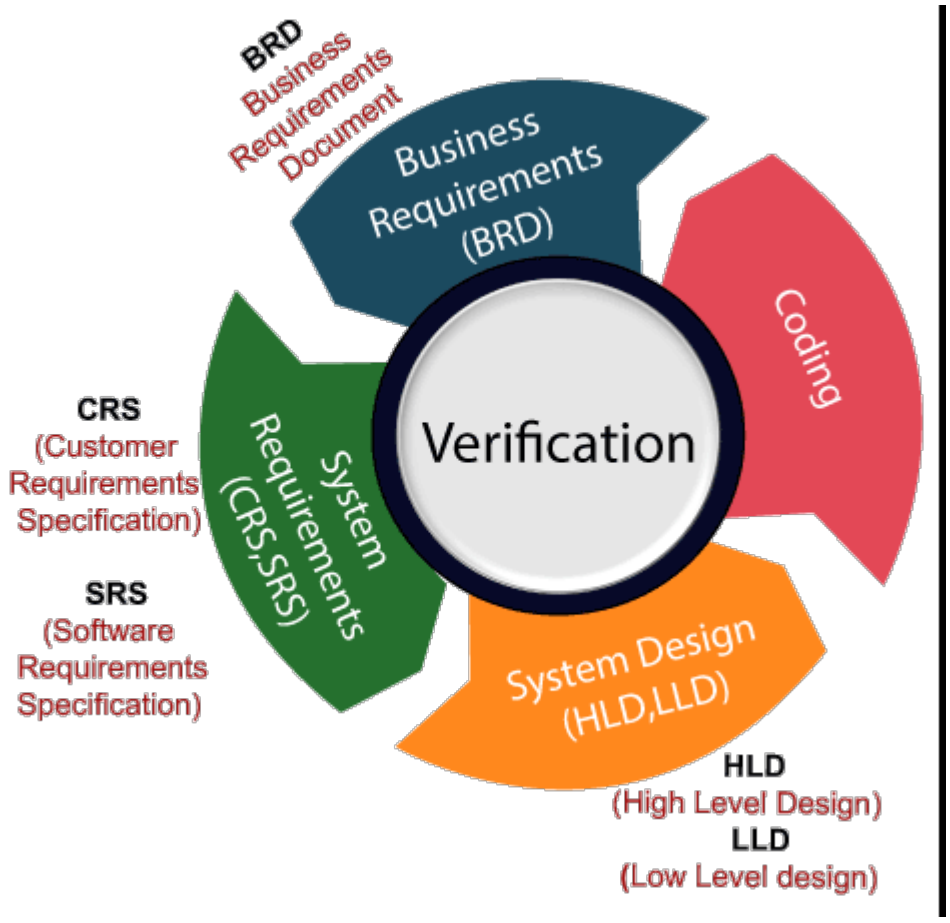
Unit-4

Verification testing

Verification testing includes different activities such as business requirements, system requirements, design review, and code walkthrough while developing a product.

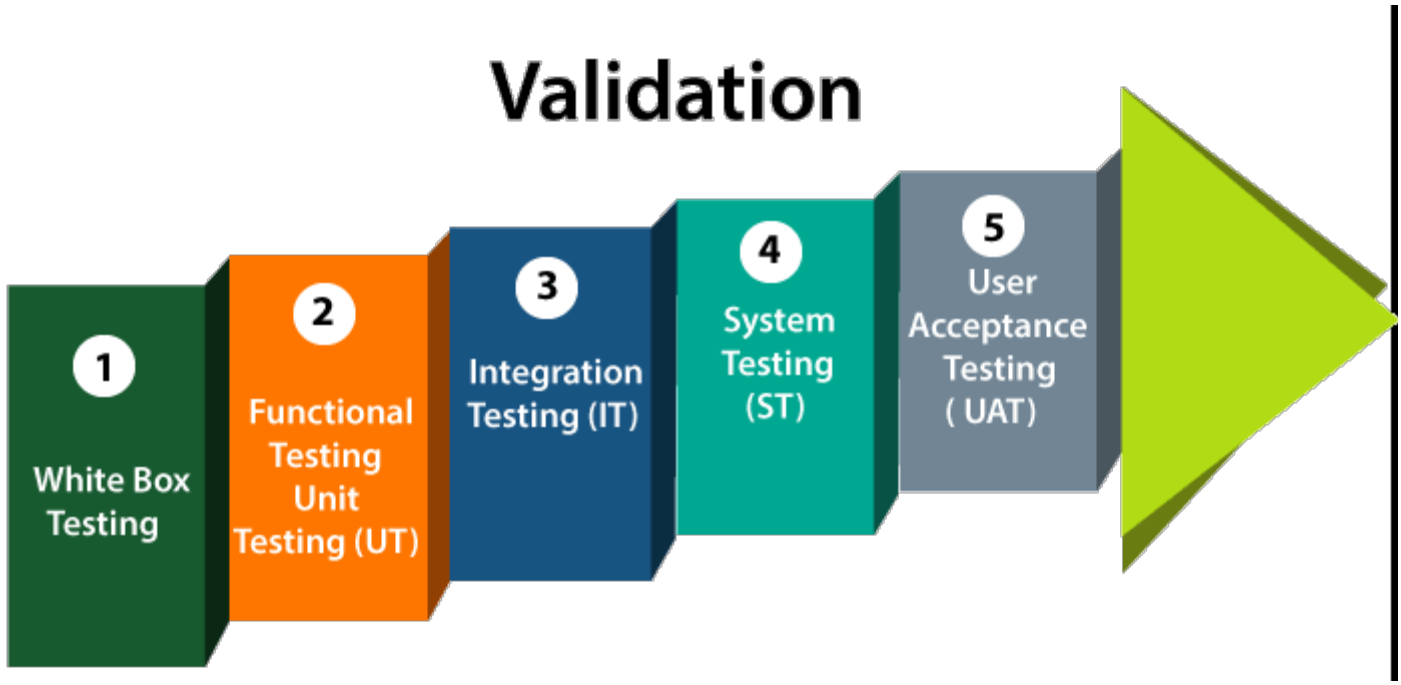
It is also known as static testing, where we are ensuring that "**we are developing the right product or not**". And it also checks that the developed application fulfilling all the requirements given by the client.



Validation testing

Validation testing is testing where tester performed functional and non-functional testing. Here **functional testing** includes Unit Testing (UT), Integration Testing (IT) and System Testing (ST), and **non-functional** testing includes User acceptance testing (UAT).

Validation testing is also known as dynamic testing, where we are ensuring that **"we have developed the product right."** And it also checks that the software meets the business needs of the client.



Difference between verification and validation testing

Verification	Validation
We check whether we are developing the right product or not.	We check whether the developed product is right.
Verification is also known as **static testing**.	Validation is also known as **dynamic testing**.
Verification includes different methods like Inspections, Reviews, and Walkthroughs.	Validation includes testing like functional testing, system testing, integration, and User acceptance testing.
It is a process of checking the work-products (not the final product) of a development cycle to decide whether the product meets the specified requirements.	It is a process of checking the software during or at the end of the development cycle to decide whether the software follow the specified business requirements.
Quality assurance comes under verification testing.	**Quality control** comes under validation testing.
The execution of code does not happen in the verification testing.	In validation testing, the execution of code happens.
In verification testing, we can find the bugs early in the development phase of the product.	In the validation testing, we can find those bugs, which are not caught in the verification process.

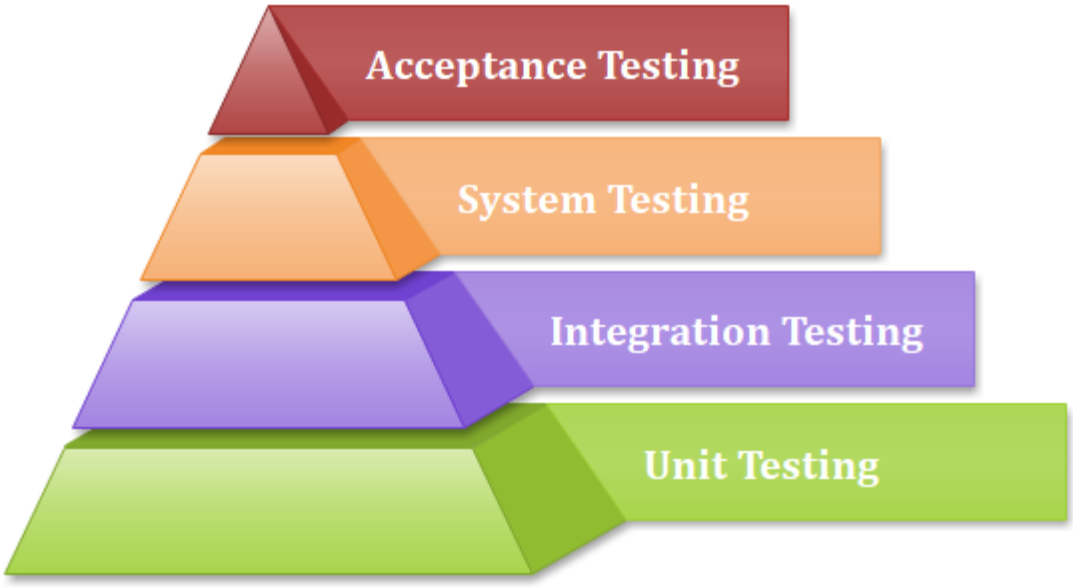
Verification testing is executed by the Quality assurance team to make sure that the product is developed according to customers' requirements.	Validation testing is executed by the testing team to test the application.
Verification is done before the validation testing.	After verification testing, validation testing takes place.
In this type of testing, we can verify that the inputs follow the outputs or not.	In this type of testing, we can validate that the user accepts the product or not.

System Testing

System Testing includes testing of a fully integrated software system. Generally, a computer system is made with the integration of software (any software is only a single element of a computer system). The software is developed in units and then interfaced with other software and hardware to create a complete computer system. In other words, a computer system consists of a group of software to perform the various tasks, but only software cannot perform the task; for that software must be interfaced with compatible hardware. System testing is a series of different type of tests with the purpose to exercise and examine the full working of an integrated software computer system against requirements.

There are four levels of software testing: unit testing, integration testing, system testing and acceptance testing, all are used for the testing purpose. Unit Testing used to test a single software; Integration Testing used to test a group of units of software, System Testing used to test a whole system and Acceptance Testing used to test the acceptability of business requirements. Here we are discussing system testing which is the third level of testing levels.

Hierarchy of Testing Levels



There are mainly two widely used methods for software testing, one is **White box testing** which uses internal coding to design test cases and another is black box testing which uses GUI or user perspective to develop test cases.

- White box testing
- Black box testing

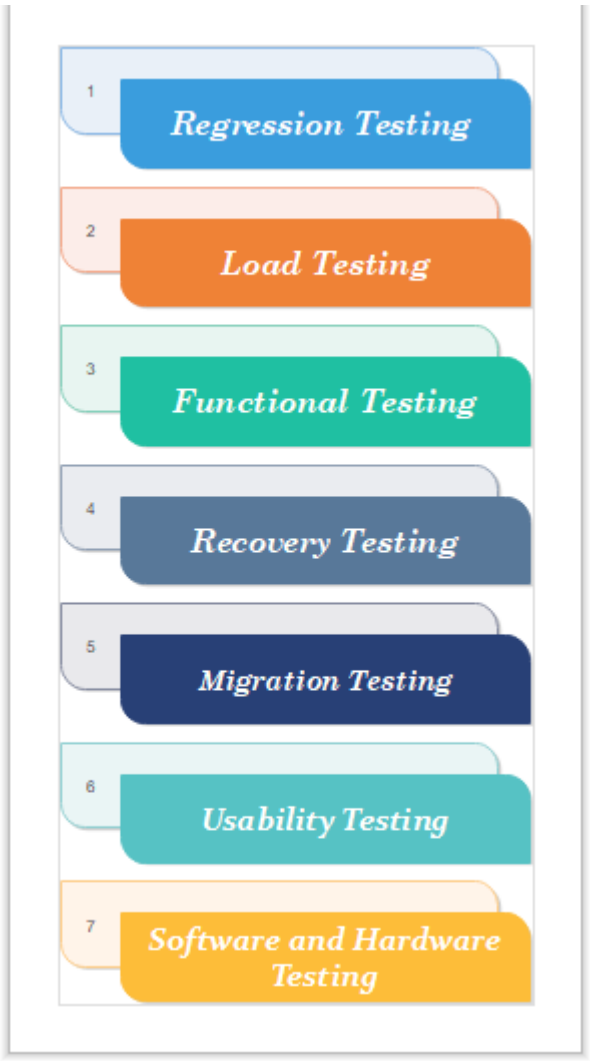
System testing falls under Black box testing as it includes testing of the external working of the software. Testing follows user's perspective to identify minor defects.

System Testing includes the following steps.

- Verification of input functions of the application to test whether it is producing the expected output or not.
- Testing of integrated software by including external peripherals to check the interaction of various components with each other.
- Testing of the whole system for End to End testing.
- Behavior testing of the application via user's experience

Types of System Testing

System testing is divided into more than 50 types, but software testing companies typically uses some of them. These are listed below:



Regression Testing

Regression testing is performed under system testing to confirm and identify that if there's any defect in the system due to modification in any other part of the system. It makes sure, any changes done during the development process have not introduced a new defect and also gives assurance; old defects will not exist on the addition of new software over the time.

Load Testing

Load testing is performed under system testing to clarify whether the system can work under real-time loads or not.

Functional Testing

Functional testing of a system is performed to find if there's any missing function in the system. Tester makes a list of vital functions that should be in the system and can be added during functional testing and should improve quality of the system.

Recovery Testing

Recovery testing of a system is performed under system testing to confirm reliability, trustworthiness, accountability of the system and all are lying on recouping skills of the system. It should be able to recover from all the possible system crashes successfully.

Migration Testing

Migration testing is performed to ensure that if the system needs to be modified in new infrastructure so it should be modified without any issue.

Usability Testing

The purpose of this testing to make sure that the system is well familiar with the user and it meets its objective for what it supposed to do.

Software and Hardware Testing

This testing of the system intends to check hardware and software compatibility. The hardware configuration must be compatible with the software to run it without any issue. Compatibility provides flexibility by providing interactions between hardware and software.

Why is System Testing Important?

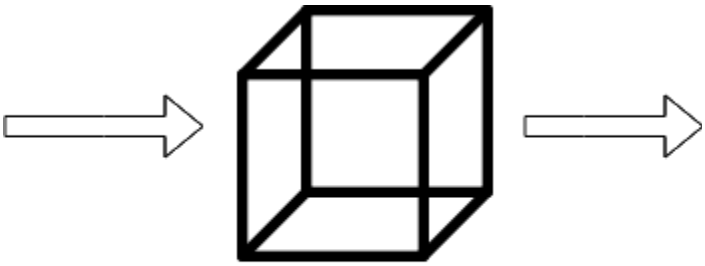
- System Testing gives hundred percent assurance of system performance as it covers end to end function of the system.
- It includes testing of System software architecture and business requirements.
- It helps in mitigating live issues and bugs even after production.
- System testing uses both existing system and a new system to feed same data in both and then compare the differences in functionalities of added and existing functions so, the user can understand benefits of new added functions of the system.

White Box Testing

The box testing approach of software testing consists of black box testing and white box testing. We are discussing here white box testing which also known as glass box is **testing, structural testing, clear box testing, open box testing and transparent box testing**. It tests internal coding and infrastructure of a software focus on checking of predefined inputs against expected and desired outputs. It is based on inner workings of an application and revolves around internal structure testing. In this type of testing programming skills are required to design test cases. The primary goal of white box testing is to focus on the flow of inputs and outputs through the software and strengthening the security of the software.

The term 'white box' is used because of the internal perspective of the system. The clear box or white box or transparent box name denote the ability to see through the software's outer shell into its inner workings.

Test cases for white box testing are derived from the design phase of the software development lifecycle. Data flow testing, control flow testing, path testing, branch testing, statement and decision coverage all these techniques used by white box testing as a guideline to create an error-free software.



Whitebox Testing

White box testing follows some working steps to make testing manageable and easy to understand what the next task to do. There are some basic steps to perform white box testing.

Generic steps of white box testing

- Design all test scenarios, test cases and prioritize them according to high priority number.
- This step involves the study of code at runtime to examine the resource utilization, not accessed areas of the code, time taken by various methods and operations and so on.
- In this step testing of internal subroutines takes place. Internal subroutines such as nonpublic methods, interfaces are able to handle all types of data appropriately or not.
- This step focuses on testing of control statements like loops and conditional statements to check the efficiency and accuracy for different data inputs.
- In the last step white box testing includes security testing to check all possible security loopholes by looking at how the code handles security.

Reasons for white box testing

- It identifies internal security holes.
- To check the way of input inside the code.
- Check the functionality of conditional loops.
- To test function, object, and statement at an individual level.

Advantages of White box testing

- White box testing optimizes code so hidden errors can be identified.
- Test cases of white box testing can be easily automated.
- This testing is more thorough than other testing approaches as it covers all code paths.
- It can be started in the SDLC phase even without GUI.

Disadvantages of White box testing

- White box testing is too much time consuming when it comes to large-scale programming applications.
- White box testing is much expensive and complex.
- It can lead to production error because it is not detailed by the developers.
- White box testing needs professional programmers who have a detailed knowledge and understanding of programming language and implementation.

Techniques Used in White Box Testing

Data Flow Testing	Data flow testing is a group of testing strategies that examines the control flow of programs in order to explore the sequence of variables according to the sequence of events.
Control Flow Testing	Control flow testing determines the execution order of statements or instructions of the program through a control structure. The control structure of a program is used to develop a test case for the program. In this technique, a particular part of a large program is selected by the tester to set the testing path. Test cases represented by the control graph of the program.
Branch Testing	Branch coverage technique is used to cover all branches of the control flow graph. It covers all the possible outcomes (true and false) of each condition of decision point at least once.
Statement Testing	Statement coverage technique is used to design white box test cases. This technique involves execution of all statements of the source code at least once. It is used to calculate the total number of executed statements in the source code, out of total statements present in the source code.
Decision Testing	This technique reports true and false outcomes of Boolean expressions. Whenever there is a possibility of two or more outcomes from the statements like do while statement, if statement and case statement (Control flow statements), it is considered as decision

	point because there are two outcomes either true or false.

Differences between Black Box Testing and White Box Testing

Criteria	**Black Box Testing**	**White Box Testing**
Definition	Black Box Testing is a software testing method in which the internal structure/ design/ implementation of the item being tested is NOT known to the tester	White Box Testing is a software testing method in which the internal structure/ design/ implementation of the item being tested is known to the tester.
Levels Applicable To	Mainly applicable to higher levels of testing:Acceptance Testing System Testing	Mainly applicable to lower levels of testing:Unit Testing Integration Testing
Responsibility	Generally, independent Software Testers	Generally, Software Developers
Programming Knowledge	Not Required	Required
Implementation Knowledge	Not Required	Required
Basis for Test Cases	Requirement Specifications	Detail Design

Smoke Testing

Smoke Testing comes into the picture at the time of receiving build software from the development team. The purpose of smoke testing is to determine whether the build software is testable or not. It is done at the time of "building software." This process is also known as "Day 0".

It is a time-saving process. It reduces testing time because testing is done only when the key features of the application are not working or if the key bugs are not fixed. The focus of Smoke Testing is on the workflow of the core and primary functions of the application.

Process to conduct Smoke Testing

Smoke testing does not require to design test cases. There's need only to pick the required test cases from already designed test cases.

As mentioned above, Smoke Testing focuses on the workflow of core applications so; we choose test case suits that covers the major functionality of the application. The number of test cases

should be minimized as much as possible and time of execution must not be more than half an hour.

Real Time Example:

Suppose, we are using an eCommerce site, and the core working of this site should be login, specific search, add an item into the cart, add an item into the favorite, payment options, etc. Here we are testing function to place an order. After testing, the tester has to be sure and confident about the functioning of the function of the application.

Steps of the workflow are given below:

- Click on item
- Description page should be open.
- Click on Add to Cart
- The cart should be open
- Click on Buy Now
- Payment options should be displayed. Choose one of them.
- Order placed

If this function is working correctly, then tester will pass it in testing and test the next function of the same application.

Software Metrics

Software metric is a measure of software characteristics which are measurable or countable. Software metrics are valuable for many reasons, including measuring software performance, planning work items, measuring productivity, and many other uses.

Within the software development process, many metrics are that are all connected. Software metrics are similar to the four functions of management: Planning, Organization, Control, or Improvement.

Classification of Software Metrics

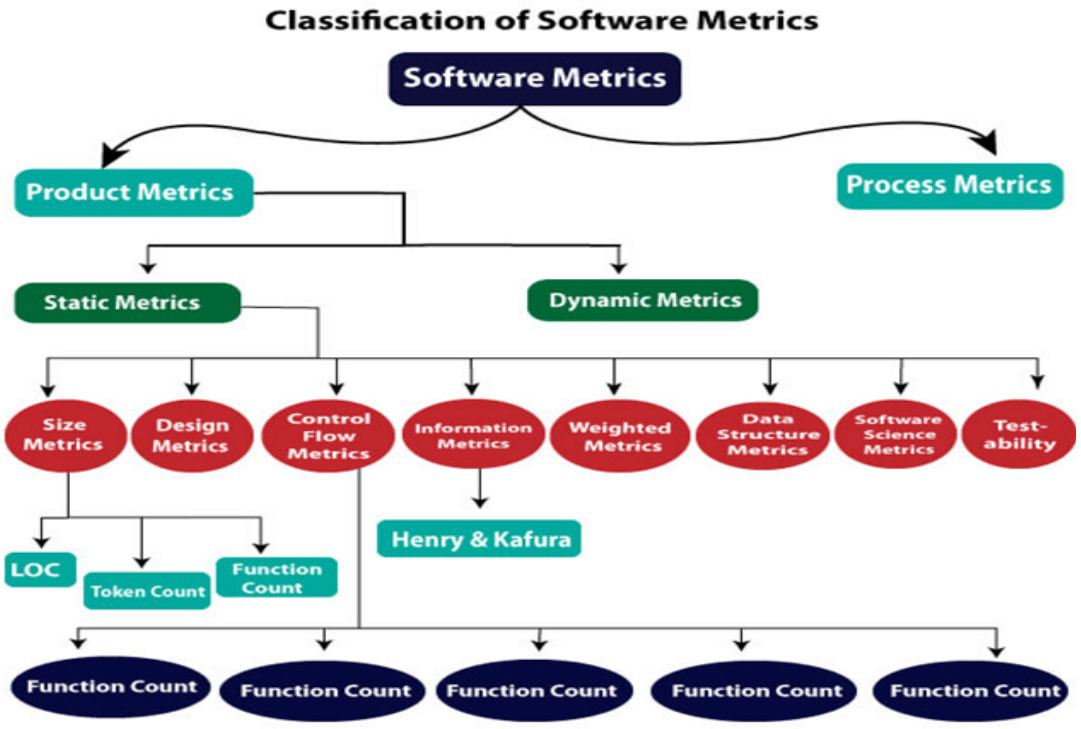
Software metrics can be classified into two types as follows:

1. Product Metrics: These are the measures of various characteristics of the software product. The two important software characteristics are:

1. Size and complexity of software.
2. Quality and reliability of software.

These metrics can be computed for different stages of SDLC.

2. Process Metrics: These are the measures of various characteristics of the software development process. For example, the efficiency of fault detection. They are used to measure the characteristics of methods, techniques, and tools that are used for developing software.



Types of Metrics

Internal metrics: Internal metrics are the metrics used for measuring properties that are viewed to be of greater importance to a software developer. For example, Lines of Code (LOC) measure.

External metrics: External metrics are the metrics used for measuring properties that are viewed to be of greater importance to the user, e.g., portability, reliability, functionality, usability, etc.

Hybrid metrics: Hybrid metrics are the metrics that combine product, process, and resource metrics. For example, cost per FP where FP stands for Function Point Metric.

Project metrics: Project metrics are the metrics used by the project manager to check the project's progress. Data from the past projects are used to collect various metrics, like time and cost; these estimates are used as a base of new software. Note that as the project proceeds, the project manager will check its progress from time-to-time and will compare the effort, cost, and time with the original effort, cost and time. Also understand that these metrics are used to decrease the development costs, time efforts and risks. The project quality can also be improved. As quality improves, the number of errors and time, as well as cost required, is also reduced.

Advantage of Software Metrics

- Comparative study of various design methodology of software systems.
- For analysis, comparison, and critical study of different programming language concerning their characteristics.
- In comparing and evaluating the capabilities and productivity of people involved in software development.
- In the preparation of software quality specifications.
- In the verification of compliance of software systems requirements and specifications.
- In making inference about the effort to be put in the design and development of the software systems.
- In getting an idea about the complexity of the code.
- In taking decisions regarding further division of a complex module is to be done or not.
- In guiding resource manager for their proper utilization.
- In comparison and making design tradeoffs between software development and maintenance cost.
- In providing feedback to software managers about the progress and quality during various phases of the software development life cycle.
- In the allocation of testing resources for testing the code.

Disadvantage of Software Metrics

- The application of software metrics is not always easy, and in some cases, it is difficult and costly.
- The verification and justification of software metrics are based on historical/empirical data whose validity is difficult to verify.
- These are useful for managing software products but not for evaluating the performance of the technical staff.
- The definition and derivation of Software metrics are usually based on assuming which are not standardized and may depend upon tools available and working environment.
- Most of the predictive models rely on estimates of certain variables which are often not known precisely.

Functional Point (FP) Analysis

Allan J. Albrecht initially developed function Point Analysis in 1979 at IBM and it has been further modified by the International Function Point Users Group (IFPUG). FPA is used to make estimate of the software project, including its testing in terms of functionality or function size of the software product. However, functional point analysis may be used for the test estimation of the product. The functional size of the product is measured in terms of the function point, which is a standard of measurement to measure the software application.

Objectives of FPA

The basic and primary purpose of the functional point analysis is to measure and provide the software application functional size to the client, customer, and the stakeholder on their request. Further, it is used to measure the software project development along with its maintenance, consistently throughout the project irrespective of the tools and the technologies.

Following are the points regarding FPs

1. FPs of an application is found out by counting the number and types of functions used in the applications. Various functions used in an application can be put under five types, as shown in Table:

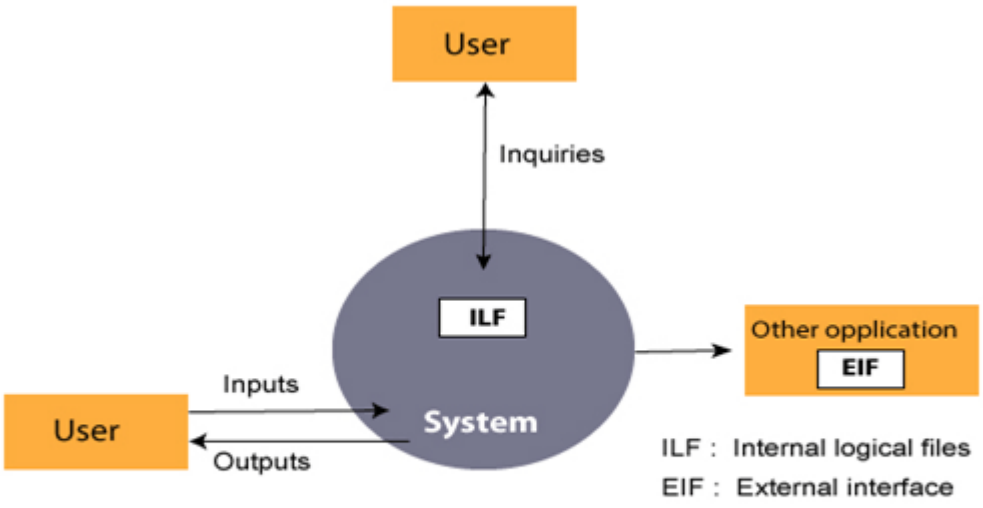
Types of FP Attributes

Measurements Parameters	Examples
1.Number of External Inputs(EI)	Input screen and tables
2. Number of External Output (EO)	Output screens and reports

3. Number of external inquiries (EQ)	Prompts and interrupts.
4. Number of internal files (ILF)	Databases and directories
5. Number of external interfaces (EIF)	Shared databases and shared routines.

All these parameters are then individually assessed for complexity.

The FPA functional units are shown in Fig:



FPAs Functional Units System

2. FP characterizes the complexity of the software system and hence can be used to depict the project time and the manpower requirement.

3. The effort required to develop the project depends on what the software does.

4. FP is programming language independent.

5. FP method is used for data processing systems, business systems like information systems.

6. The five parameters mentioned above are also known as information domain characteristics.

7. All the parameters mentioned above are assigned some weights that have been experimentally determined and are shown in Table

Weights of 5-FP Attributes

Measurement Parameter	Low	Average	High
1. Number of external inputs (EI)	7	10	15
2. Number of external outputs (EO)	5	7	10
3. Number of external inquiries (EQ)	3	4	6
4. Number of internal files (ILF)	4	5	7
5. Number of external interfaces (EIF)	3	4	6

The functional complexities are multiplied with the corresponding weights against each function, and the values are added up to determine the UFP (Unadjusted Function Point) of the subsystem.

Computing FPs

Measurement Parameter	Count		Weighing factor			
			Simple	Average	Complex	
1. Number of external inputs (EI)	—	*	3	4	6 =	—
2. Number of external Output (EO)	—	*	4	5	7 =	—
3. Number of external Inquiries (EQ)	—	*	3	4	6 =	—
4. Number of internal Files (ILF)	—	*	7	10	15 =	—
5. Number of external interfaces(EIF)	—	*	5	7	10 =	—
Count-total →						

Here that weighing factor will be simple, average, or complex for a measurement parameter type.

The Function Point (FP) is thus calculated with the following formula.

$$\mathbf{FP = Count\text{-}total * [0.65 + 0.01 * \sum(f_i)]}$$
$$\mathbf{= Count\text{-}total * CAF}$$

where Count-total is obtained from the above Table.

$$\mathbf{CAF = [0.65 + 0.01 * \sum(f_i)]}$$

and $\mathbf{\sum(f_i)}$ is the sum of all 14 questionnaires and show the complexity adjustment value/ factor-CAF (where i ranges from 1 to 14). Usually, a student is provided with the value of $\sum(f_i)$

Also note that $\mathbf{\sum(f_i)}$ ranges from 0 to 70, i.e.,

$$0 <= \sum(f_i) <= 70$$

and CAF ranges from 0.65 to 1.35 because

a. When $\mathbf{\sum(f_i)}$ = 0 then CAF = 0.65
b. When $\mathbf{\sum(f_i)}$ = 70 then CAF = 0.65 + (0.01 * 70) = 0.65 + 0.7 = 1.35

Based on the FP measure of software many other metrics can be computed:

a. Errors/FP
b. $/FP.

c. Defects/FP
d. Pages of documentation/FP
e. Errors/PM.
f. Productivity = FP/PM (effort is measured in person-months).
g. $/Page of Documentation.

Example: Compute the function point, productivity, documentation, cost per function for the following data:

1. Number of user inputs = 24
2. Number of user outputs = 46
3. Number of inquiries = 8
4. Number of files = 4
5. Number of external interfaces = 2
6. Effort = 36.9 p-m
7. Technical documents = 265 pages
8. User documents = 122 pages
9. Cost = $7744/ month

Various processing complexity factors are: 4, 1, 0, 3, 3, 5, 4, 4, 3, 3, 2, 2, 4, 5.

Solution:

Measurement Parameter	**Count**		**Weighing factor**
1. Number of external inputs (EI)	24	*	4 = 96
2. Number of external outputs (EO)	46	*	4 = 184
3. Number of external inquiries (EQ)	8	*	6 = 48
4. Number of internal files (ILF)	4	*	10 = 40
5. Number of external interfaces (EIF) Count-total →	2	*	5 = 10 378

So sum of all f_i ($i \leftarrow 1$ to 14) = 4 + 1 + 0 + 3 + 5 + 4 + 4 + 3 + 3 + 2 + 2 + 4 + 5 = 43

FP = Count-total * [0.65 + 0.01 *$\sum(f_i)$]
= 378 * [0.65 + 0.01 * 43]

= 378 * [0.65 + 0.43]
= 378 * 1.08 = 408

$$\text{Productivity} = \frac{\text{FP}}{\text{Effort}} = \frac{408}{36.9} = 11.1$$

Total pages of documentation = technical document + user document
= 265 + 122 = 387pages

Documentation = Pages of documentation/FP
= 387/408 = 0.94

$$\text{Cost per function} = \frac{\text{cost}}{\text{productivity}} = \frac{7744}{11.1} = \$700$$