UNIT-IV

Testing Strategies: A strategic approach to software testing, test strategies for conventional software, black-box and white-box testing, validation testing, system testing, the art of debugging.

Product metrics: Software quality, metrics for analysis model, metrics for design model, metrics for source code, metrics for testing, metrics for maintenance.

A strategic Approach for Software testing

- Software Testing
  - One of the important phases of software development
  - Testing is the process of execution of a program with the intention of finding errors
  - Involves 40% of total project cost
  - Testing Strategy
  - A road map that incorporates test planning, test case design, test execution and resultant data collection and execution
  - **Validation** refers to a different set of activities that ensures that the software is traceable to the customer requirements.
  - V&V encompasses a wide array of Software Quality Assurance
  - Perform Formal Technical reviews(FTR) to uncover errors during software development
  - Begin testing at component level and move outward to integration of entire component based system.
  - Adopt testing techniques relevant to stages of testing
  - Testing can be done by software developer and independent testing group ➢ Testing and debugging are different activities. Debugging follows testing ➢ Low level tests verifies small code segments.
  - High level tests validate major system functions against customer requirements

Testing Strategies for Conventional Software

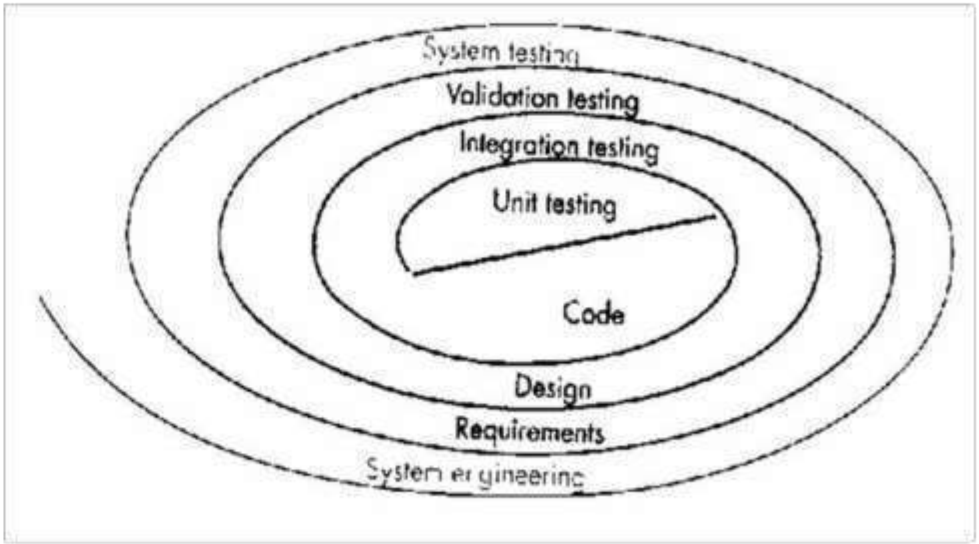
1)Unit Testing

2) Integration Testing

3)Validation Testing and

4)System Testing

Spiral Representation for Conventional Software



Criteria for completion of software testing

- No body is absolutely certain that software will not fail
- Based on statistical modeling and software reliability models
- 95 percent confidence(probability) that 1000 CPU hours of failure free operation is at least 0.995

Software Testing

- Two major categories of software testing
  - Black box testing
  - White box testing

Black box testing

Treats the system as black box whose behavior can be determined by studying its input and related output Not concerned with the internal structure of the program

Black Box Testing

- It focuses on the functional requirements of the software ie it enables the sw engineer to derive a set of input conditions that fully exercise all the functional requirements for that program.
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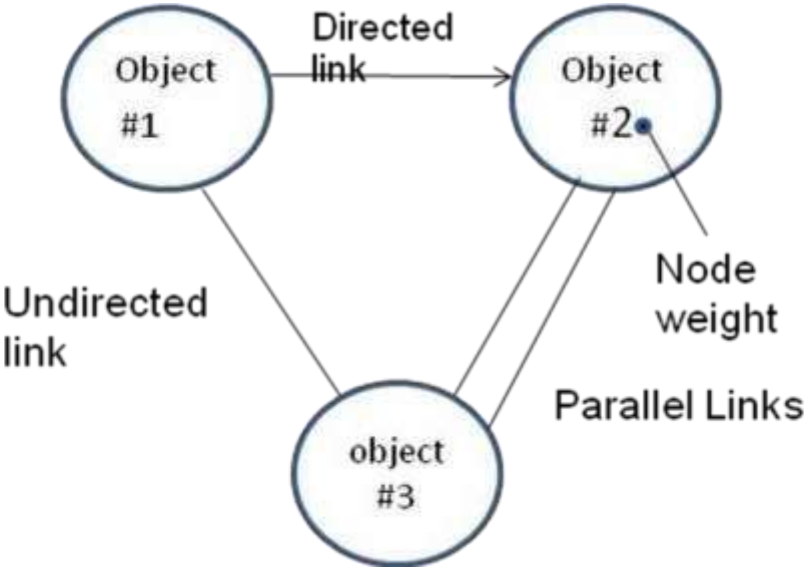
Concerned with functionality and implementation

1)Graph based testing method

2) Equivalence partitioning Graph

based testing

- Draw a graph of objects and relations
- Devise test cases t uncover the graph such that each object and its relationship exercised.



Equivalence partitioning

- Divides all possible inputs into classes such that there are a finite equivalence classes.
- Equivalence class

-- Set of objects that can be linked by relationship

- Reduces the cost of testing
- <u>Example</u>
- Input consists of 1 to 10
- Then classes are n<1,1<=n<=10,n>10
- Choose one valid class with value within the allowed range and two invalid classes where values are greater than maximum value and smaller than minimum value.

Boundary Value analysis

- Select input from equivalence classes such that the input lies at the edge of the equivalence classes
- Set of data lies on the edge or boundary of a class of input data or generates the data that lies at the boundary of a class of output data

<u>Example</u>

If 0.0<=x<=1.0

Then test cases (0.0,1.0) for valid input and (-0.1 and 1.1) for invalid input

Orthogonal array Testing

To problems in which input domain is relatively small but too large for exhaustive testing

Example

Three inputs A,B,C each having three values will require 27 test cases

L9 orthogonal testing will reduce the number of test case to 9 as shown below

A B C

1. 1 1

1 2 2

2. 3 3 3.

1 3 4. 2

3 5. 3 1

6. 1 3

7. 2 1

3 3 2

White Box testing

- Also called glass box testing
- Involves knowing the internal working of a program
- Guarantees that all independent paths will be exercised at least once.
- Exercises all logical decisions on their true and false sides
- Executes all loops
- Exercises all data structures for their validity
- White box testing techniques

1. Basis path testing
2. Control structure testing

Basis path testing

- Proposed by Tom McCabe
- Defines a basic set of execution paths based on logical complexity of a procedural design
- Guarantees to execute every statement in the program at least once
- Steps of Basis Path Testing
- Draw the flow graph from flow chart of the program
- Calculate the cyclomatic complexity of the resultant flow graph
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- Prepare test cases that will force execution of each path
- Three methods to compute Cyclomatic complexity number

- V(G)=E-N+2(E is number of edges, N is number of nodes V(G)=Number of regions
- V(G)= Number of predicates +1
- Control Structure testing
- Basis path testing is simple and effective
- It is not sufficient in itself
- Control structure broadens the basic test coverage and improves the quality of white box testing
- Condition Testing
- Data flow Testing
- Loop Testing
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Condition Testing

- --Exercise the logical conditions contained in a program module
- --Focuses on testing each condition in the program to ensure that it does contain errors
- --Simple condition
- E1<relation operator>E2
- --Compound condition
- simple condition<Boolean operator>simple condition

Data flow Testing

- Selects test paths according to the locations of definitions and use of variables in a program
- Aims to ensure that the definitions of variables and subsequent use is tested •
  First construct a definition-use graph from the control flow of a program

Loop Testing

- Focuses on the validity of loop constructs
- Four categories can be defined

1. Simple loops
2. Nested loops
3. Concatenated loops 4. Unstructured loops Testing of simple loops
   -- N is the maximum number of allowable passes through the loop

Skip the loop entirely
Only one pass through the loop Two
passes through the loop m passes through
the loop where m>N
N-1,N,N+1 passes the loop

Nested Loops

1. Start at the innermost loop. Set all other loops to maximum values
2. Conduct simple loop test for the innermost loop while holding the outer loops at their minimum iteration parameter.

3. Work outward conducting tests for the next loop but keeping all other loops at minimum. Concatenated loops

- Follow the approach defined for simple loops, if each of the loop is independent of other.
- If the loops are not independent, then follow the approach for the nested loops Unstructured Loops
- Redesign the program to avoid unstructured loops Validation Testing
- It succeeds when the software functions in a manner that can be reasonably expected by the customer.

1) Validation Test Criteria

2)Configuration Review

3)Alpha And Beta Testing

System Testing

- Its primary purpose is to test the complete software.

1)Recovery Testing

2) Security Testing

3Stress Testing and

4)Performance Testing The Art

of Debugging

- Debugging occurs as a consequences of successful testing.
- Debugging Stratergies 1)Brute Force Method.

2)Back Tracking

3)Cause Elimination and

4)Automated debugging

- Brute force

-- Most common and least efficient

-- Applied when all else fails --
Memory dumps are taken

-- Tries to find the cause from the load of information

- Back tracking

-- Common debugging approach

-- Useful for small programs

-- Beginning at the system where the symptom has been uncovered, the source code traced backward until the site of the cause is found.

- Cause Elimination

-- Based on the concept of Binary partitioning

-- A list of all possible causes is developed and tests are conducted to eliminate each

Software Quality

- Conformance to explicitly stated functional and performance requirements, explicitly documented development standards, and implicit characteristics that are expected of all professionally developed software.
- Factors that affect software quality can be categorized in two broad groups:

1) Factors that can be directly measured (e.g. defects uncovered during testing)
2) Factors that can be measured only indirectly (e.g. usability or maintainability)

- McCall's quality factors

1) Product operation
    a. Correctness
    b. Reliability
    c. Efficiency
    d. Integrity
    e. Usability
2) Product Revision
    a. Maintainability
    b. Flexibility
    c. Testability

3. Product Transition
    a. Portability
    b. Reusability
    c. Interoperability

ISO 9126 Quality Factors

1.Functionality

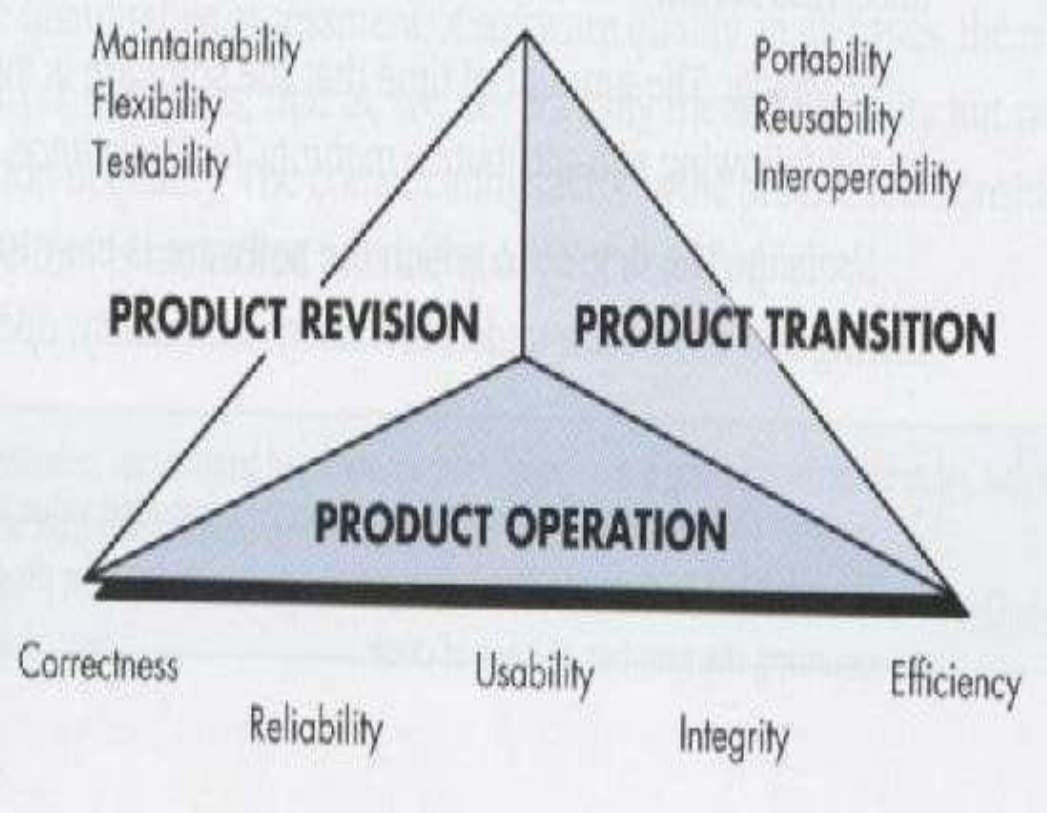
2. Reliability

3.Usability

4.Efficiency

5.Maintainability

6.Portability



Product metrics

- Product metrics for computer software helps us to assess quality.
- Measure

-- Provides a quantitative indication of the extent, amount, dimension, capacity or size of some attribute of a product or process

- Metric(IEEE 93 definition)

-- A quantitative measure of the degree to which a system, component or process possess a given attribute

- Indicator

-- A metric or a combination of metrics that provide insight into the software process, a software project or a product itself

Product Metrics for analysis,Design,Test and maintenance

- **<u>Product metrics for the Analysis model</u>**

❖ Function point Metric

- First proposed by Albrecht
- Measures the functionality delivered by the system
- FP computed from the following parameters

1) Number of external inputs(EIS) 2)
Number external outputs(EOS)
3) Number of external Inquiries(EQS)
4) Number of Internal Logical Files(ILF)
5) Number of external interface files(EIFS)

Each parameter is classified as simple, average or complex and weights are assigned as follows

• Information Domain	Count	Simple	avg	Complex
EIS	3		4	6
EOS	4		5	7
EQS	3		4	6
ILFS	7		10	15
EIFS	5		7	10

FP=Count total *[0.65+0.01*E(Fi)]

Metrics for Design Model

- DSQI(Design Structure Quality Index)
- US air force has designed the DSQI
- Compute s1 to s7 from data and architectural design
- S1:Total number of modules
- S2:Number of modules whose correct function depends on the data input
- S3:Number of modules whose function depends on prior processing
- S4:Number of data base items
- S5:Number of unique database items
- S6: Number of database segments
- S7:Number of modules with single entry and exit
- Calculate D1 to D6 from s1 to s7 as follows:
- D1=1 if standard design is followed otherwise D1=0
- D2(module independence)=(1-(s2/s1))
- D3(module not depending on prior processing)=(1-(s3/s1))
- D4(Data base size)=(1-(s5/s4))
- D5(Database compartmentalization)=(1-(s6/s4)
- D6(Module entry/exit characteristics)=(1-(s7/s1))
- DSQI=sigma of WiDi
- i=1 to 6,Wi is weight assigned to Di
- If sigma of wi is 1 then all weights are equal to 0.167
- DSQI of present design be compared with past DSQI. If DSQI is significantly lower than the average, further design work and review are indicated

METRIC FOR SOURCE CODE

- HSS(Halstead Software science)
- Primitive measure that may be derived after the code is generated or estimated once design is complete
- n_1 = the number of distinct operators that appear in a program • n_2 = the number of distinct operands that appear in a program • N_1 = the total number of operator occurrences.
- N_2 = the total number of operand occurrence.
- Overall program length N can be computed:
- $N = n_1 \log2\ n_1 + n_2 \log2\ n_2$ • $V = N \log_2 (n_1 + n_2)$

METRIC FOR TESTING

- n_1 = the number of distinct operators that appear in a program • n_2 = the number of distinct operands that appear in a program • N_1 = the total number of operator occurrences.
- N_2 = the total number of operand occurrence.
- Program Level and Effort
- PL = $1/[(n_1 / 2) \times (N_2 / n_2 l)]$
- e = V/PL
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METRICS FOR MAINTENANCE

- M_t = the number of modules in the current release
- F_c = the number of modules in the current release that have been changed • F_a = the number of modules in the current release that have been added.
- F_d = the number of modules from the preceding release that were deleted in the current release
- The Software Maturity Index, SMI, is defined as:
- SMI = [Mt – (Fc + Fa + Fd)/ Mt]