 characters. Lines longer than this may not be visible properly on some terminals and tools. Some printers will truncate lines longer than 80 columns.

2. Spacing: The appropriate use of spaces within a line of code can improve readability.

3. The code should be well-documented: As a rule of thumb, there must be at least one comment line on the average for every three-source line.

4. The length of any function should not exceed 10 source lines: A very lengthy function is generally very difficult to understand as it possibly carries out many various functions. For the same reason, lengthy functions are possible to have a disproportionately larger number of bugs.

5. Do not use goto statements: Use of goto statements makes a program unstructured and very tough to understand.

6. Inline Comments: Inline comments promote readability

Software Reliability

Software Reliability means **Operational reliability**. It is described as the ability of a system or component to perform its required functions under static conditions for a specific period.

Software reliability is also defined as the probability that a software system fulfils its assigned task in a given environment for a predefined number of input cases, assuming that the hardware and the input are free of error.

Software Reliability is an essential connect of software quality, composed with functionality, usability, performance, serviceability, capability, installability, maintainability, and documentation.

Software Reliability is hard to achieve because the complexity of software turn to be high. While any system with a high degree of complexity, containing software, will be hard to reach a certain level of reliability, system developers tend to push complexity into the software layer, with the speedy growth of system size and ease of doing so by upgrading the software.

For example, large next-generation aircraft will have over 1 million source lines of software on-board; next-generation air traffic control systems will contain between one and two million lines; the upcoming International Space Station will have over two million lines on-board and over 10 million lines of ground support software; several significant life-critical defense systems will have over 5 million source lines of software. While the complexity of software is inversely associated with software reliability, it is directly related to other vital factors in software quality, especially functionality, capability, etc.

Software Reliability Models

A software reliability model indicates the form of a random process that defines the behaviour of software failures to time.

Software reliability models have appeared as people try to understand the features of how and why software fails, and attempt to quantify software reliability.

Over 200 models have been established since the early 1970s, but how to quantify software reliability remains mostly unsolved.

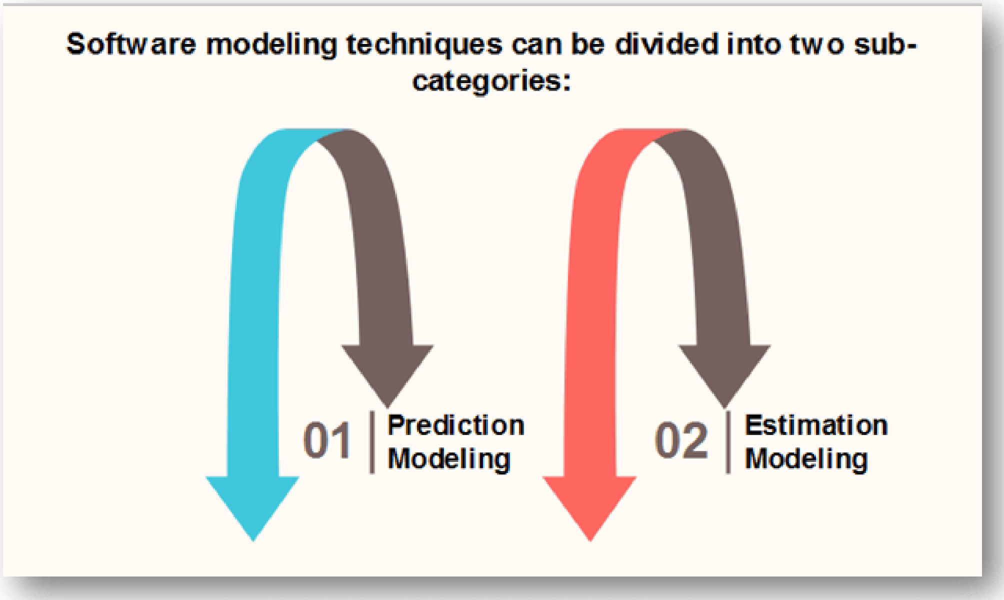
There is no individual model that can be used in all situations. No model is complete or even representative.

Most software models contain the following parts:

- Assumptions
- Factors

A mathematical function that includes the reliability with the elements. The mathematical function is generally higher-order exponential or logarithmic.

Software Reliability Modelling Techniques


Software modeling techniques can be divided into two sub-categories:
01 | Prediction Modeling
02 | Estimation Modeling

Both kinds of modelling methods are based on observing and accumulating failure data and analysing with statistical inference.

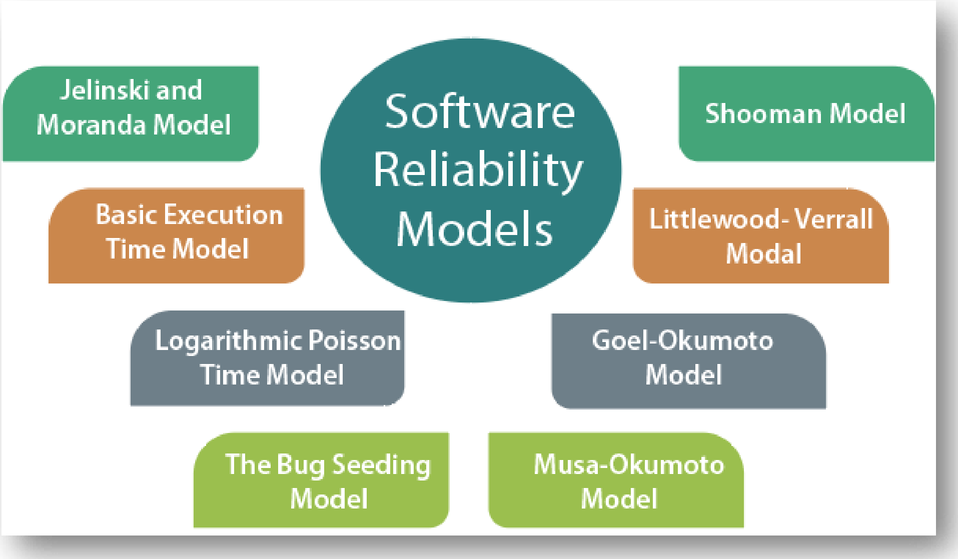
Differentiate between software reliability prediction models and software reliability estimation models

Basics	Prediction Models	Estimation Models
Data Reference	Uses historical information	Uses data from the current software development effort.
When used in development cycle	Usually made before development or test phases; can be used as early as concept phase.	Usually made later in the life cycle (after some data have been collected); not typically used in concept or development phases.
Time Frame	Predict reliability at some future time.	Estimate reliability at either present or some next time.

Reliability Models

A reliability growth model is a numerical model of software reliability, which predicts how software reliability should improve over time as errors are discovered and repaired. These models help the manager in deciding how much efforts should be devoted to testing. The objective of the project manager is to test and debug the system until the required level of reliability is reached.

Following are the Software Reliability Models:


Software Reliability Models
Jelinski and Moranda Model
Shooman Model
Basic Execution Time Model
Littlewood- Verrall Modal
Logarithmic Poisson Time Model
Goel-Okumoto Model
The Bug Seeding Model
Musa-Okumoto Model

- Jelinski and Moranda Model
- Basic Execution Time Model
- Goel-Okumoto (GO) Model
- Logarithmic Poisson Model
- The Bug Seeding Model
- Littlewood-VerrallModel
- Shooman Model
- Musa-Okumoto Model

Software Maintenance

Software maintenance is a part of the Software Development Life Cycle. Its primary goal is to modify and update software application after delivery to correct errors and to improve performance. Software is a model of the real world. When the real world changes, the software require alteration wherever possible.

Software Maintenance is an inclusive activity that includes error corrections, enhancement of capabilities, deletion of obsolete capabilities, and optimization.

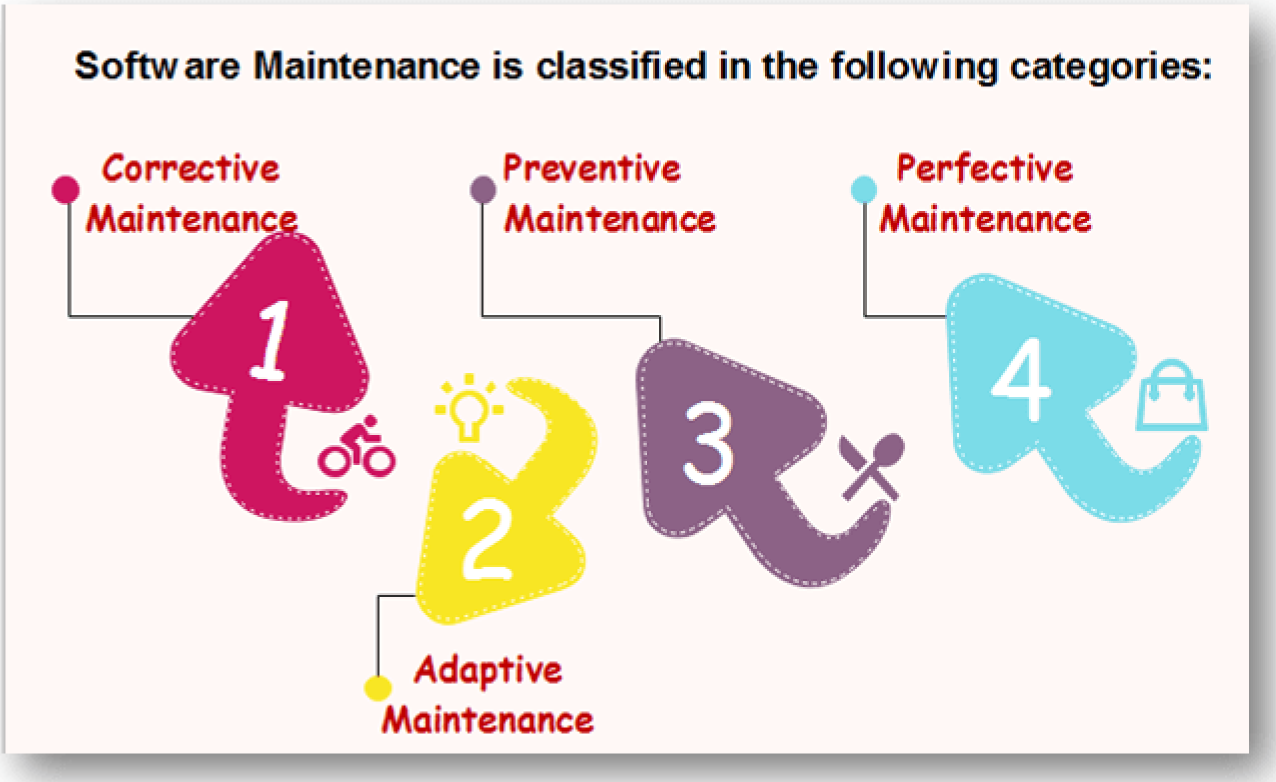
Need for Maintenance

Software Maintenance is needed for:-

- Correct errors
- Change in user requirement with time
- Changing hardware/software requirements
- To improve system efficiency
- To optimize the code to run faster
- To modify the components
- To reduce any unwanted side effects.

Thus the maintenance is required to ensure that the system continues to satisfy user requirements.

Types of Software Maintenance



1. Corrective Maintenance

Corrective maintenance aims to correct any remaining errors regardless of where they may cause specifications, design, coding, testing, and documentation, etc.

2. Adaptive Maintenance

It contains modifying the software to match changes in the ever-changing environment.

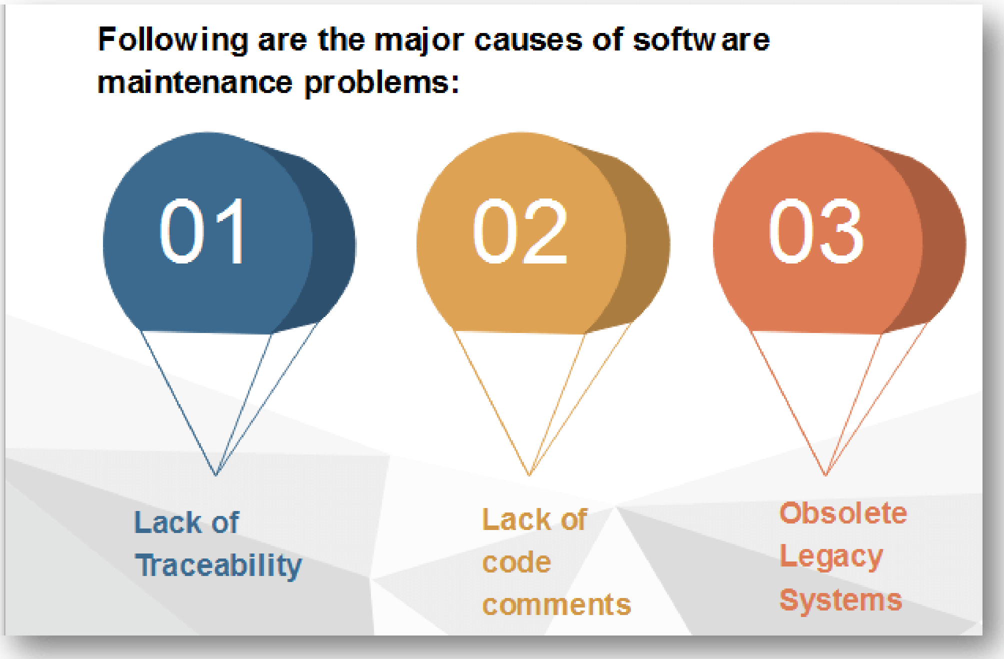
3. Preventive Maintenance

It is the process by which we prevent our system from being obsolete. It involves the concept of reengineering & reverse engineering in which an old system with old technology is re-engineered using new technology. This maintenance prevents the system from dying out.

4. Perfective Maintenance

It defines improving processing efficiency or performance or restricting the software to enhance changeability. This may contain enhancement of existing system functionality, improvement in computational efficiency, etc.

Causes of Software Maintenance Problems



Following are the major causes of software maintenance problems:

Lack of Traceability

- Codes are rarely traceable to the requirements and design specifications.
- It makes it very difficult for a programmer to detect and correct a critical defect affecting customer operations.
- Like a detective, the programmer pores over the program looking for clues.
- Life Cycle documents are not always produced even as part of a development project.

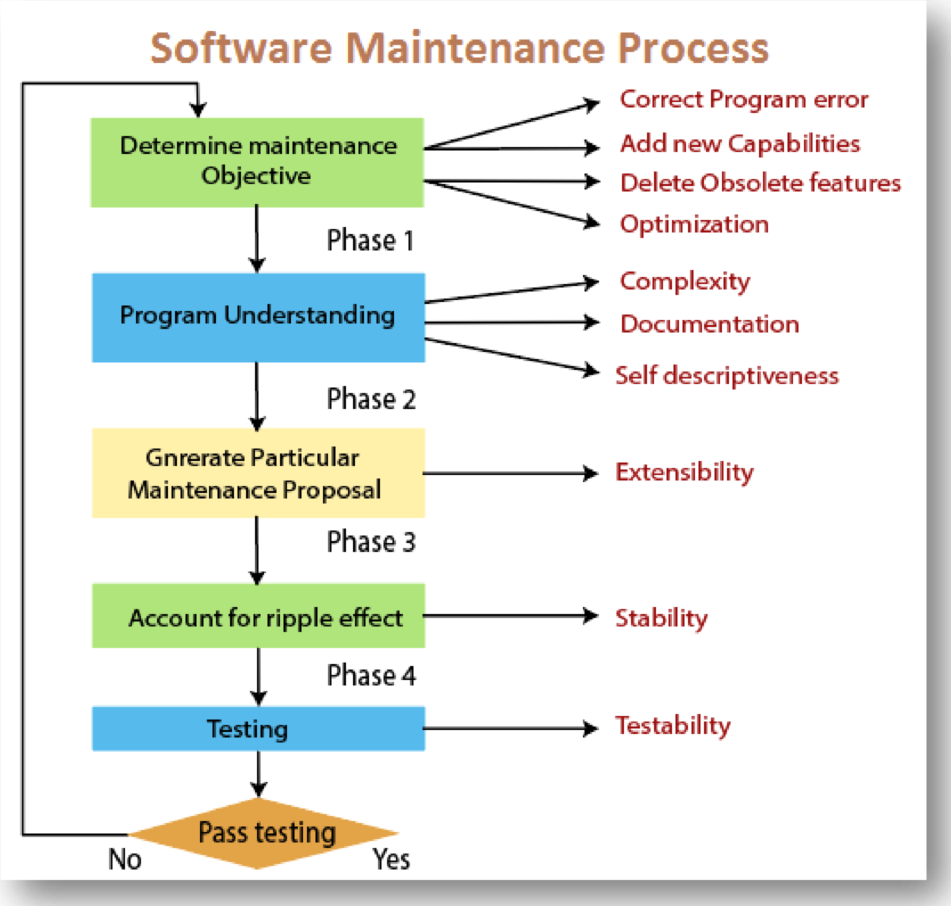
Lack of Code Comments

- Most of the software system codes lack adequate comments. Lesser comments may not be helpful in certain situations.

Obsolete Legacy Systems

- In most of the countries worldwide, the legacy system that provides the backbone of the nation's critical industries, e.g., telecommunications, medical, transportation utility services, were not designed with maintenance in mind.
- They were not expected to last for a quarter of a century or more!
- As a consequence, the code supporting these systems is devoid of traceability to the requirements, compliance to design and programming standards and often includes dead, extra and uncommented code, which all make the maintenance task next to the impossible.

Software Maintenance Process



Program Understanding

The first step consists of analysing the program to understand.

Generating a Particular maintenance problem

The second phase consists of creating a particular maintenance proposal to accomplish the implementation of the maintenance goals.

Ripple Effect

The third step consists of accounting for all of the ripple effects as a consequence of program modifications.

Modified Program Testing

The fourth step consists of testing the modified program to ensure that the revised application has at least the same reliability level as prior.

Maintainability

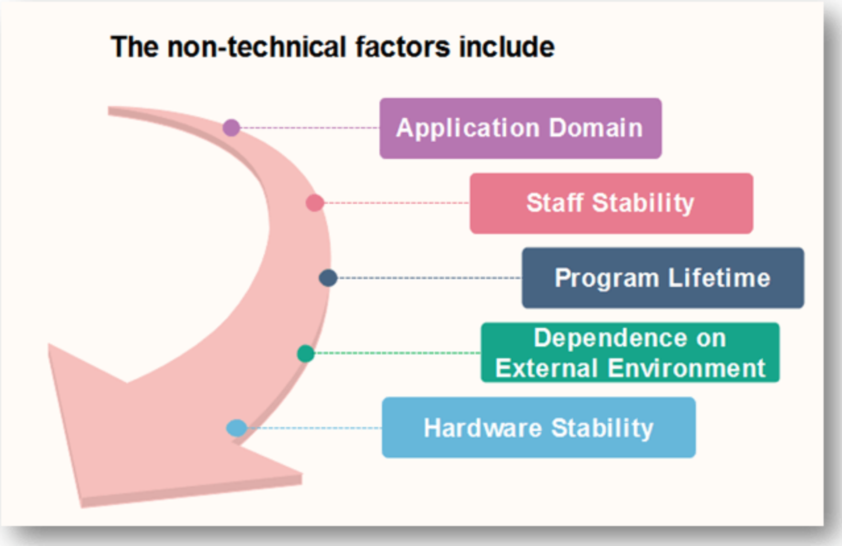
Each of these four steps and their associated software quality attributes is critical to the maintenance process. All of these methods must be combined to form maintainability.

Software Maintenance Cost Factors

There are two types of cost factors involved in software maintenance.

- Non-Technical Factors and Technical Factors

Non-Technical Factors


The non-technical factors include
Application Domain
Staff Stability
Program Lifetime
Dependence on External Environment
Hardware Stability

1. Application Domain

- If the application of the program is defined and well understood, the system requirements may be definitive and maintenance due to changing needs minimized.
- If the form is entirely new, it is likely that the initial conditions will be modified frequently, as user gain experience with the system.

2. Staff Stability

- It is simple for the original writer of a program to understand and change an application rather than some other person who must understand the program by the study of the reports and code listing.
- In practice, the feature of the programming profession is such that persons change jobs regularly. It is unusual for one user to develop and maintain an application throughout its useful life.

3. Program Lifetime

- Programs become obsolete when the program becomes obsolete, or their original hardware is replaced, and conversion costs exceed rewriting costs.

4. Dependence on External Environment

- If an application is dependent on its external environment, it must be modified as the climate changes.
- For example:
- Changes in a taxation system might need payroll, accounting, and stock control programs to be modified.
- A program used in mathematical applications does not typically depend on humans changing the assumptions on which the program is based.

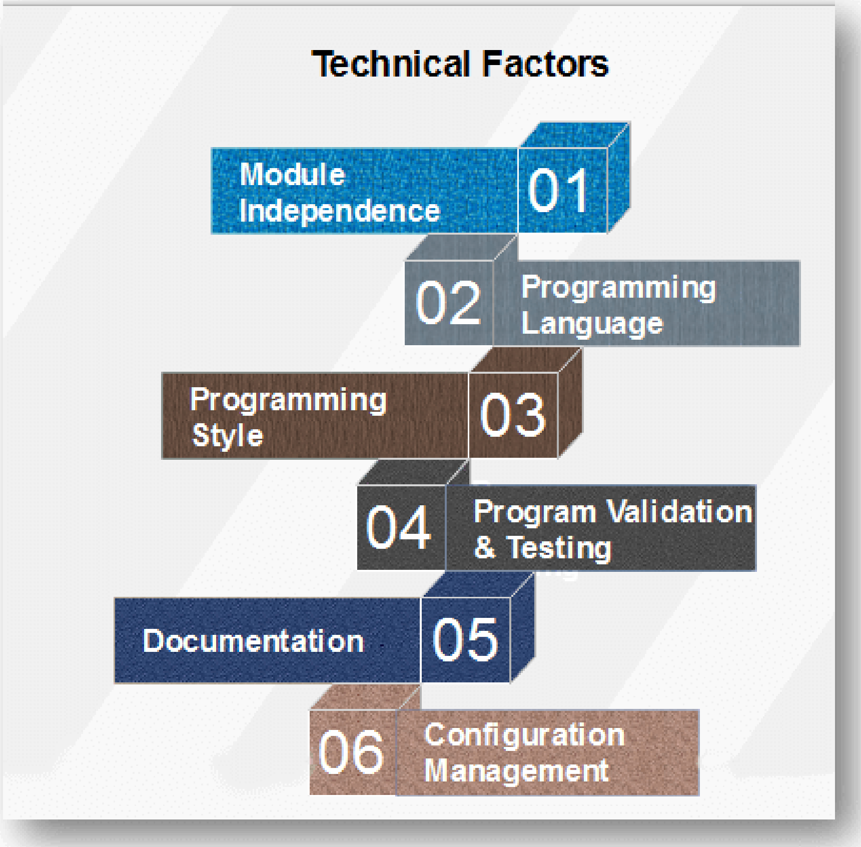
5. Hardware Stability

- If an application is designed to operate on a specific hardware configuration and that configuration does not changes during the program's lifetime, no maintenance costs due to hardware changes will be incurred.

- Hardware developments are so increased that this situation is rare.
- The application must be changed to use new hardware that replaces obsolete equipment.

Technical Factors

Technical Factors include the following:



Module Independence

It should be possible to change one program unit of a system without affecting any other unit.

Programming Language

Programs written in a high-level programming language are generally easier to understand than programs written in a low-level language.

Programming Style

The method in which a program is written contributes to its understandability and hence, the ease with which it can be modified.

Program Validation and Testing

- Generally, more the time and effort are spent on design validation and program testing, the fewer bugs in the program and, consequently, maintenance costs resulting from bugs correction are lower.
- Maintenance costs due to bug's correction are governed by the type of fault to be repaired.
- Coding errors are generally relatively cheap to correct, design errors are more expensive as they may include the rewriting of one or more program units.
- Bugs in the software requirements are usually the most expensive to correct because of the drastic design which is generally involved.

Documentation

- If a program is supported by clear, complete yet concise documentation, the functions of understanding the application can be associatively straight-forward.
- Program maintenance costs tends to be less for well-reported systems than for the system supplied with inadequate or incomplete documentation.

Configuration Management Techniques

- One of the essential costs of maintenance is keeping track of all system documents and ensuring that these are kept consistent.
- Effective configuration management can help control these costs.