UNIT V SOFTWARE TESTING & SCM

Software Testing Fundamentals – White Box Testing - Black-Box Testing. Unit Testing-Integration Testing-System Testing-User Acceptance Testing - Agile testing principles- testing methodologies-Agile testing quadrants – Scrum testing - Software Configuration Management - The SCM Repository - The SCM Process.

The goal of testing is to find errors, and a good test is one that has a high probability of finding an error. Set of characteristics that achieve the goal of finding the most errors with a minimum of effort.

Testability. James Bach1 provides the following definition for testability: "*Software testability* is simply how easily [a computer program] can be tested." The following characteristics lead to testable software.

Operability. "The better it works, the more efficiently it can be tested." If a system is designed and implemented with quality in mind, relatively few bugs will block the execution of tests, allowing testing to progress without fits and starts.

Observability. "What you see is what you test." Inputs provided as part of testing produce distinct outputs. System states and variables are visible or queriable during execution. Incorrect output is easily identified. Internal errors are automatically detected and reported. Source code is accessible.

Controllability. "The better we can control the software, the more the testing can be automated and optimized." All possible outputs can be generated through some combination of input, and I/O formats are consistent and structured.

Decomposability. "By controlling the scope of testing, we can more quickly isolate problems and perform smarter retesting." The software system is built from independent modules that can be tested independently.

Simplicity. "The less there is to test, the more quickly we can test it." The program should exhibit *functional simplicity* (e.g., the feature set is the minimum necessary to meet requirements); *structural simplicity* (e.g., architecture is modularized to limit the propagation of faults), and *code simplicity* (e.g., a coding standard is adopted for ease of inspection and maintenance).

Stability. "The fewer the changes, the fewer the disruptions to testing." Changes to the software are infrequent, controlled when they do occur, and do not invalidate existing tests. The software recovers well from failures.

Understandability. "The more information we have, the smarter we will test." The architectural design and the dependencies between internal, external, and shared components are well understood.

Test Characteristics.

A good test has a high probability of finding an error.

A good test is not redundant.
A good test should be “best of breed”
A good test should be neither too simple nor too complex.

White-box testing :

White-box testing, sometimes called *glass-box testing,* is a test-case design philosophy that uses the control structure described as part of component-level design to derive test cases. Using white-box testing methods, you can derive test cases that (1) guarantee that all independent paths within a module have been exercised at least once, (2) exercise all logical decisions on their true and false sides, (3) execute all loops at their boundaries and within their operational bounds, and (4) exercise internal data structures to ensure their validity.

Black-box testing :

Black-box testing, also called behavioral testing, focuses on the functional requirements of the software. That is, black-box testing techniques enable you to derive sets of input conditions that will fully exercise all functional requirements for a program.
Black-box testing is not an alternative to white-box techniques. Rather, it is a complementary approach that is likely to uncover a different class of errors than whitebox methods.
Black-box testing attempts to find errors in the following categories: (1) incorrect or missing functions, (2) interface errors, (3) errors in data structures or external database access,
(4) behavior or performance errors, and (5) initialization and termination errors.

Unlike white-box testing, which is performed early in the testing process, blackbox testing tends to be applied during later stages of testing (see Chapter 17). Because black-box testing purposely disregards control structure, attention is focused on the information domain.

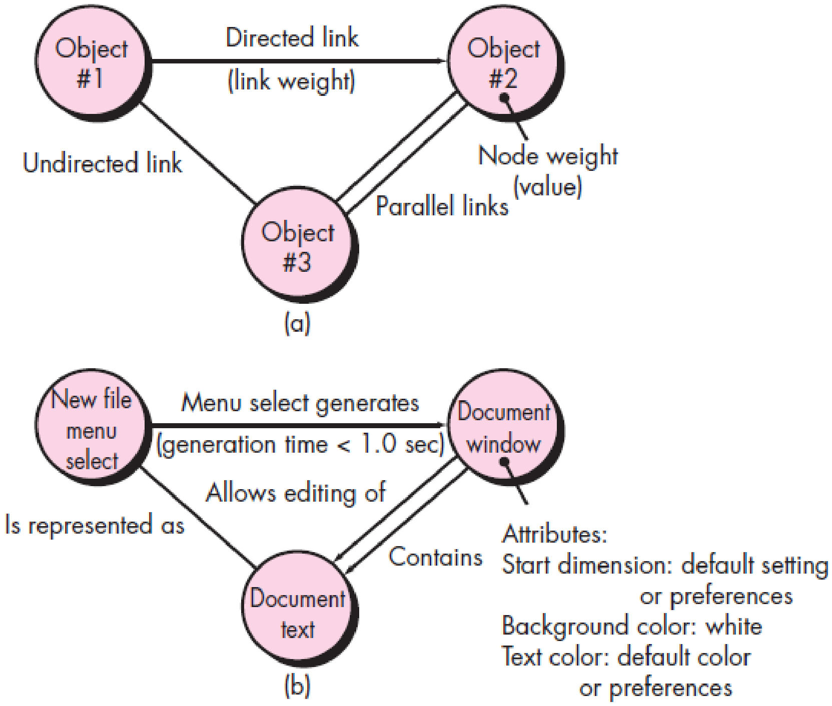
Tests are designed to answer the following questions:
- How is functional validity tested?
- How are system behavior and performance tested?
- What classes of input will make good test cases?
- Is the system particularly sensitive to certain input values?
- How are the boundaries of a data class isolated?
- What data rates and data volume can the system tolerate?
- What effect will specific combinations of data have on system operation?

1. Graph-Based Testing Methods :

The first step in black-box testing is to understand the objects5 that are modeled in software and the relationships that connect these objects. Once this has been accomplished, the next step is to define a series of tests that verify “all objects have the expected relationship to one another”
Stated in another way, software testing begins by creating a graph of important objects and their relationships and then devising a series of tests that will cover the graph so that each object and relationship is exercised and errors are uncovered.

To accomplish these steps, you begin by creating a *graph*—a collection of *nodes* that represent objects, *links* that represent the relationships between objects, *node weights* that describe the properties of a node (e.g., a specific data value or state behavior), and *link weights* that describe some characteristic of a link.

Object #1 _ **newFile** (menu selection)
Object #2 _ **documentWindow**
Object #3 _ **documentText**



Behavioral testing methods that can make use of graphs:

Transaction flow modeling. The nodes represent steps in some transaction (e.g., the steps required to make an airline reservation using an online service), and the links represent the logical connection between steps (e.g., **flightInformationInput** is followed by *validationAvailabilityProcessing*). The data flow diagram (Chapter 7) can be used to assist in creating graphs of this type.

Finite state modeling. The nodes represent different user-observable states of the software (e.g., each of the "screens" that appear as an order entry clerk takes a phone order), and the links represent the transitions that occur to move from state to state (e.g., **orderInformation** is verified during *inventoryAvailabilityLook- up* and is followed by **customerBillingInformation** input). The state diagram (Chapter 7) can be used to assist in creating graphs of this type.

Data flow modeling. The nodes are data objects, and the links are the transformations that occur to translate one data object into another. For example, the node FICA tax withheld (**FTW**) is computed from gross wages (**GW**) using the relationship, **FTW _ 0.62 _ GW.**

Timing modeling. The nodes are program objects, and the links are the sequential connections between those objects. Link weights are used to specify the required execution times as the program executes.

2. Equivalence Partitioning

Equivalence partitioning is a black-box testing method that divides the input domain of a program into classes of data from which test cases can be derived. An ideal test case single-handedly uncovers a class of errors (e.g., incorrect processing of all character data) that might otherwise require many test cases to be executed before the general error is observed.

Test-case design for equivalence partitioning is based on an evaluation of *equivalence classes* for an input condition. Using concepts introduced in the preceding section, if a set of objects can be linked by relationships that are symmetric, transitive, and reflexive, an equivalence class is present [Bei95]. An equivalence class represents a set of valid or invalid states for input conditions. Typically, an input condition is either a specific numeric value, a range of values, a set of related values, or a Boolean condition.

Equivalence classes may be defined according to the following guidelines:

1. If an input condition specifies a range, one valid and two invalid equivalence classes are defined.
2. If an input condition requires a specific value, one valid and two invalid equivalence classes are defined.
3. If an input condition specifies a member of a set, one valid and one invalid equivalence class are defined.
4. If an input condition is Boolean, one valid and one invalid class are defined.

By applying the guidelines for the derivation of equivalence classes, test cases for each input domain data item can be developed and executed. Test cases are selected so that the largest number of attributes of an equivalence class are exercised at once.

3. Boundary Value Analysis

A greater number of errors occurs at the boundaries of the input domain rather than in the "center." It is for this reason that *boundary value analysis* (BVA) has been developed as a testing technique. Boundary value analysis leads to a selection of test cases that exercise bounding values.

Boundary value analysis is a test-case design technique that complements equivalence partitioning. Rather than selecting any element of an equivalence class, BVA leads to the selection of test cases at the "edges" of the class. Rather than focusing solely on input conditions, BVA derives test cases from the output domain as well [Mye79].

Guidelines for BVA are similar in many respects to those provided for equivalence partitioning:

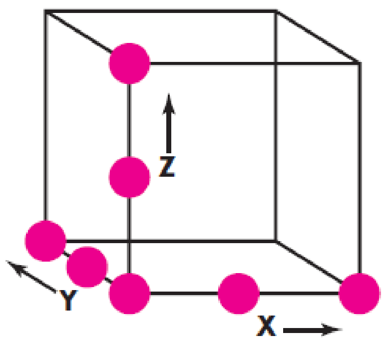
1. If an input condition specifies a range bounded by values *a* and *b*, test cases should be designed with values *a* and *b* and just above and just below *a* and *b*.
2. If an input condition specifies a number of values, test cases should be developed that exercise the minimum and maximum numbers. Values just above and below minimum and maximum are also tested.
3. Apply guidelines 1 and 2 to output conditions. For example, assume that a temperature versus pressure table is required as output from an engineering analysis program. Test cases should be designed to create an output report that produces the maximum (and minimum) allowable number of table entries.
4. If internal program data structures have prescribed boundaries (e.g., a table has a defined limit of 100 entries), be certain to design a test case to exercise the data structure at its boundary.

4. Orthogonal Array Testing

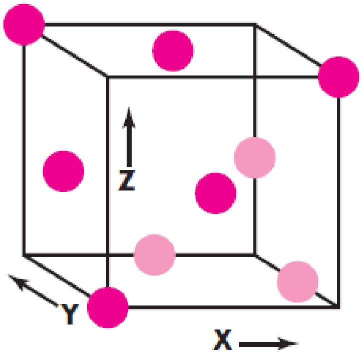
There are many applications in which the input domain is relatively limited. That is, the number of input parameters is small and the values that each of the parameters may take are clearly bounded. When these numbers are very small (e.g., three input parameters taking on three discrete values each), it is possible to consider every input permutation and exhaustively test the input domain. However, as the number of input values grows and the number of discrete values for each data item increases, exhaustive testing becomes impractical or impossible.

Orthogonal array testing can be applied to problems in which the input domain is relatively small but too large to accommodate exhaustive testing. The orthogonalarray testing method is particularly useful in finding *region faults*—an error category associated with faulty logic within a software component.

To illustrate the difference between orthogonal array testing and more conventional "one input item at a time" approaches, consider a system that has three input items, *X, Y,* and *Z.* Each of these input items has three discrete values associated with it. There are 33 _ 27 possible test cases. Phadke [Pha97] suggests a geometric view of the possible test cases associated with X, Y, and Z illustrated in Figure 18.9. Referring to the figure, one input item at a time may be varied in sequence along each input axis. This results in relatively limited coverage of the input domain (represented by the left-hand cube in the figure). When orthogonal array testing occurs, an L9 *orthogonal array* of test cases is created. The L9 orthogonal array has a "balancing property" [Pha97]. That is, test cases (represented by dark dots in the figure) are "dispersed uniformly throughout the test domain," as illustrated in the right-hand cube in Figure. Test coverage across the input domain is more complete.

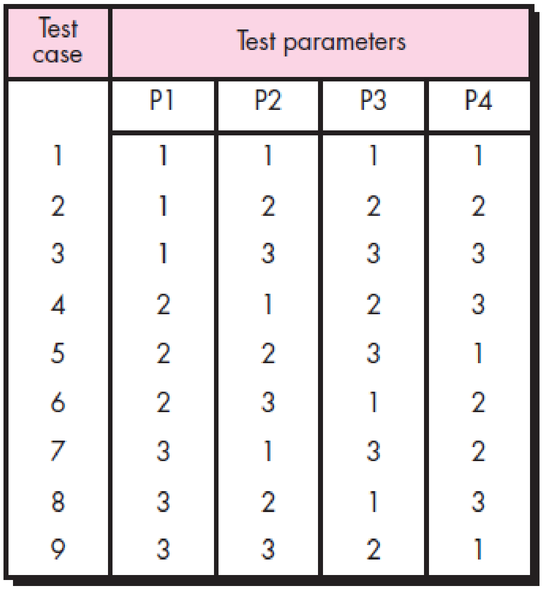


One input item at a time



L9 orthogonal array

To illustrate the use of the L9 orthogonal array, consider the *send* function for a fax application. Four parameters, P1, P2, P3, and P4, are passed to the *send* function.
Each takes on three discrete values. For example, P1 takes on values:
P1 _ 1, send it now
P1 _ 2, send it one hour later
P1 _ 3, send it after midnight
P2, P3, and P4 would also take on values of 1, 2, and 3, signifying other send functions.
If a "one input item at a time" testing strategy were chosen, the following sequence of tests (P1, P2, P3, P4) would be specified: (1, 1, 1, 1), (2, 1, 1, 1), (3, 1, 1, 1), (1, 2, 1, 1), (1, 3, 1, 1), (1, 1, 2, 1), (1, 1, 3, 1), (1, 1, 1, 2), and (1, 1, 1, 3).



Test case	Test parameters			
	P1	P2	P3	P4
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

An L9 orthogonal array

The result of tests using the L9 orthogonal array in the following manner:

Detect and isolate all single mode faults. A single mode fault is a consistent problem with any level of any single parameter. For example, if all test cases of factor P1 _ 1 cause an error condition, it is a single mode failure. In this example tests 1, 2 and 3 [Figure 18.10] will show errors. By analyzing the information about which tests show errors, one can identify which parameter values cause the fault. In this example, by noting that tests 1, 2, and 3 cause an error, one can isolate [logical processing associated with “send it now” (P1 _ 1)] as the source of the error. Such an isolation of fault is important to fix the fault.

Detect all double mode faults. If there exists a consistent problem when specific levels of two parameters occur together, it is called a *double mode fault.* Indeed, a double mode fault is an indication of pairwise incompatibility or harmful interactions between two test parameters.

Multimode faults. Orthogonal arrays [of the type shown] can assure the detection of only single and double mode faults. However, many multimode faults are also detected by these tests.