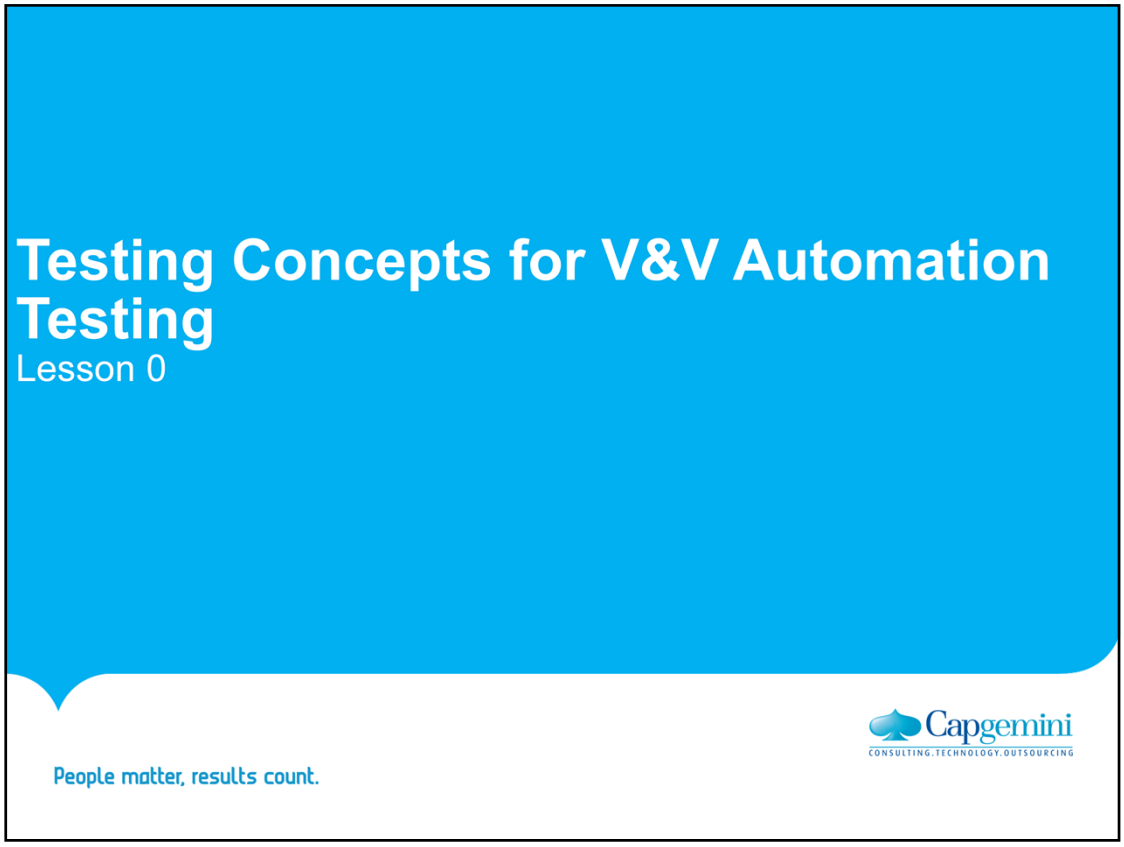
Testing Concepts for V&V Automation Testing
Lesson 0
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People matter, results count.

Document History

Date	Course Version No.	Software Version No.	Developer / SME	Reviewer(s)	Approver	Change Record Remarks
	1.0	MS Office 2003				Content Creation
May-2009	1.0	MS Office 2007	Priya Rane			Material Revamp
June-2011	1.1	MS Office 2007	Hema G.			Material Revamp
April-2014	2.0	MS Office 2010	Dayanand Patil	Samir Attar	Shilpa Bhosle	Material Revamp
Dec-2015	2.1	MS Office 2010	Shilpa Bhosle	Samir Attar	Shilpa Bhosle	Customized for V&V – Automation Testing LoT

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Course Goals and Non Goals

- Course Goals
  - At the end of this program, participants gain an understanding of how to create effective test cases using the different testing techniques to get a good test coverage of a software application.
- Course Non Goals
  - This course does not cover automation process of testing.

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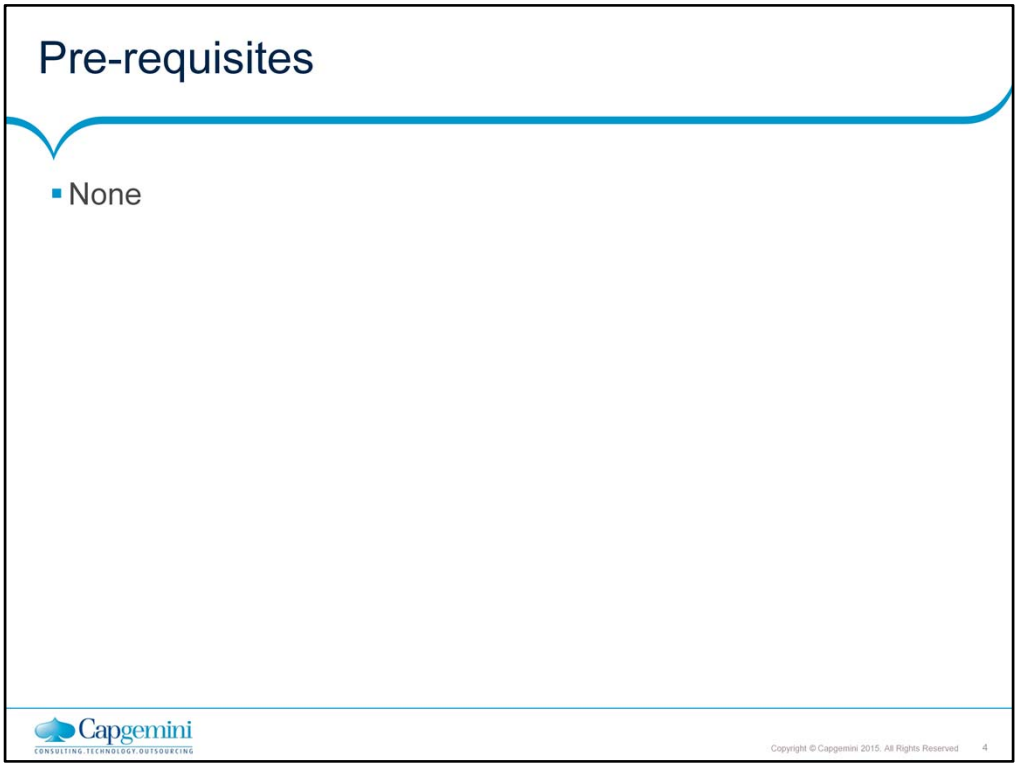
Pre-requisites
None
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Intended Audience

- Test Engineers, Software Engineers and Senior Software Engineers.

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Day Wise Schedule

- Day 1
  - Lesson 1: Introduction to Software Testing
  - Lesson 2: Types of Testing Techniques & Test Case Design
- Day 2
  - Lesson 2: Types of Testing Techniques & Test Case Design (Cont.)
  - Lesson 3: Types of System Testing
- Day 3
  - Lesson 3: Types of System Testing (Cont.)
  - Lesson 4: Test Case Execution / Testing Metrics

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References

- Student material:
  - Class Book (presentation slides with notes)
  - Lab book
- Book:
  - Testing Computer Software – Cem Kaner
  - Software Testing in the Real World – Edward Kit
  - Effective methods for Software testing – William E. Perry
  - Software Engineering -A Practitioner's Approach – Roger S. Pressman
  - Software Testing Techniques – Boris Beizer
- Web-site:
  - http://www.softwaretesting.org
  - http://www.onestoptesting.com/introduction/

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Next Step Courses

- None

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Testing Concepts for V&V Automation Testing

Lesson 1: Introduction to Software Testing

Lesson Objectives

- To understand the following topics:
  - Testing Overview
  - What is Testing
  - Why testing
  - How testing
  - Testing principles
  - Objective of testing
  - Exhaustive testing
  - Limitations of software Testing
  - Psychology of testing
  - Test case
  - Test case formats
  - Other related terminologies

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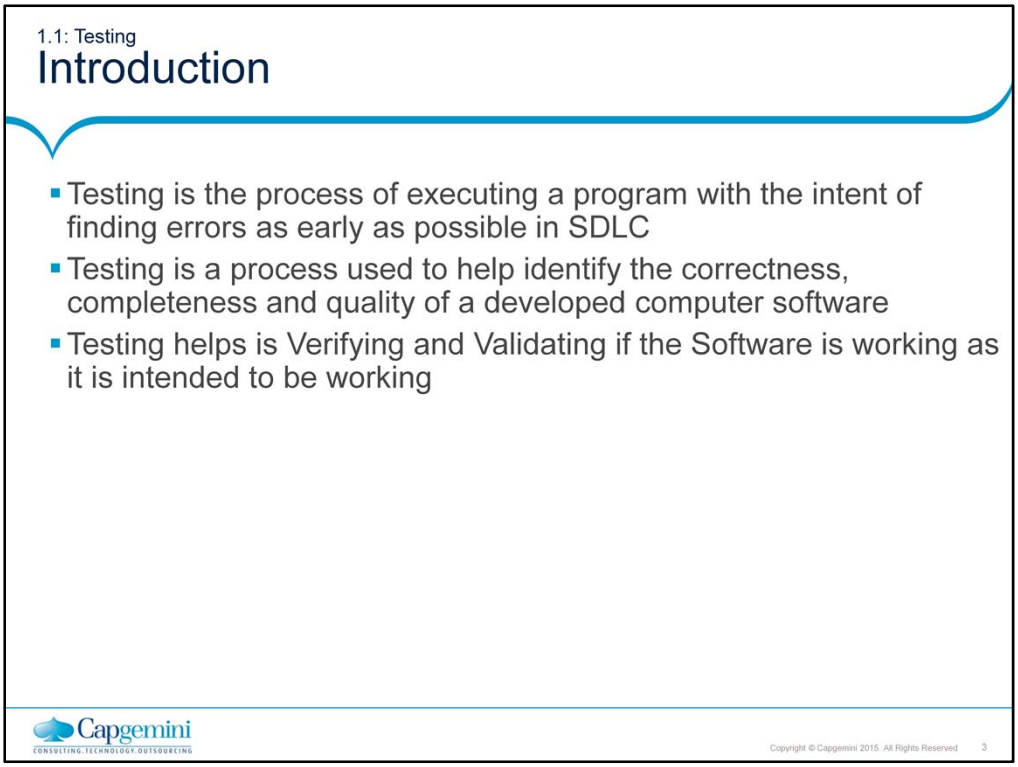
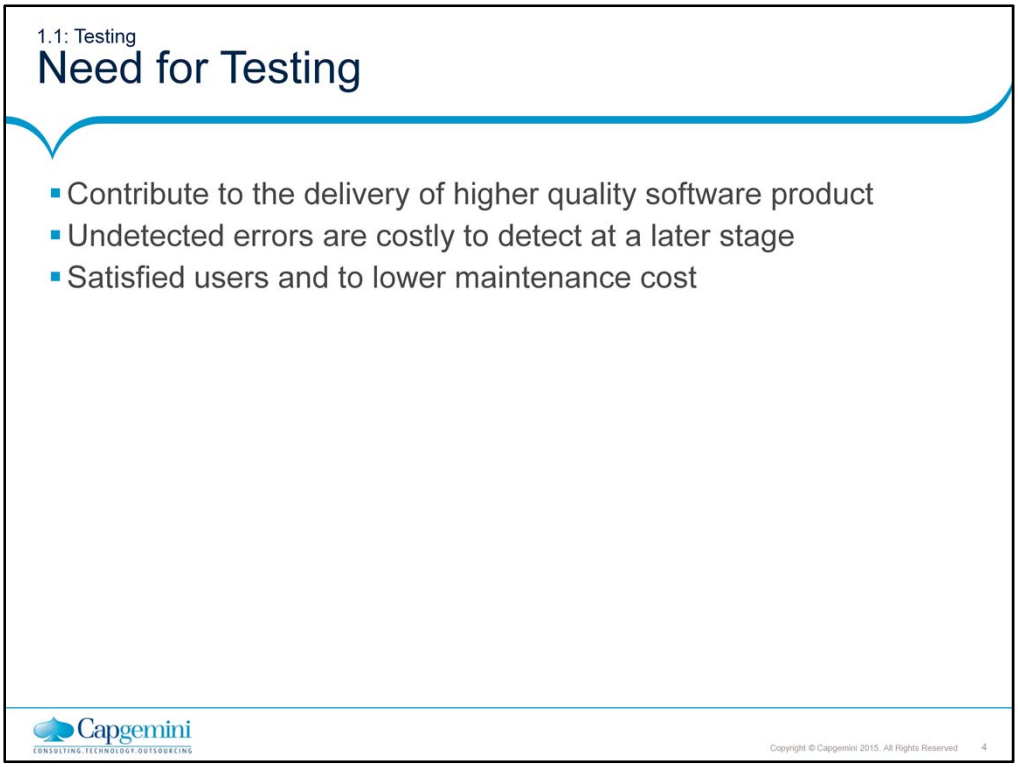


What is software testing?

Exercising (analyzing) a system or component with

- defined inputs
- capturing monitored outputs
- comparing outputs with specified or intended
- Requirements

To maximize the number of errors found by a finite no of test cases.
Testing is successful if you can prove that the product does what it should not do and does not do what it should do.

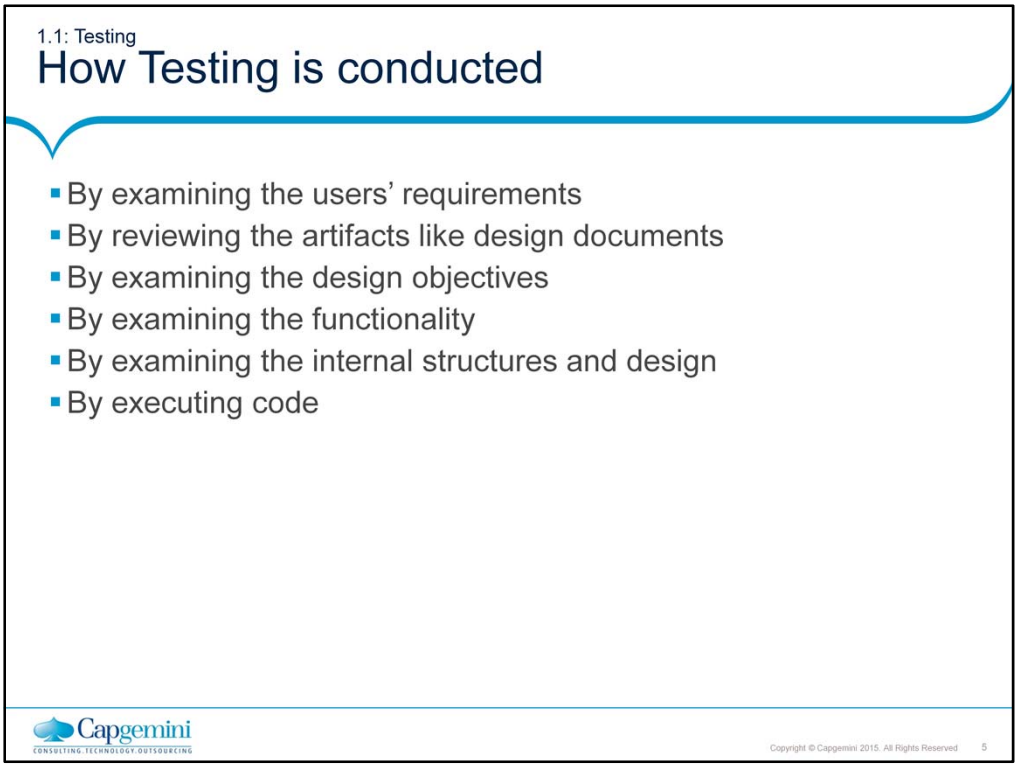


Why is testing becoming such a crucial activity?

1. Because applications are becoming very complex with n-tiers in an
2. application.
3. When one tests a program one adds value to it through improved quality and reliability.
4. If not tested it can cause an unpleasant navigational error in case of a browsing applications or death or injury in case of safety critical applications.
5. End customers are becoming more demanding & conscious about quality

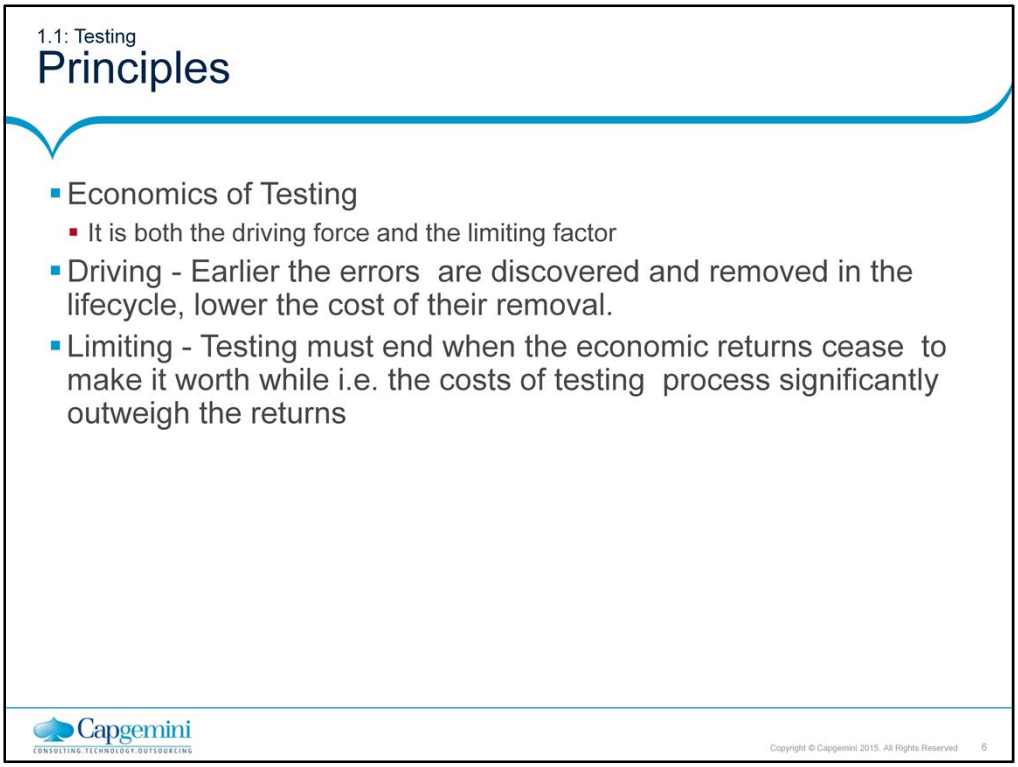
Why are company's outsourcing the testing phase?

It is being realized that testing is an extremely important phase, customers today are conscious of quality as they need to be more competitive in the market.
It is being realized that the best people to test an application are the ones who have not developed the application. The testers would have the approach of a user and have an unbiased mind.



How testing is conducted?

Testing is conducted with the help of users requirements, design documents, functionality, internal structures & design, by executing code.



Although testing is itself an expensive activity, the cost of not testing is potentially much higher. The most damaging errors are those which are not discovered during the testing process and therefore remain when the system goes live.

Limiting - It is infeasible to test exhaustively all but the most simple or the most vital of s/w.

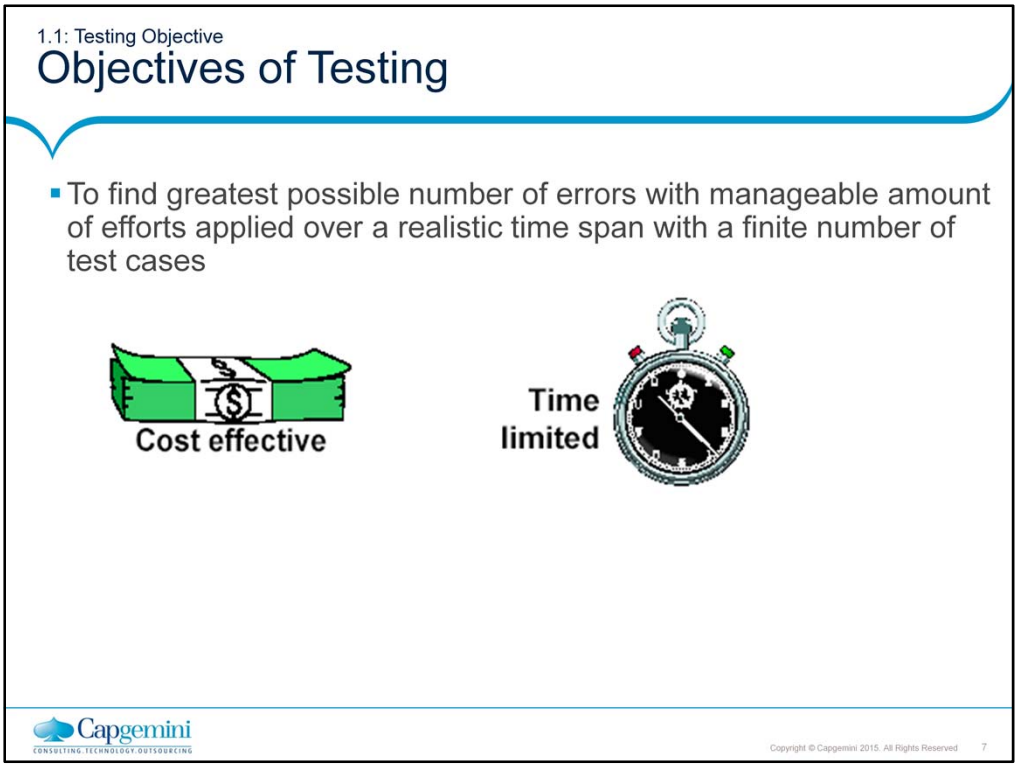
Here we discuss how exhaustive testing is impossible to achieve.

Consider the following example:

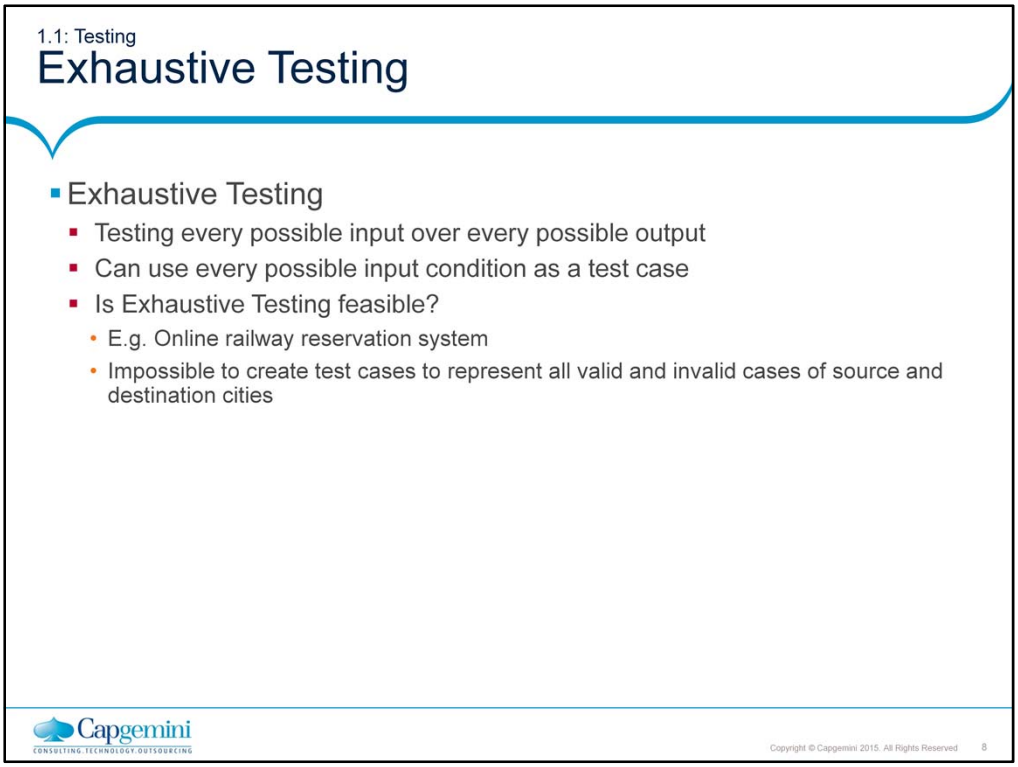
Exhaustive input testing (Black box)

Lets assume that we have written a function say ax2 + bx +c=0
Assume 16 bit numbers

So each input is 2power16
And so total test cases is 2 power16*2power16*2power16=2power48 test cases which is impractical.



We have found that we do not hesitate to change and improve well-tested code, whereas we fear changing untested code.



Exhaustive Path testing (white box)

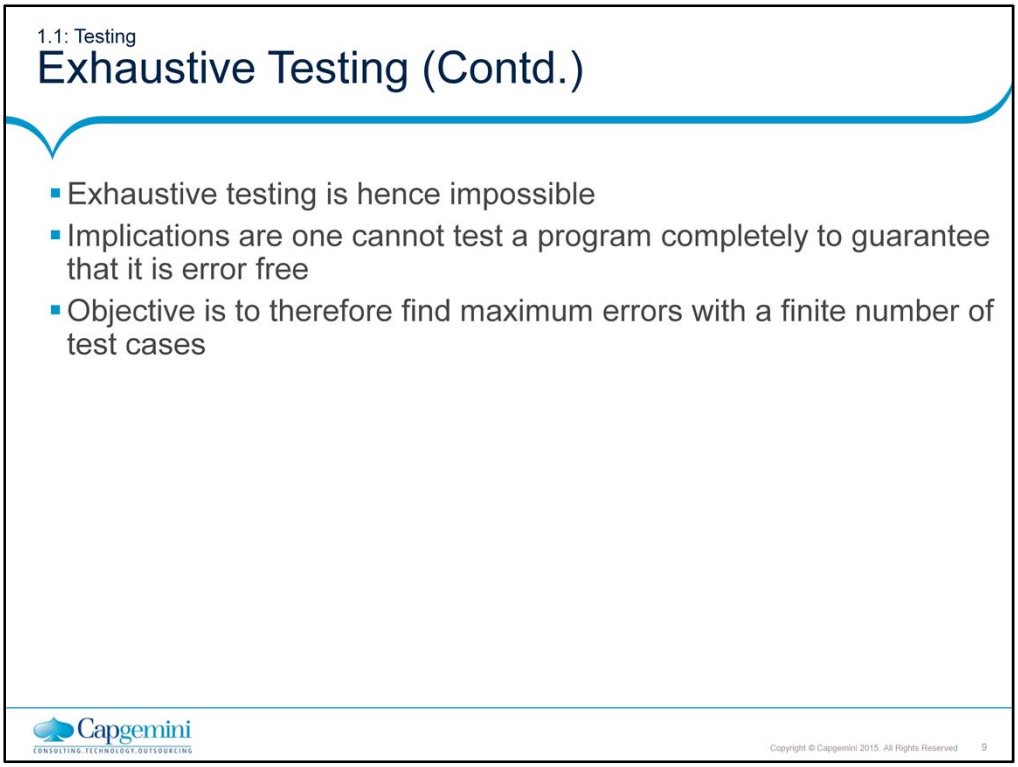
Even if all the paths are covered we can still not say that the program is correct for the reasons that the program may have missed some of the requirements the program may have some missed paths.

Since both exhaustive input and exhaustive path testing are not useful strategies we need to combine the elements of both to arrive at a reasonable testing strategy which we will be discussing in the next chapter.

For E.g. COBOL Compiler

• Impossible to create test cases to represent all valid cases.
• Impossible to create test cases for all invalid COBOL Programs

The compiler has to be tested to see that it does not do what it is not supposed to do E.g. to successfully compile a syntactically incorrect program


1.1: Testing
Exhaustive Testing (Contd.)
Exhaustive testing is hence impossible
Implications are one cannot test a program completely to guarantee that it is error free
Objective is to therefore find maximum errors with a finite number of test cases
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1.1: Testing

Limitations of Software Testing

- Even if we could generate the input, run the tests, and evaluate the output, we would not detect all faults
- Correctness is not checked
  - The programmer may have misinterpreted the specs, the specs may have misinterpreted the requirements
- There is no way to find missing paths due to coding errors

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1.1: Testing

Psychology of Testing

- Test Engineers pursue defects not people
- Don’t assume that no error(s) will be found
- Test for Valid and Expected as well as Invalid and Unexpected
- The probability of the existence of more errors in a section of a program is proportional to the number of errors already found in that section
- Testing is extremely creative and intellectually challenging

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Testing is in a way a destructive process and a successful test case is one that brings out an error in the program . Detection of an error/failure is a success as far as a test engineer is concerned.

Read the following example:

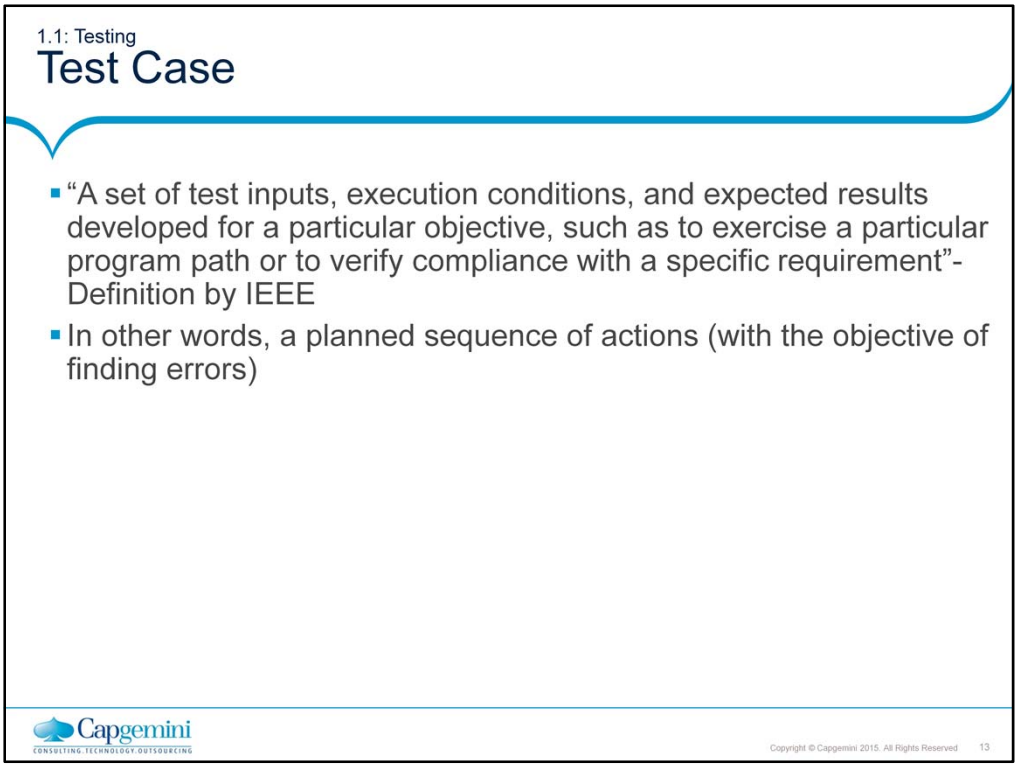
A doctor asks a patient to get all the laboratory tests and if the test could not locate any problem then it is not a successful test as it did not find out the cause of the patient's problems and only wasted the laboratory fees and efforts in getting the tests done.
The psychology of people towards treating testing as the process of demonstrating that errors are not present and treating testing as the process of uncovering errors needs be discussed here

Retesting is required when errors are found. So the test cases need to be documented and retained. This gives us indication on where the errors are found most and make more investments and investigation on those areas.
Writing automated tests is harder than writing the code itself, in many cases. The most expert programmers are the best testers. When faced with seemingly mundane coding tasks, coming up with creative tests provides an intellectual challenge that expert programmers thrive on.

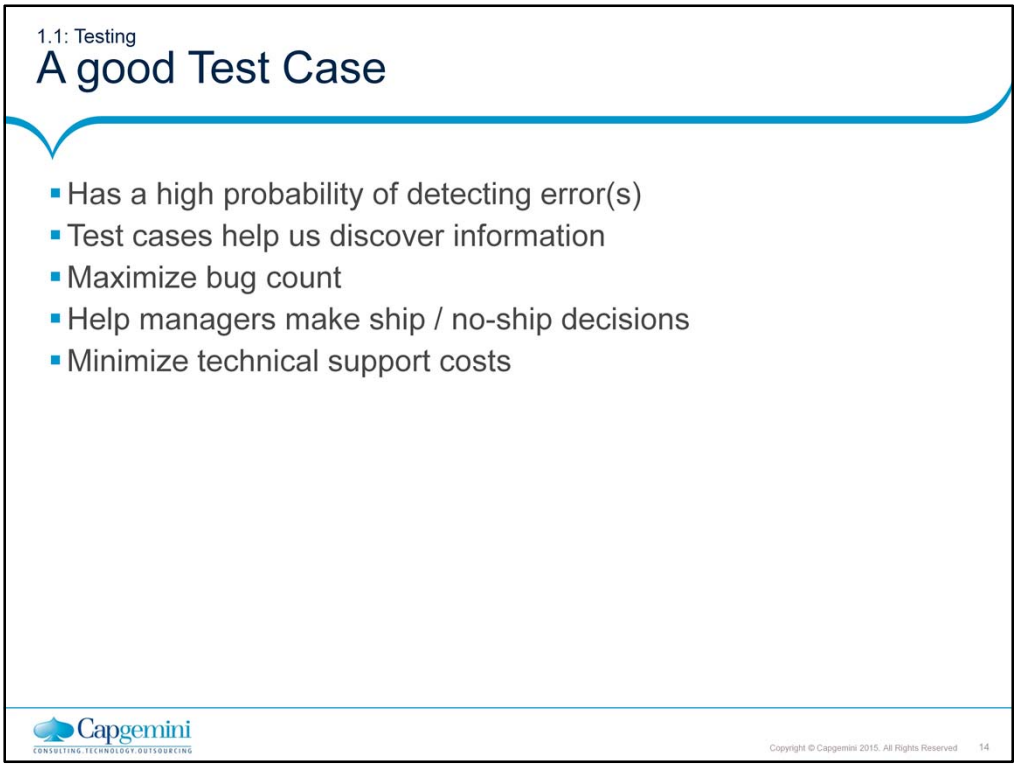
Beginners typically need expert assistance when writing tests. This is where pair-programming helps, because experts work side-by-side with beginners as they learn the art of testing.

Just like coding is an art, testing is an art.
In many organizations, testing is relegated to the least-experienced programmers. We often encounter the misconception that testing consists of people completing written checklists as they manually execute the application. This approach is completely unscalable, because it takes longer and longer for humans (monkeys?) to test every feature as the application grows.

Modern OO languages like Java are complex, particularly when it comes to dependencies between classes. One change can easily introduce bugs in seemingly unrelated classes. Gone are the days when each character-based screen is a standalone program. OO apps are far more complex and demand automated tests.



A Test case is a planned sequence of actions.



Information Objectives:

So what are we trying to learn or achieve when we run tests? Here are some examples:

Find defects. This is the classic objective of testing. A test is run in order to trigger failures that expose defects. Generally, we look for defects in all interesting parts of the product.

Maximize bug count. The distinction between this and "find defects" is that total number of bugs is more important than coverage. We might focus narrowly, on only a few high-risk features, if this is the way to find the most bugs in the time available.

Help managers make ship / no-ship decisions. Managers are typically concerned with risk in the field. They want to know about coverage (maybe not the simplistic code coverage statistics, but some indicators of how much of the product has been addressed and how much is left), and how important the known problems are. Problems that appear significant on paper but will not lead to customer dissatisfaction are probably not relevant to the ship decision.

Minimize technical support costs. Working in conjunction with a technical support or help desk group, the test team identifies the issues that lead to calls for support. These are often peripherally related to the product under test--for example, getting the product to work with a specific printer or to import data successfully from a third party database might prevent more calls than a low-frequency, data-corrupting crash.

Assess conformance to specification. Any claim made in the specification is checked. Program characteristics not addressed in the specification are not (as part of *this* objective) checked.

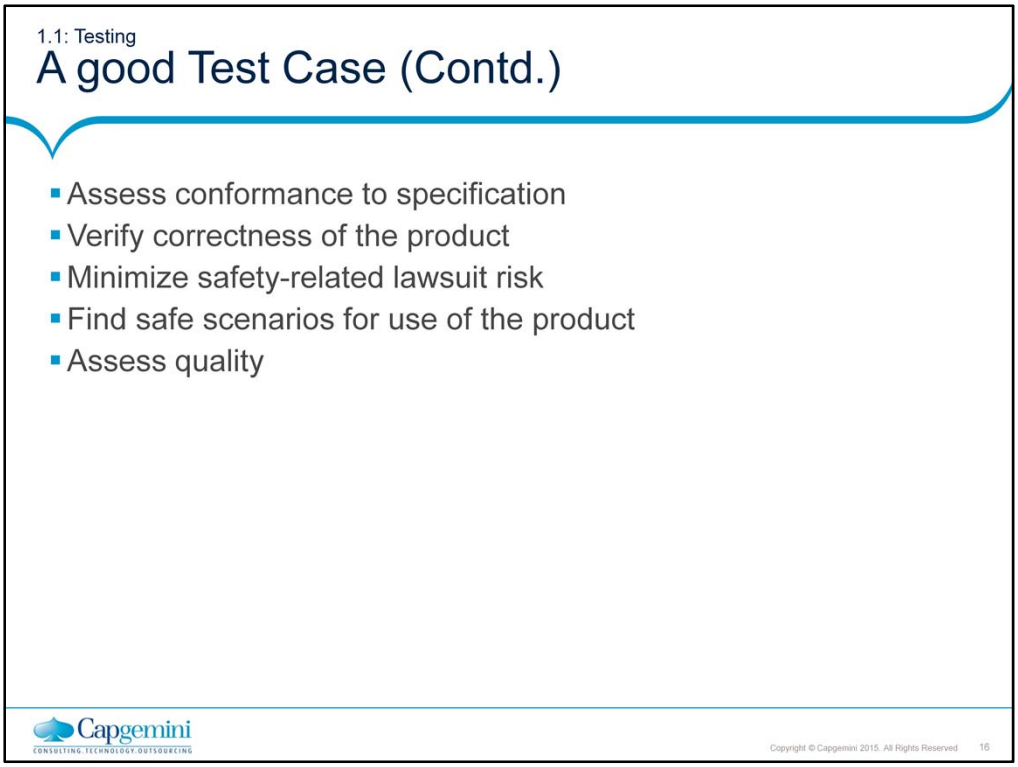
Conform to regulations. If a regulation specifies a certain type of coverage (such as, at least one test for every claim made about the product), the test group creates the appropriate tests. If the regulation specifies a style for the specifications or other documentation, the test group probably checks the style. In general, the test group is focusing on anything covered by regulation and (in the context of *this objective*) nothing that is not covered by regulation.

Minimize safety-related lawsuit risk. Any error that could lead to an accident or injury is of primary interest. Errors that lead to loss of time or data or corrupt data, but that don't carry a risk of injury or damage to physical things are out of scope.

Find safe scenarios for use of the product (find ways to get it to work, in spite of the bugs). Sometimes, all that you're looking for is one way to do a task that will consistently work--one set of instructions that someone else can follow that will reliably deliver the benefit they are supposed to lead to. In this case, the tester is not looking for bugs. He is trying out, empirically refining and documenting, a way to do a task.

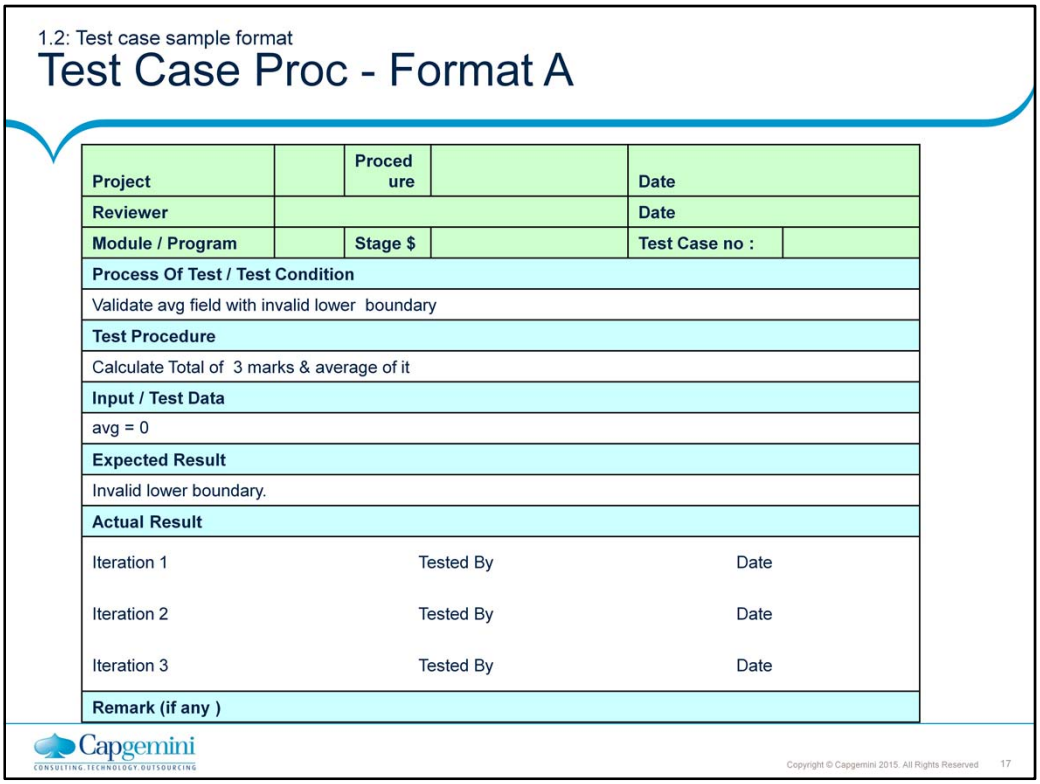
Assess quality. This is a tricky objective because quality is multi-dimensional. The nature of quality depends on the nature of the product. For example, a computer game that is rock solid but not entertaining is a lousy game. To assess quality -- to measure and report back on the level of quality -- you probably need a clear definition of the most important quality criteria for this product, and then you need a theory that relates test results to the definition.

For example, reliability is not just about the number of bugs in the product. It is (or is often defined as being) about the number of reliability-related failures that can be expected in a period of time or a period of use. (Reliability-related? In measuring reliability, an organization might not care, for example, about misspellings in error messages.) To make this prediction, you need a mathematically and empirically sound model that links test results to reliability. Testing involves gathering the data needed by the model. This might involve extensive work in areas of the product believed to be stable as well as some work in weaker areas. Imagine a reliability model based on counting bugs found (perhaps weighted by some type of severity) per N lines of code or per K hours of testing. Finding the bugs is important. Eliminating duplicates is important. Troubleshooting to make the bug report easier to understand and more likely to fix is (in the context of assessment) out of scope.



Verify correctness of the product. It is impossible to do this by testing. You can prove that the product is not correct or you can demonstrate that you didn't find any errors in a given period of time using a given testing strategy. However, you can't test exhaustively, and the product might fail under conditions that you did not test. The best you can do (if you have a solid, credible model) is assessment--test-based estimation of the probability of errors. (See the discussion of reliability, above).

Assure quality. Despite the common title, quality assurance, you can't assure quality by testing. You can't assure quality by gathering metrics. You can't assure quality by setting standards. Quality assurance involves building a high quality product and for that, you need skilled people throughout development who have time and motivation and an appropriate balance of direction and creative freedom. This is out of scope for a test organization. It is within scope for the project manager and associated executives. The test organization can certainly help in this process by performing a wide range of technical investigations, but those investigations are not quality assurance. Given a testing objective, the good test series provides information directly relevant to that objective. Different types of tests are more effective for different classes of information.



1.2: Test case sample format

Test Case Proc - Format A

Project		**Proced ure**		**Date**	
Reviewer				**Date**	
Module / Program		**Stage $**		**Test Case no :**	
Process Of Test / Test Condition					
Validate avg field with invalid lower boundary					
Test Procedure					
Calculate Total of 3 marks & average of it					
Input / Test Data					
avg = 0					
Expected Result					
Invalid lower boundary.					
Actual Result					
Iteration 1		Tested By		Date	
Iteration 2		Tested By		Date	
Iteration 3		Tested By		Date	
Remark (if any)					

Format A has different sections like Test condition, Test procedure, Input/Test data, Expected result, Actual result and Remarks.

Format A specifies the sample test case for calculating total and average from it. The above example demonstrates the test case for invalid lower boundary value.

1.3: Test case example

Test Case Proc - Format B

Test Case ID	Preconditions (If any)	Test Condition / Scenario	Test Steps	Input/Test Data	Expected Result
TC_1	Total of 3 marks & average of it	Validate avg field with invalid lower boundary	Enter average	avg = 0	Error1
TC_2	Total of 3 marks & average of it	Validate day field with invalid higher boundary	Enter average	avg = 101	Error2
TC_3	Total of 3 marks & average of it	Validate day field with valid boundary	Enter average	avg = 50	Message1
TC_4	Total of 3 marks & average of it	Validate day field with valid boundary	Enter average	avg = 69	Message2
TC_5	Total of 3 marks & average of it	Validate day field with valid boundary	Enter average	avg = 85	Message3

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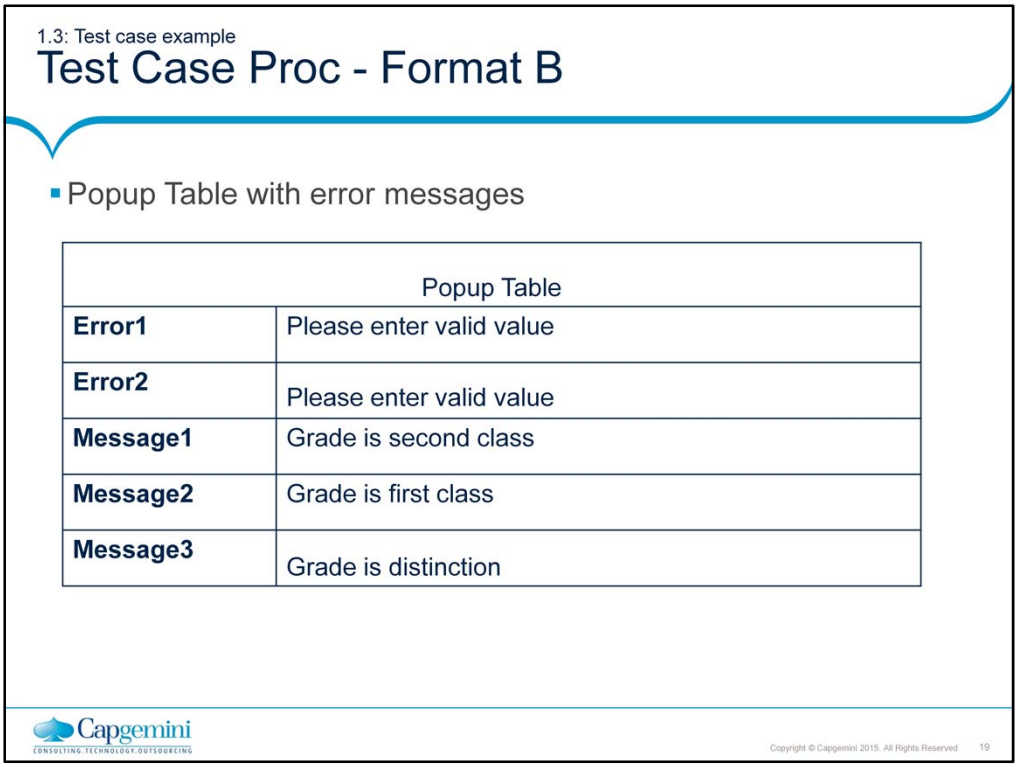
Above example demonstrates about writing test cases for Software Testing course.

For finding grade by calculating average marks of the 3 subjects & calculating average of it.

If the average marks fall in between 40 – 59 - grade 2nd. If the average marks fall in between 60 – 74 - grade 1st . If the average marks are more than 75, grade is distinction. Detailing of the error messages & other messages should be logged in other excel sheet.

Similarly, for negative values, the expected result should generate an error message.

For all the valid cases message has to be appeared.

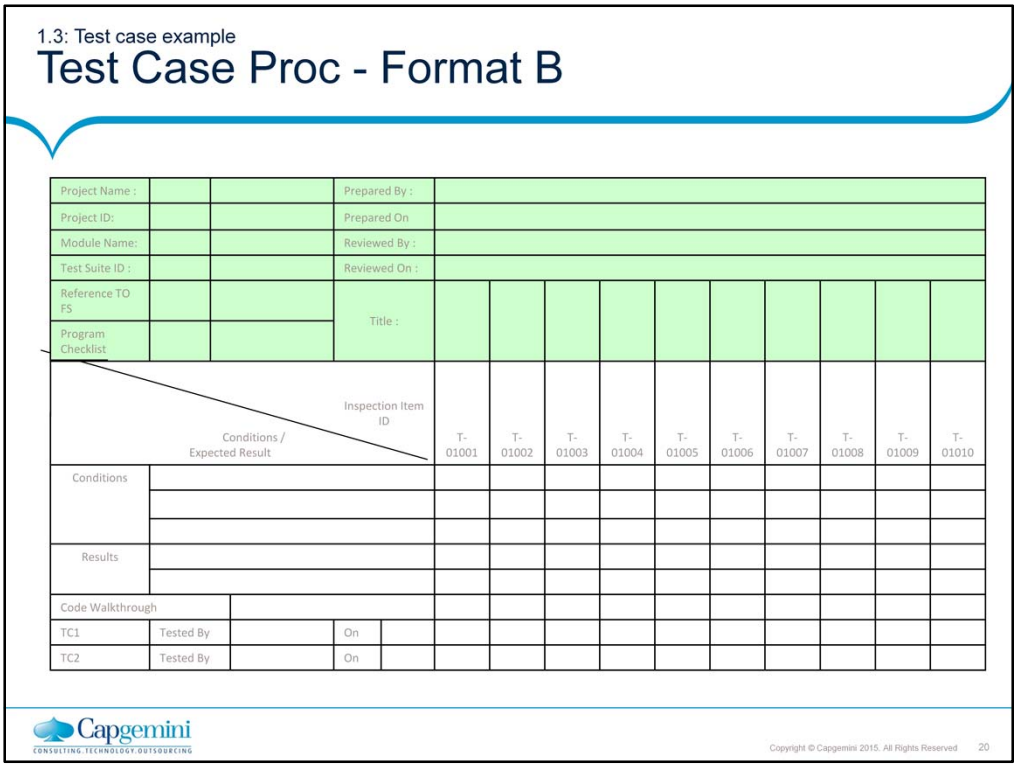


Above is the popup table that lists all the error messages & other messages, correspond to the test cases that are listed in the previous slide.

Detail description about the errors & messages is to be covered in popup table

For E.g. If the user is entering the invalid value, the hyperlink will prompt it to the popup table on the different sheet of the same excel document.

It will prompt a proper messages for a given test case.



1.3: Test case example

Test Case Proc - Format B

Project Name :			Prepared By :										
Project ID:			Prepared On										
Module Name:			Reviewed By :										
Test Suite ID :			Reviewed On :										
Reference TO FS			Title :										
Program Checklist													
Conditions / Expected Result — Inspection Item ID				T-01001	T-01002	T-01003	T-01004	T-01005	T-01006	T-01007	T-01008	T-01009	T-01010
Conditions													
Results													
Code Walkthrough													
TC1	Tested By		On										
TC2	Tested By		On										

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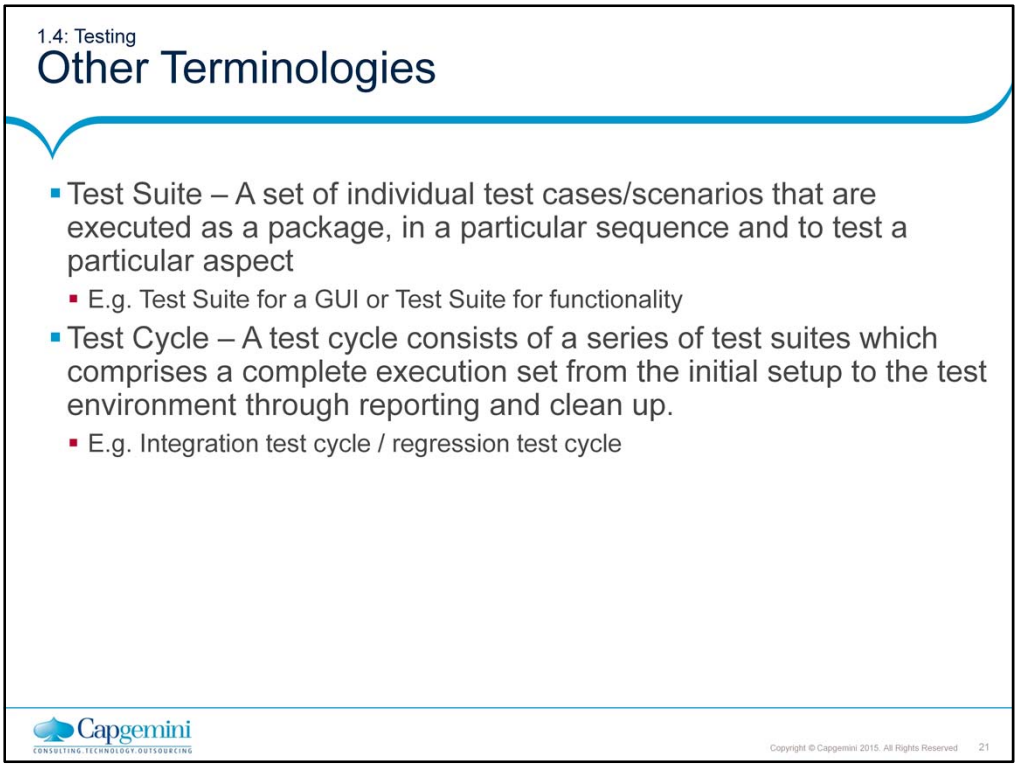
Format C shows a matrix that focuses on conditions, results, bug number reference across inspection item that is the test case.
In spite of different formats the test case creation highlights on 3 items: main test condition, input test data and the expected result from the test case.



Test case is a triplet [I, S, O] where

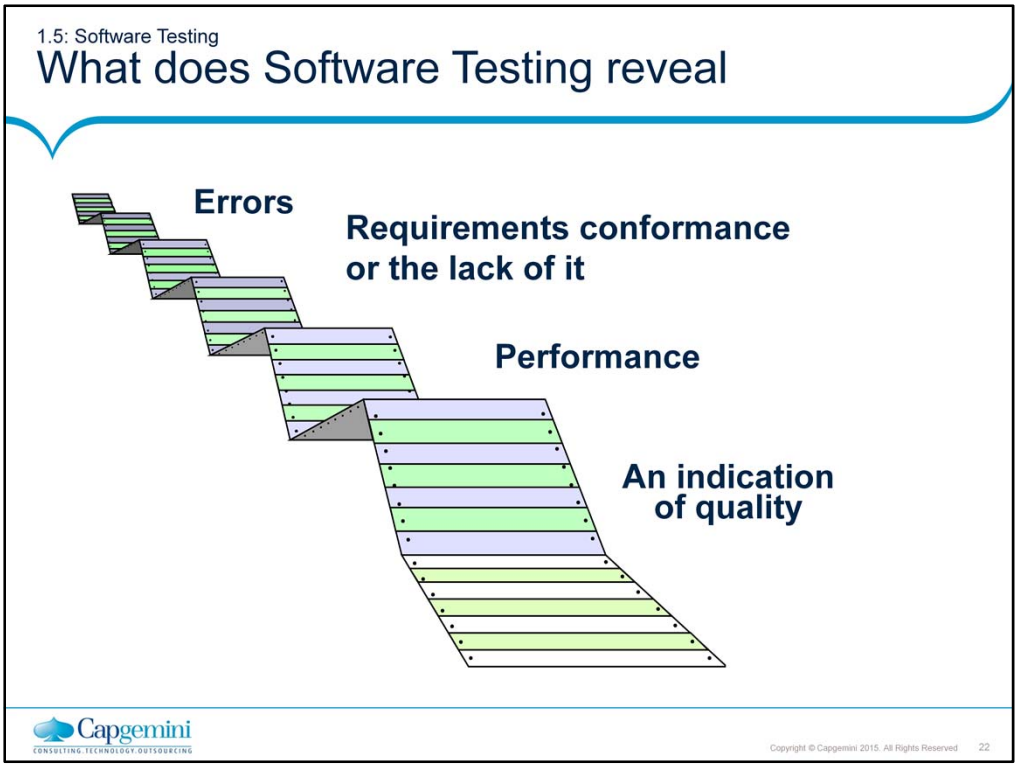
- I is input data
- S is state of system at which data will be input
- O is the **expected** output

Test Suite – Test suite is set of all test cases. Suites are usually related by the area of the application they exercise or by their priority or content.
For E.g. When you Login to the screen, some functionalities like validating user name, password with different invalid inputs can act as Test suites.
E.g. In case of ATM machine, deposit, withdraw, balance check are separate test suites that carry out different test cases

Test Cycle – It's a combination of series of test suites.
For E.g. The Test Cycle for the same application is combination of multiple Test Suites like, Functional validations, Database validations, GUI validations, etc. form the Test Cycle.
E.g. Combination of all test suites like deposit, withdraw, balance check in case of ATM machine, forms a complete cycle

Test Scenario -– A set of test cases that ensure that the business process flows are tested from end to end. They may be independent tests or a series of tests that follow each other, each dependent on the output of the previous one. The terms "test scenario" and "test case" are often used synonymously.

Test cases are not randomly selected. Instead even they need to be designed.a



Software testing exposes all the possible, noticed & unnoticed Errors.

It also takes care of the requirements conformance with respect to the end product.

It checks for the performance test.

The very crucial aim of all of these activities is Quality. It ensures the product in terms of quality.

Summary

- In this lesson, you have learnt:
  - Testing is an extremely creative & intellectually challenging task
  - No software exists without bug
  - Testing is conducted with the help of users requirements, design documents, functionality, internal structures & design, by executing code
  - The cost of not testing is potentially much higher
  - Testing is in a way a destructive process
  - A successful test case is one that brings out an error in program

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Review Question

- Question 1: _____ is a planned sequence of actions
- Question 2: One cannot test a program completely to guarantee that it is error free
  - Option: True / False
- Question 3: One can find missing paths due to coding errors
  - Option: True / False

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Review Question: Match the Following

Economics of limiting	A. Driving
2. Testing	B. Exhaustive testing
3. A good test case	C. Limiting
4. Use every possible input condition as a test case	D. Test cycle
	E. Comparing outputs with specified or intended
	F. Maximize bug count

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Testing Concepts for V&V Automation Testing

Lesson 2: Types of Testing Techniques & Test Case Design

Lesson Objectives

- To understand the following topics:
  - Types of testing techniques
  - Static testing - Self Review, Code inspection, Walkthrough Desk check.
  - Dynamic testing - White Box, Black Box.
  - Test Case Construction
  - Test Data Preparation
  - Test Case Design Techniques – Black Box Testing
  - What is positive testing and negative testing
  - Example of positive and negative testing
  - Scenarios of positive and negative testing
  - What is basic and alternate testing
  - Importance of writing positive,negative,basic,alternate tests while designing test cases

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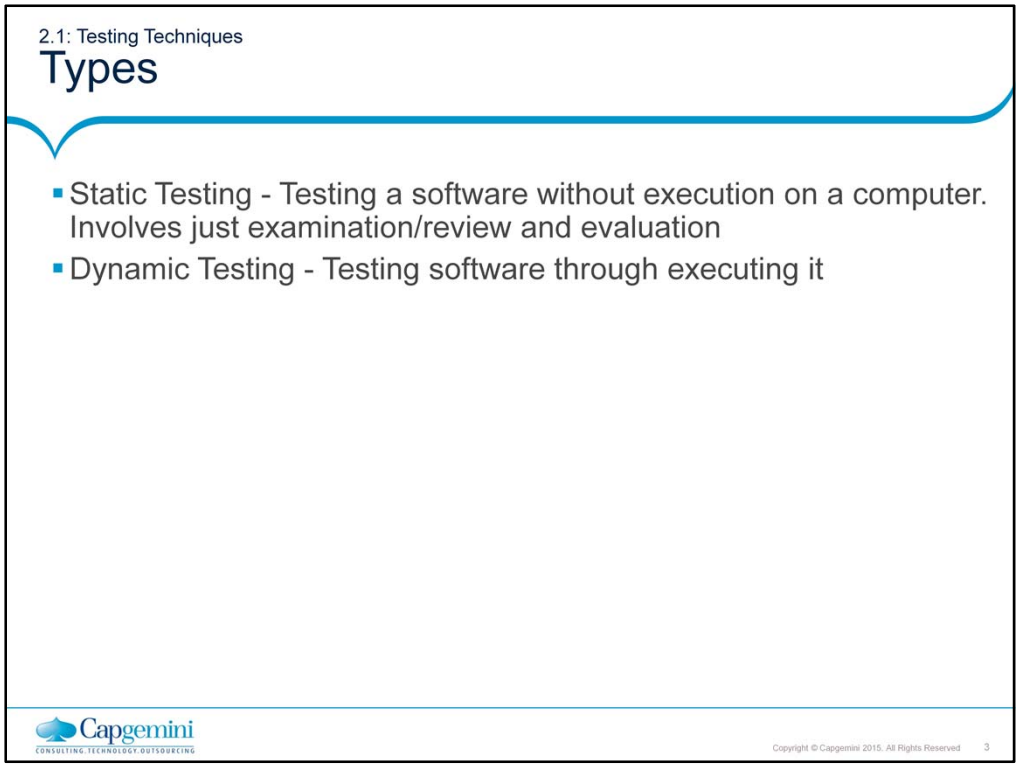
2.1: Testing Techniques
Types
Static Testing - Testing a software without execution on a computer. Involves just examination/review and evaluation
Dynamic Testing - Testing software through executing it
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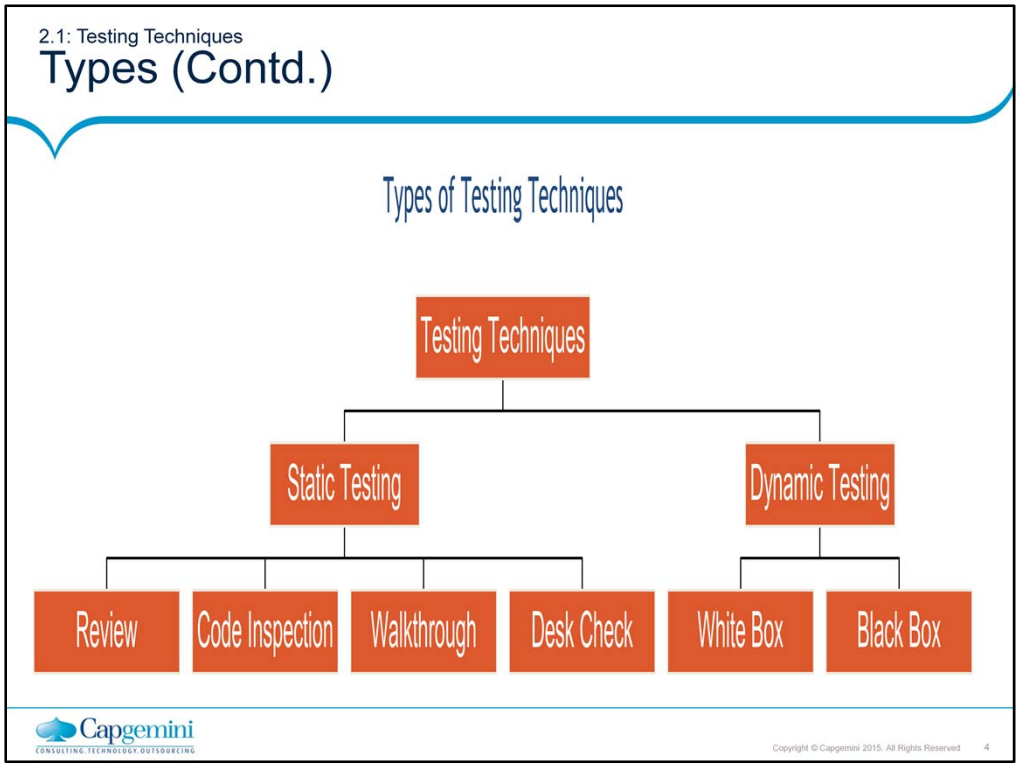
2.1: Testing Techniques
Types (Contd.)
Types of Testing Techniques
Testing Techniques
Static Testing
Dynamic Testing
Review
Code Inspection
Walkthrough
Desk Check
White Box
Black Box
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2.1: Static Testing

Introduction

- Static Testing is a process of reviewing the work product and reviewing is done using a checklist
- Static Testing helps weed out many errors/bugs at an early stage
- Static Testing lays strict emphasis on conforming to specifications
- Static Testing can discover dead codes, infinite loops, uninitialized and unused variables, standard violations and is effective in finding 30-70% of errors

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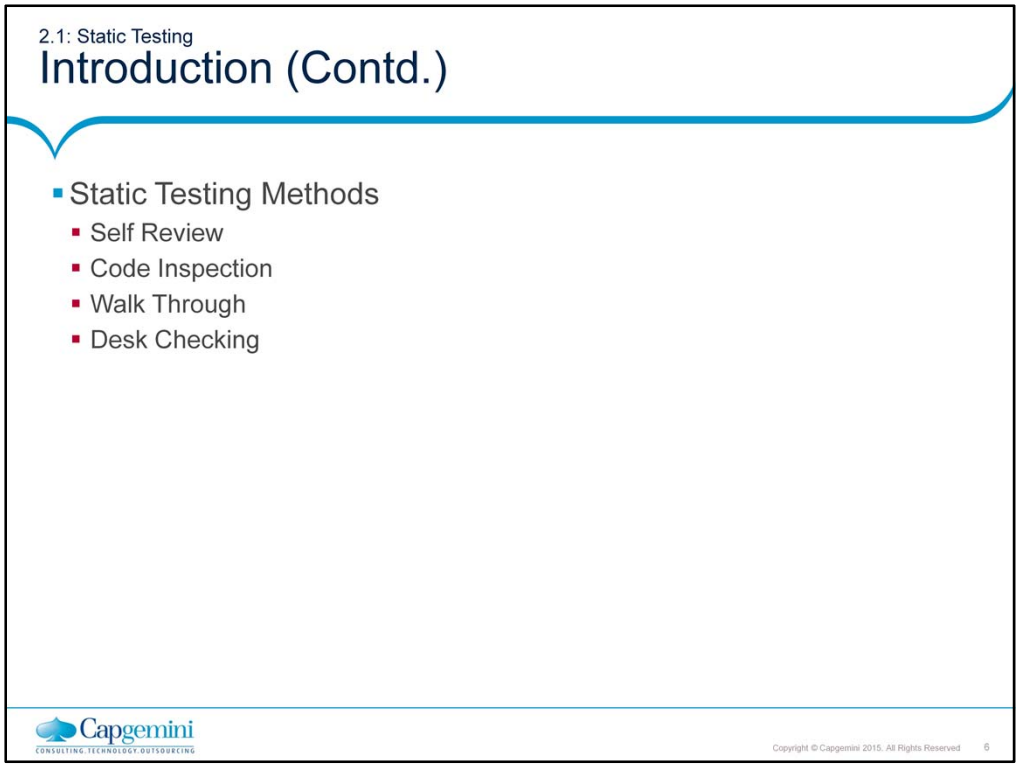
2.1: Static Testing
Introduction (Contd.)
Static Testing Methods
Self Review
Code Inspection
Walk Through
Desk Checking
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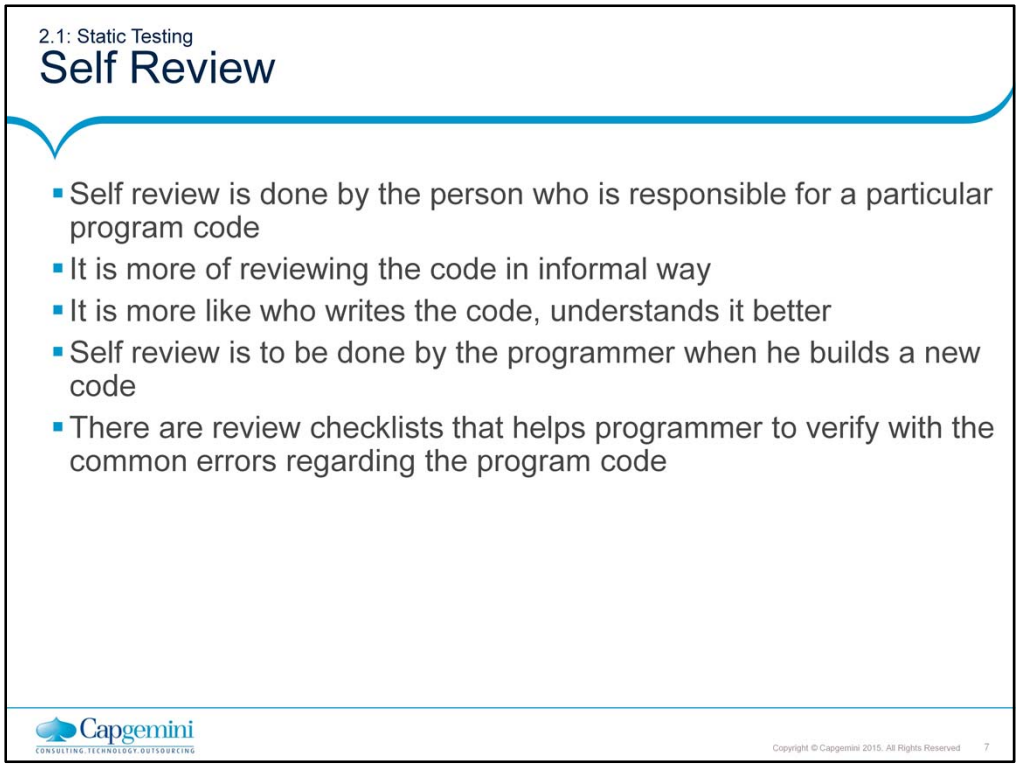


ERROR CHECKLIST FOR INSPECTION

1. Data Reference Errors

For each array reference, is each subscript value within defined bounds?

Dangling reference problem: arises when the lifetime of a pointer is greater than the lifetime of a referenced storage.

If a data structure is referenced in multiple procedures or subroutines, is the structure defined identically in each procedure?

2. Data Declaration errors

Is each variable has been assigned correct length, type, and storage class?

Are there any variables with similar names (not an error but may have been confused with in the program)?

3. Computation errors

Are there any computations using same data types but different lengths?

Is an underflow or overflow occurs during computation?

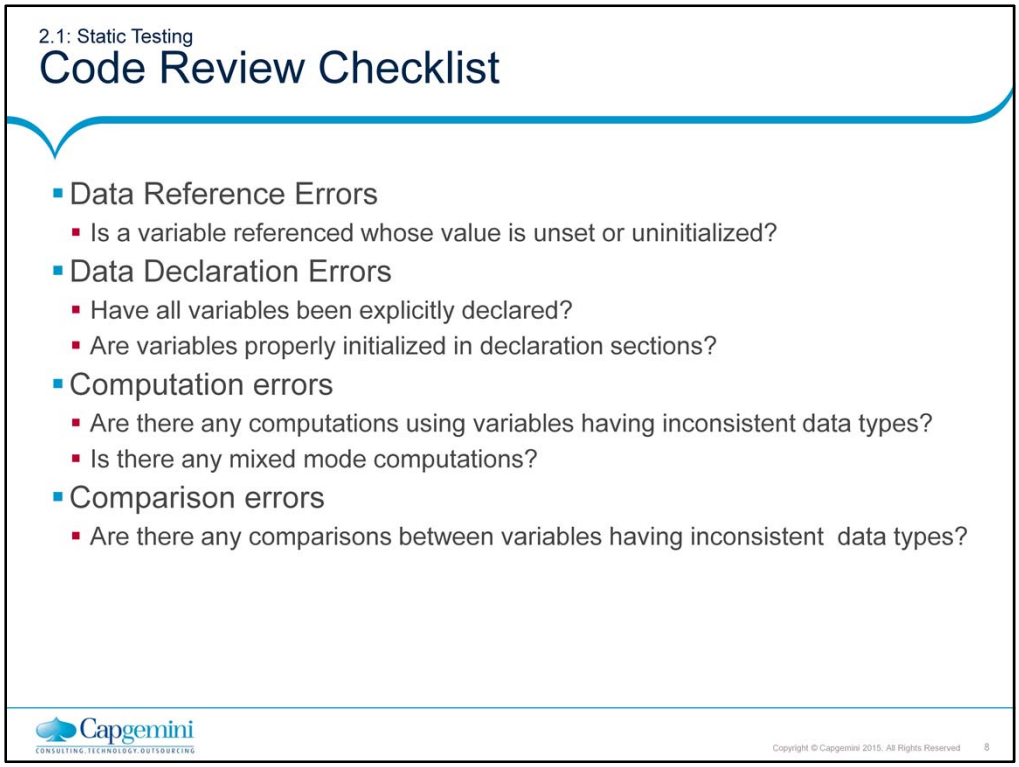
Division by zero and square root of a negative number errors.

Are the order of evaluation and precedence of operators correct?

4. Comparison errors:

Are there any mixed mode computations or comparisons between variables of different lengths?

Is the comparison operator correct? Does each Boolean expression state what it is supposed to do? Are the operands of a Boolean operator Boolean?



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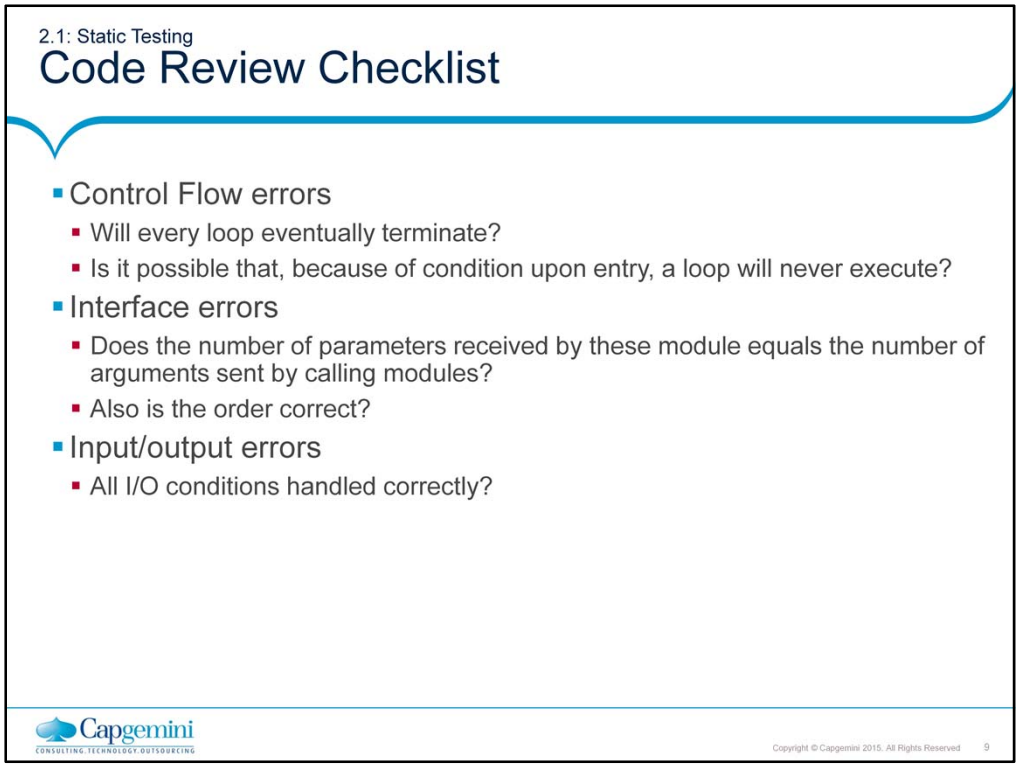


ERROR CHECKLIST FOR INSPECTION

5. Control Flow errors:

Will the program, module or subroutine eventually terminate?

Is there any nonexhaustive decision? Correct and appropriate number of END statements for group statements.

6. Interface errors:

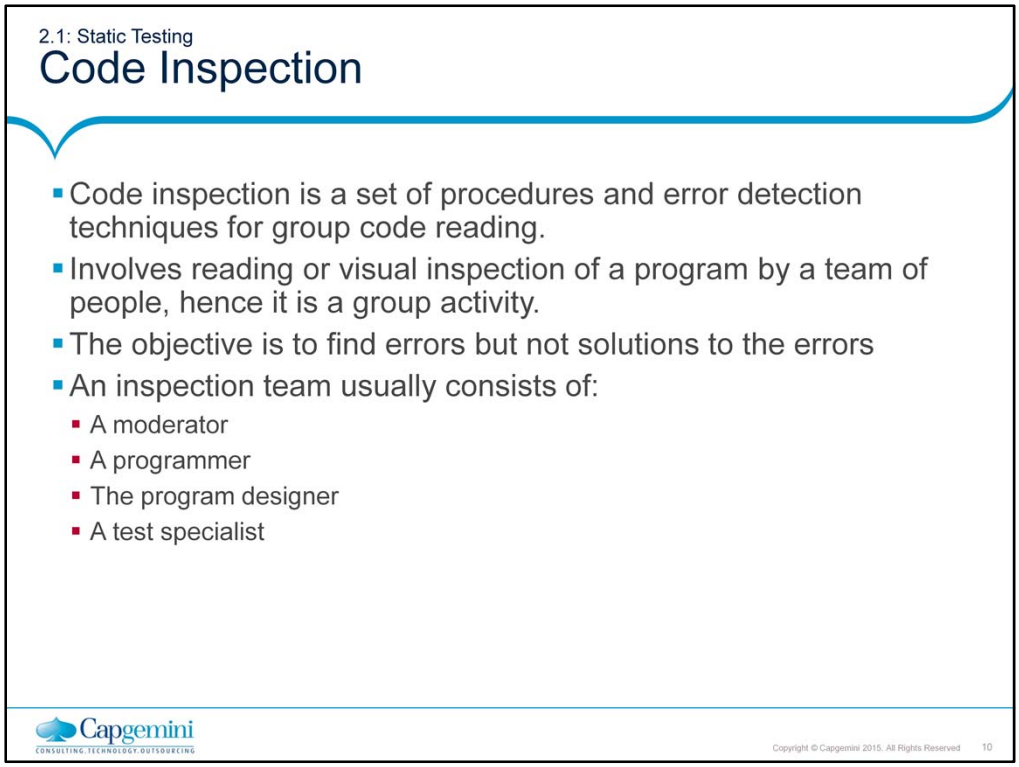
Do the attributes (Size, type and unit system if any) of parameters match with that of the arguments?

Does a subroutine alter a parameter that is intended to be only an input value?

7. Input/output errors:

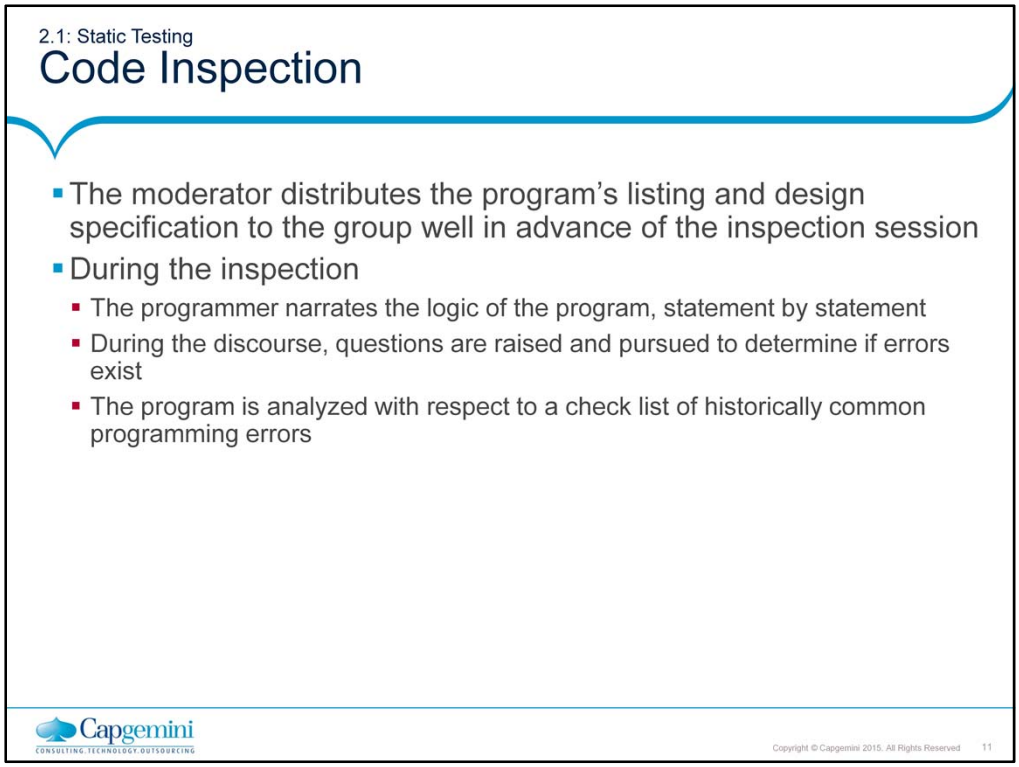
Are all the files opened properly with correct attribute in the open statement?

Are end-of-file conditions detected and handled properly? Does the format specification agree with the information in the I/O statement?

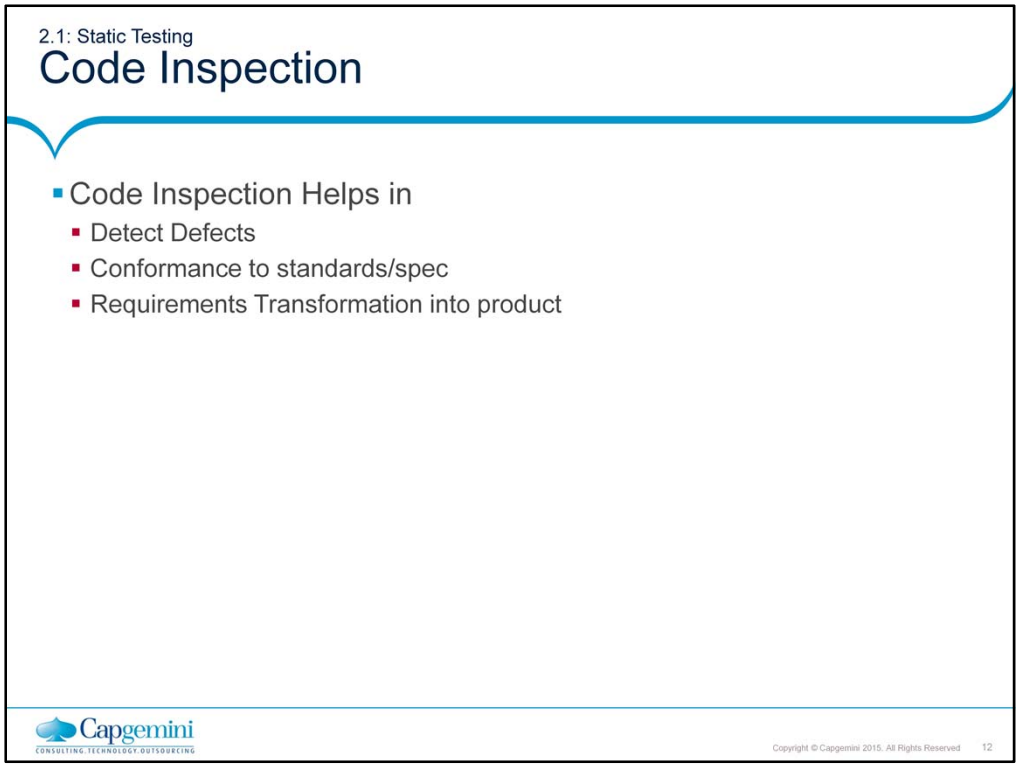


Moderator duties includes:

1. Distribution materials,
2. Scheduling the Inspection Session
3. Leading the session
4. Recording all errors found
5. Ensures that the errors found are subsequently corrected.



Code inspection focuses on discovering errors and not correcting them. The Inspection process is the way of identifying error prone sections early, helping to concentrate on the most sensitive sections during testing process.


2.1: Static Testing
Code Inspection
Code Inspection Helps in
Detect Defects
Conformance to standards/spec
Requirements Transformation into product
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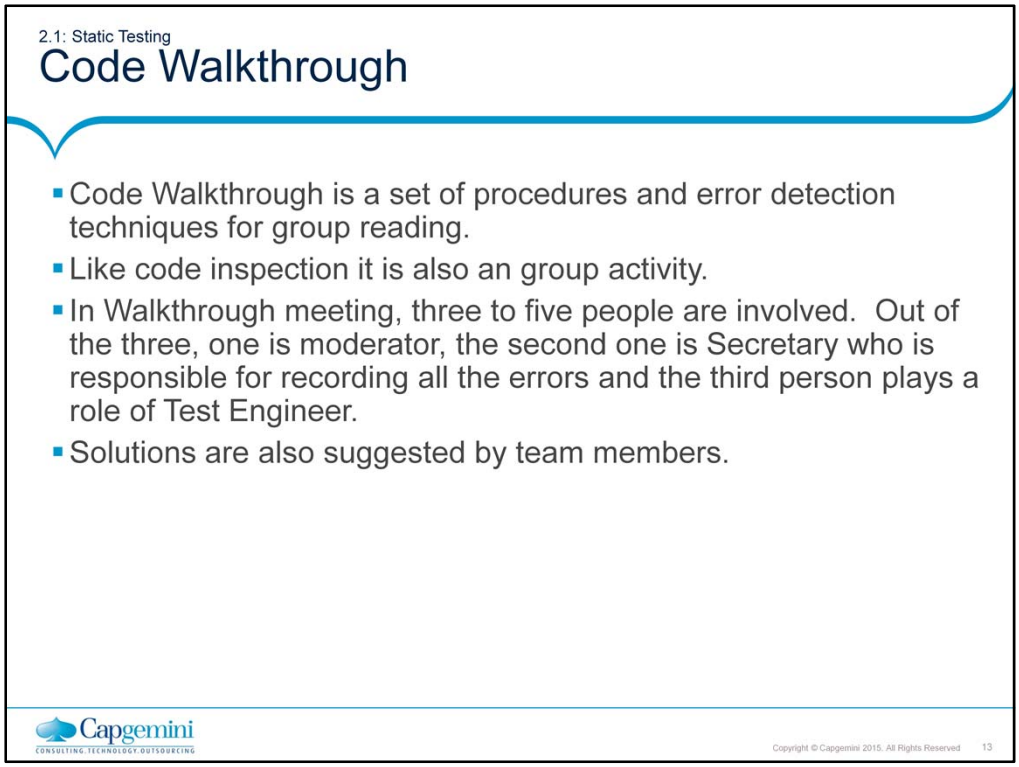


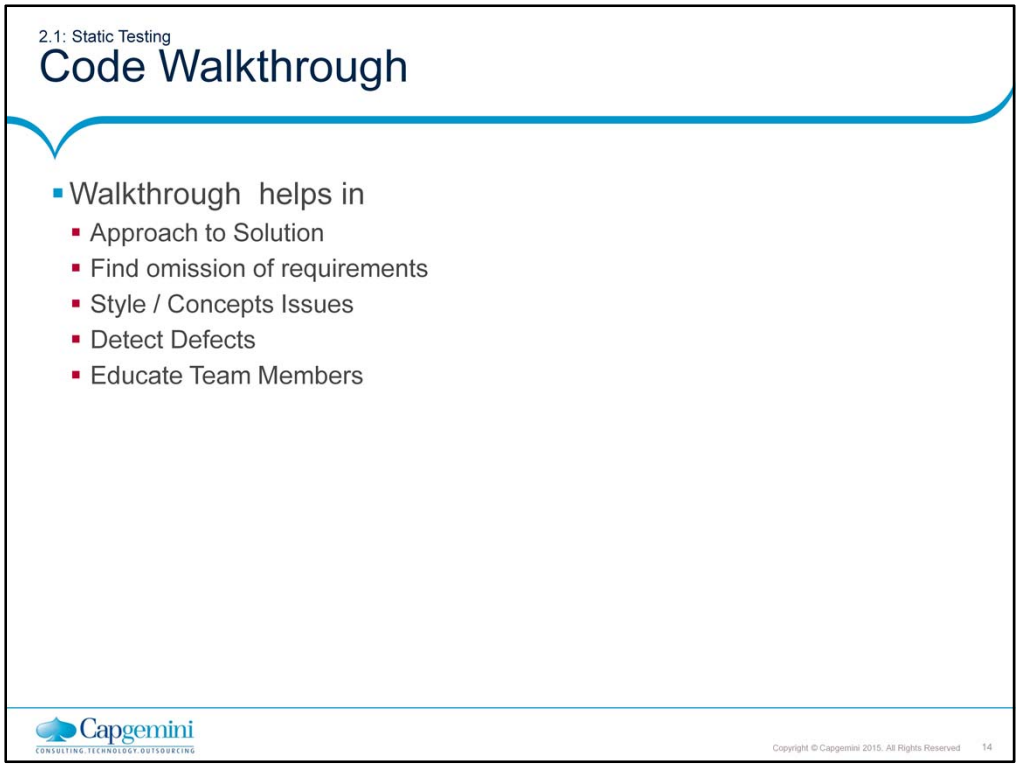
Walkthrough meeting.

This meeting will includes following members:

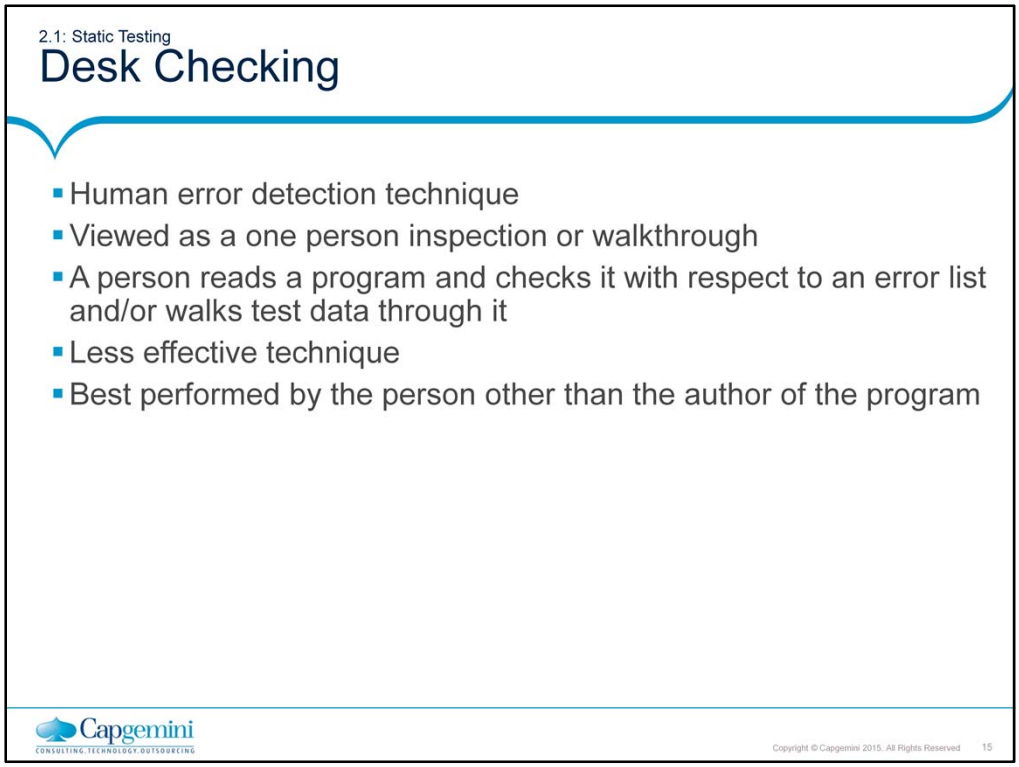
1. A highly experienced programmer
2. A programming language expert
3. A new programmer
4. The person who maintains the program
5. Some person from a different project
6. Some one from the same team as a programmer.

Walk through procedure

1. The designer simulates the program.
2. She/he shows, step by step what the program will do with the test data supplied by the reviewers.
3. The simulation shows how different pieces of the system interact and can expose awkwardness, redundancy and many missed details.
4. Different from inspection that it needs the participants to be ready with test cases.



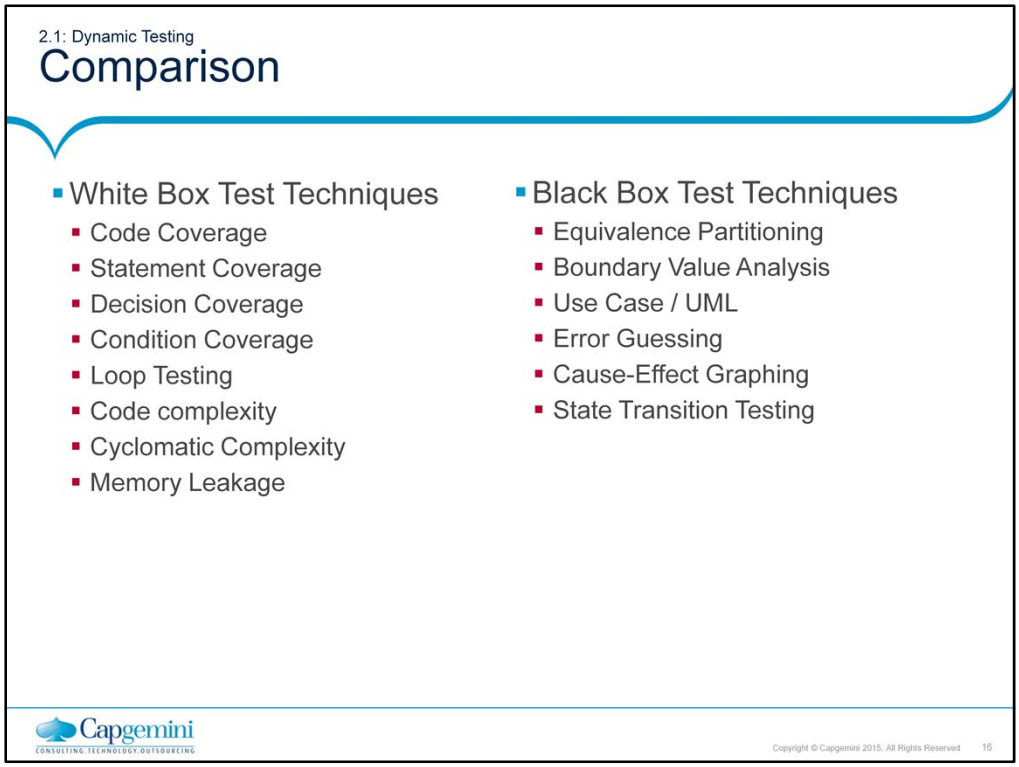
Tester prepares test cases. During meeting, each test case is manually executed. Test data are walked through the logic of the program.



It is the dry run of the program. It is completely informal process. Desk checking is best performed by a person other than the author of the program.

E.g. Two programmers might swap the program rather than desk checking their own programs.

It is less effective than inspection and walkthrough of the code.


2.1: Dynamic Testing
Comparison
White Box Test Techniques
Code Coverage
Statement Coverage
Decision Coverage
Condition Coverage
Loop Testing
Code complexity
Cyclomatic Complexity
Memory Leakage
Black Box Test Techniques
Equivalence Partitioning
Boundary Value Analysis
Use Case / UML
Error Guessing
Cause-Effect Graphing
State Transition Testing
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2.1: Dynamic Testing

White Box Test Techniques

- White box is logic driven testing and permits Test Engineer to examine the internal structure of the program
- Examine paths in the implementation
- Make sure that each statement, decision branch, or path is tested with at least one test case
- Desirable to use tools to analyze and track Coverage
- White box testing is also known as structural, glass-box and clear-box

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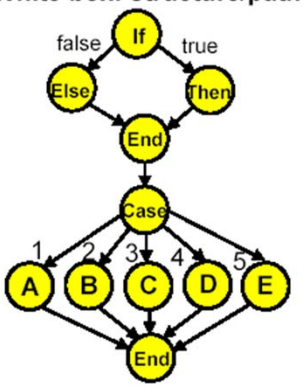
2.1: Dynamic Testing

White Box Test Techniques

- White Box Test Techniques
  - Code Coverage
    - Statement Coverage
    - Decision Coverage
    - Condition Coverage
    - Loop Testing
  - Code complexity
  - Memory Leakage

White box: structure/path



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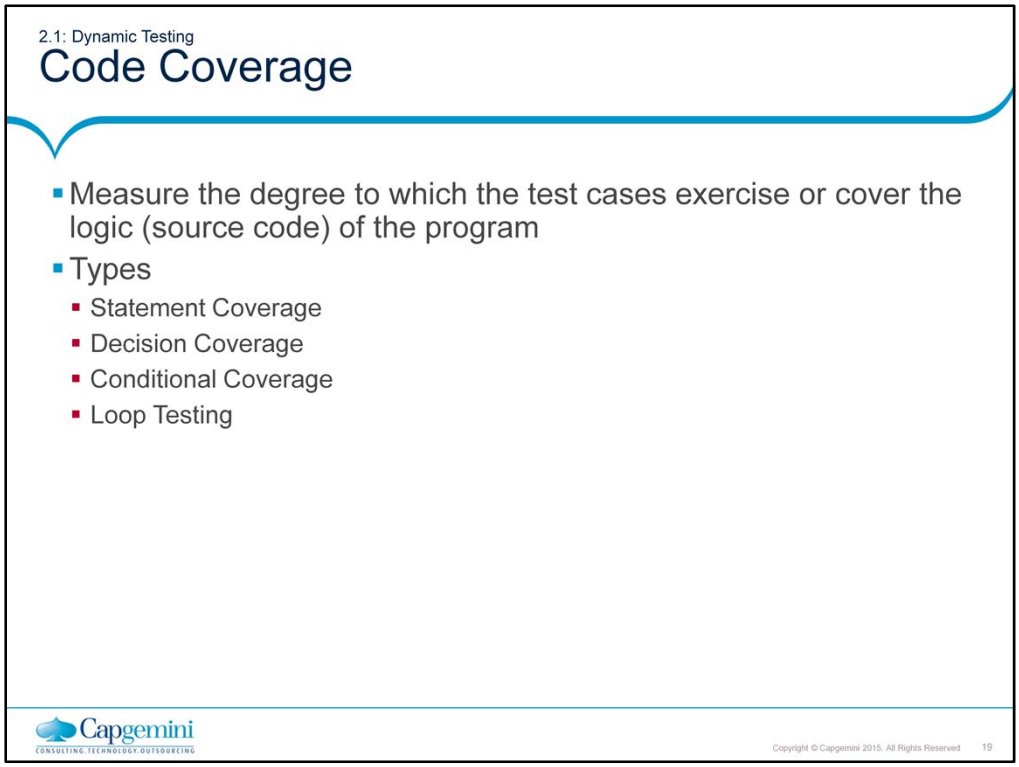
Using white box testing methods, you can derive test cases that

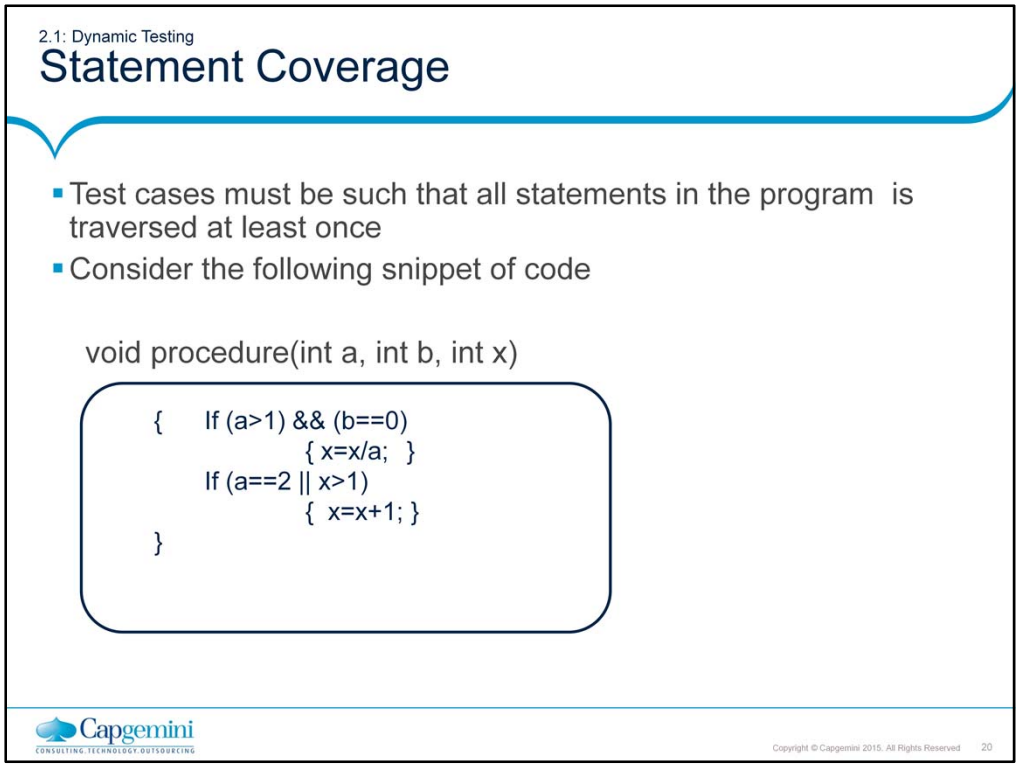
(1) guarantee that all independent paths within a module have been excised at least once
(2) exercise all logical decisions on their true and false sides
(3) execute all loops at their boundaries and within their operational bounds
(4) exercise internal data structures to ensure their validity.



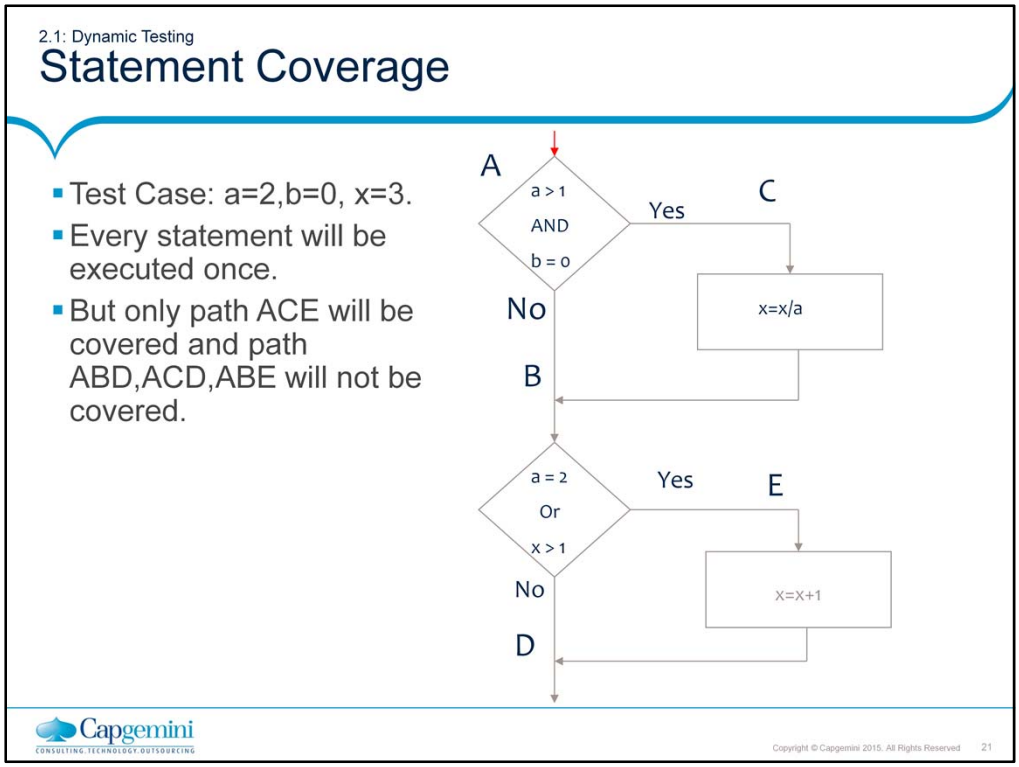
Code coverage is also known as logic coverage. The goal is to execute every statement of the code at least once. Test engineers can derive test cases using

White box testing methods, that

1. All independent paths within a module are traversed at least once
2. Exercise all logical decisions on their true and false sides
3. Execute all loops at their boundaries and within operational bounds
4. Exercise internal data structures to ensure their validity.



The goal is to execute every statement in the program at least once. Every statement must be executed.



Every statement can be executed by writing a single test case. This case covers only ACE path.
This criteria is weak one. Since it is not considering other paths to traverse. So the path ABD, ACD, ABE would go undetected.

2.1: Dynamic Testing

Statement Coverage

- In the above code one test case is sufficient to execute each of the two if statements at least once:
  - Test Case : a=2 , b=0 , x=3
  - (Decision1 is True, Decision2 is True)
- However this test case does not help in detecting many of the many of the bugs which may go unnoticed as the false outcomes of the conditions a>1 & b=0 , a=2 or x>1 are not tested

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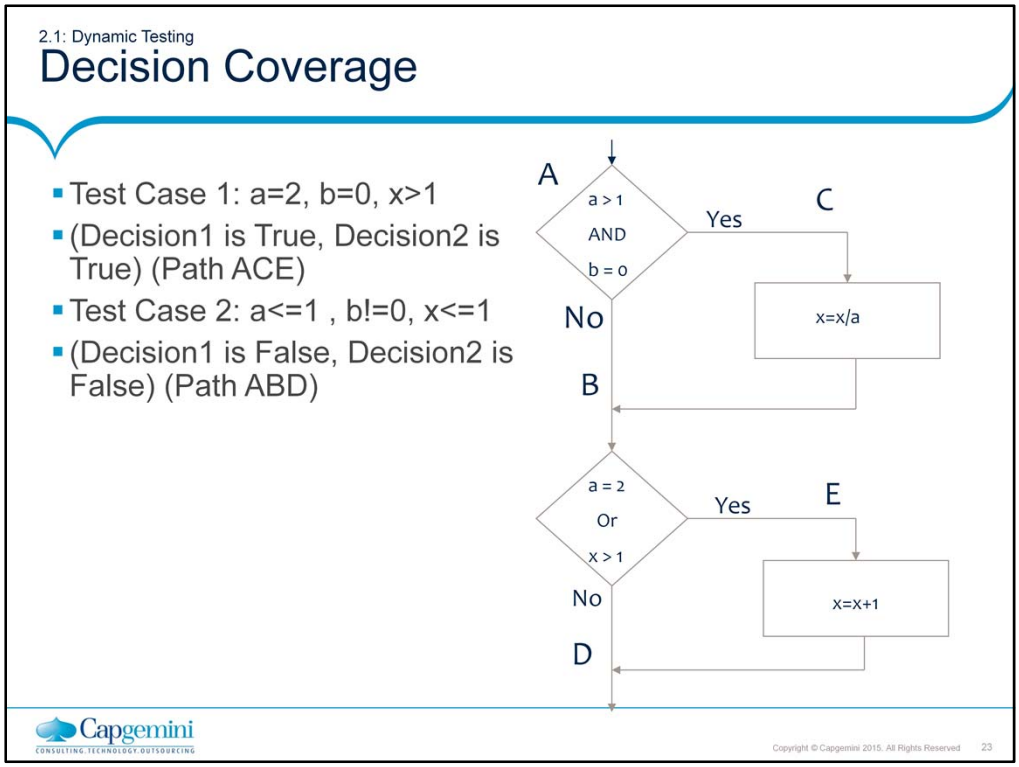
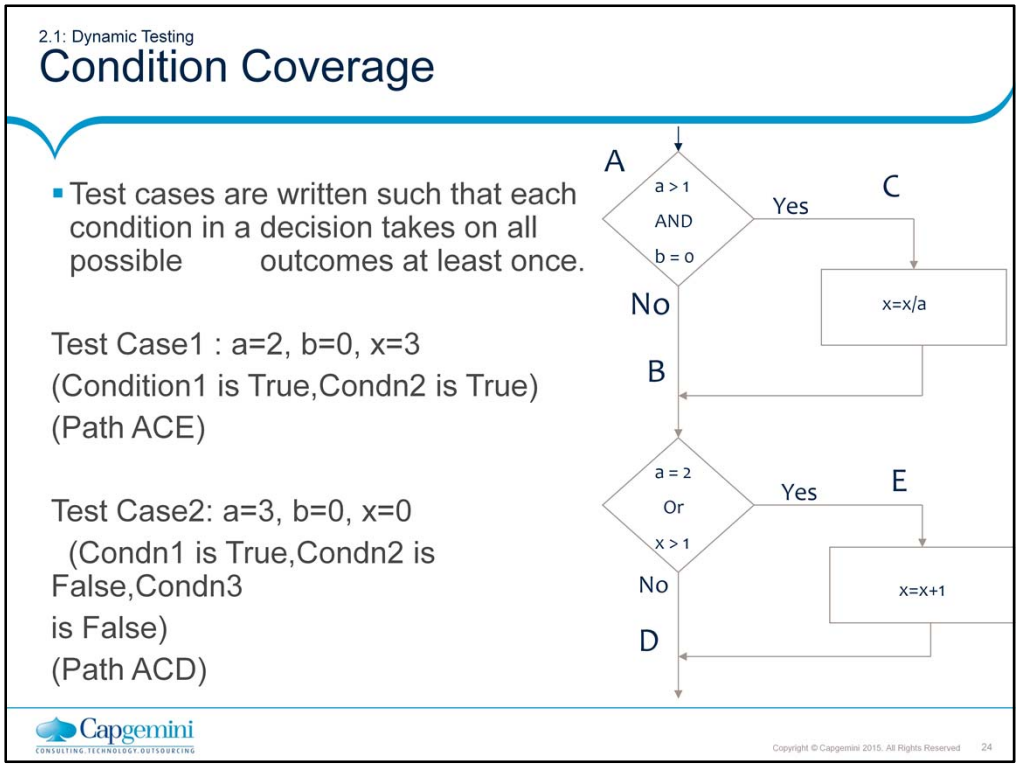


Decision coverage can cover two test cases covering paths ACE and ABD. Even if the above test cases satisfy decision coverage it still does not cover the path ACD and path ABE. Hence decision coverage though stronger criteria than statement it is still weak. There is only 50 percent chance that we would explore the path.



Condition testing is a test case design method that exercises the logical conditions contained in a program module. A simple condition is a Boolean variable or a relational expression. Relational operator is one of the following <, <=, =, not =, > , =>.

A compound condition is composed of two or more simple conditions, Boolean operators, and parentheses.

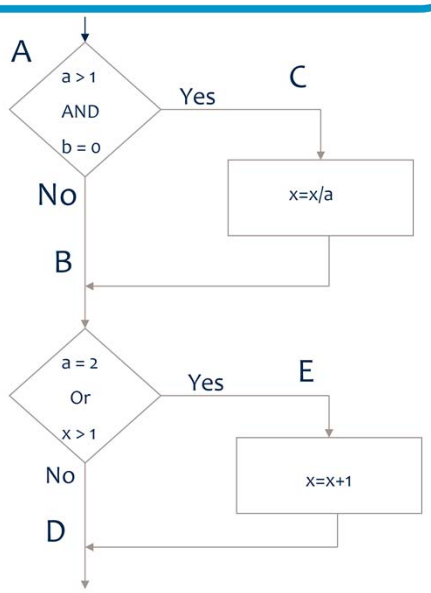
Condition coverage focuses on testing each condition in a program. The purpose of the condition testing is to detect not only errors in the conditions of a program but also other errors in the program.

2.1: Dynamic Testing

Condition Coverage

- Test Case3 : a=1, b=0, x=3
- (Condition1 is False,Condition2 is True)
- (Path ABE)

- Test Case4: a=1, b=1, x=1
- (Condition1 is False,Condition2 is False)
- (Path ABD)



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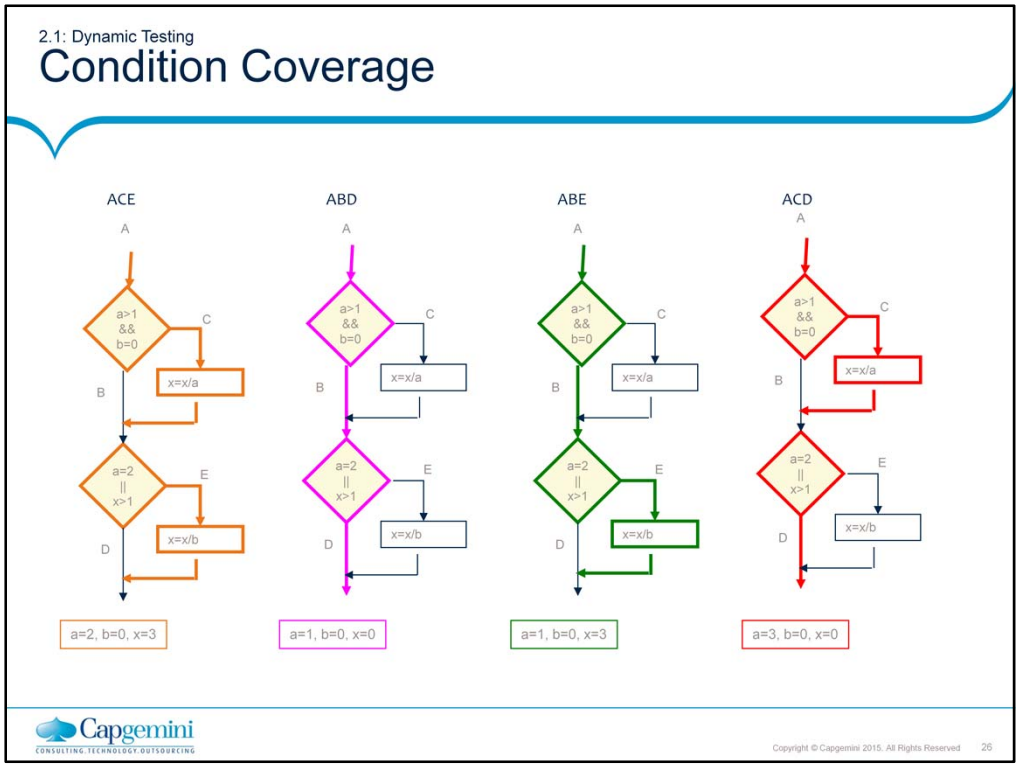
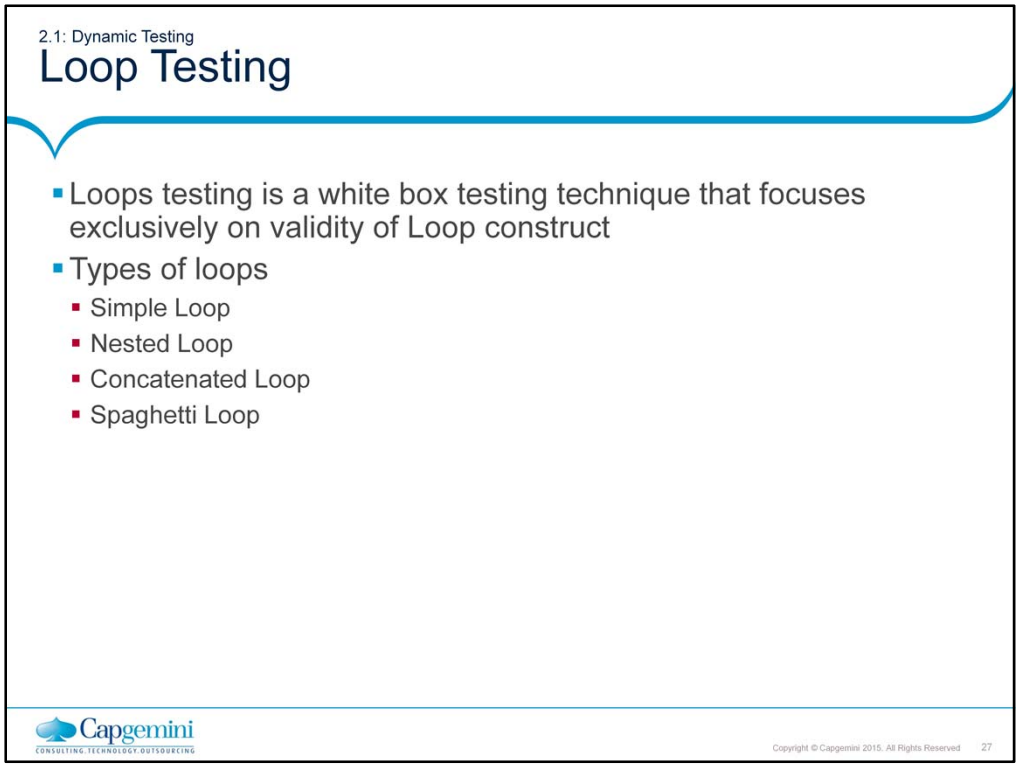


What does "coverage" mean?

- NOT all possible combinations of data values or paths can be tested
- Coverage is a way of defining how many of the paths were actually exercised by the tests
- Coverage goals can vary by risk, trust, and level of test

In the above diagrams, each condition in decision takes all possible outcomes at least once.

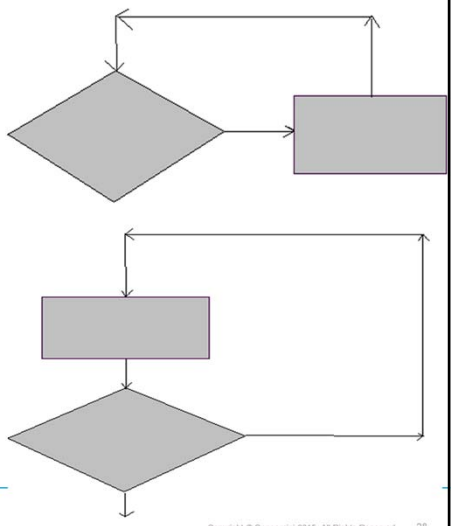


Loops are cornerstones for may algorithms. It is very important to test every loop carefully.

2.1: Dynamic Testing

Loop Testing

- Simple Loop Testing Procedure:
  - skip the entire loop
  - only one pass through the loop
  - make 2 passes through loop
  - m passes through loop where m<n
  - n-1, n, n+1 passes through the loop
- Where n is the maximum number of allowable passes through the loop



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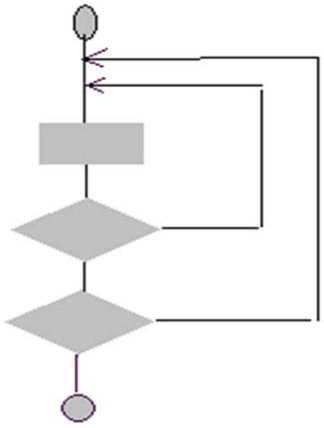
2.1: Dynamic Testing

Loop Testing

- Nested Loop Testing Procedure:
  - start at the innermost loop
  - conduct simple loop test for the innermost loop
  - work outward, conducting tests for the
  - next loop but keeping all other loops at minimum
  - continue until all the outer loops are tested



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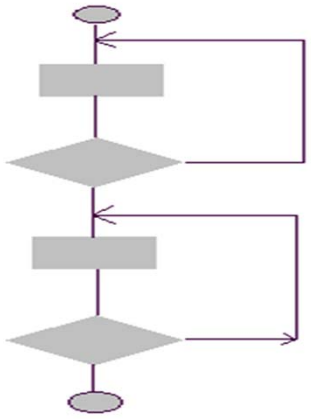
Number of test cases increases as the loop gets extended.

2.1: Dynamic Testing

Loop Testing

- Concatenated Loop Testing Procedure:
  - If each loop is independent of the other, test them as simple loops, else test them as nested loops



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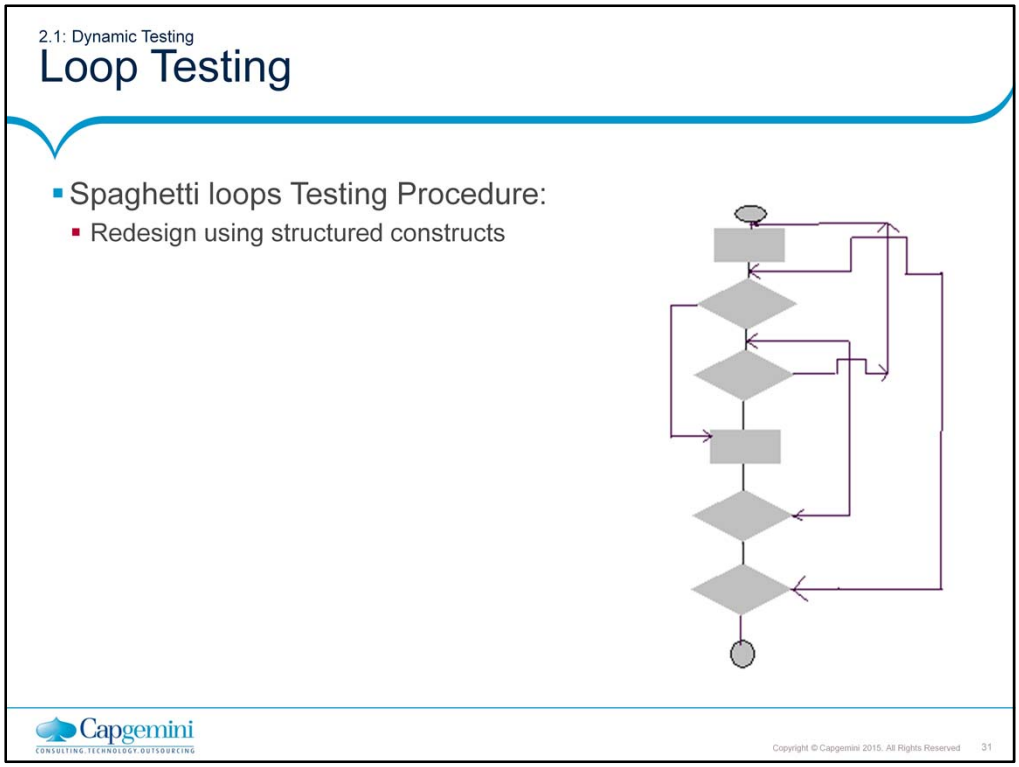
If the loops are independent of others, concatenated loops can be tested using simple loop testing approach. However, if the loops are concatenated and are not independent, the loop counter for loop 1 is used as the initial value for loop 2.



These are the unstructured loops. These loops should be redesigned to structured constructs.

2.1: Dynamic Testing

Basis Path Testing

- Basis Path Testing is a white box testing technique that enables the test case designer to derive a logical complexity measure of a procedural design and use this measure as a guide for defining the basis set of execution paths
- Test Cases derived to exercise the basis set are guaranteed to execute every statement in the program at least one time during testing

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2.1: Dynamic Testing

Flow Graph

- Main tool for test case identification
- Shows the relationship between program segments , which is the sequence of statements having the property that if the first member of the sequence is executed then all other statements in that sequence will also be executed

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2.1: Dynamic Testing

Flow Graph Symbols

- Nodes represent one program segment
- Areas bounded by edges and nodes are called regions
- An independent path is any path through the program that introduces at least one new set of processing statements or a new condition
- Each node containing a condition called a predicate node

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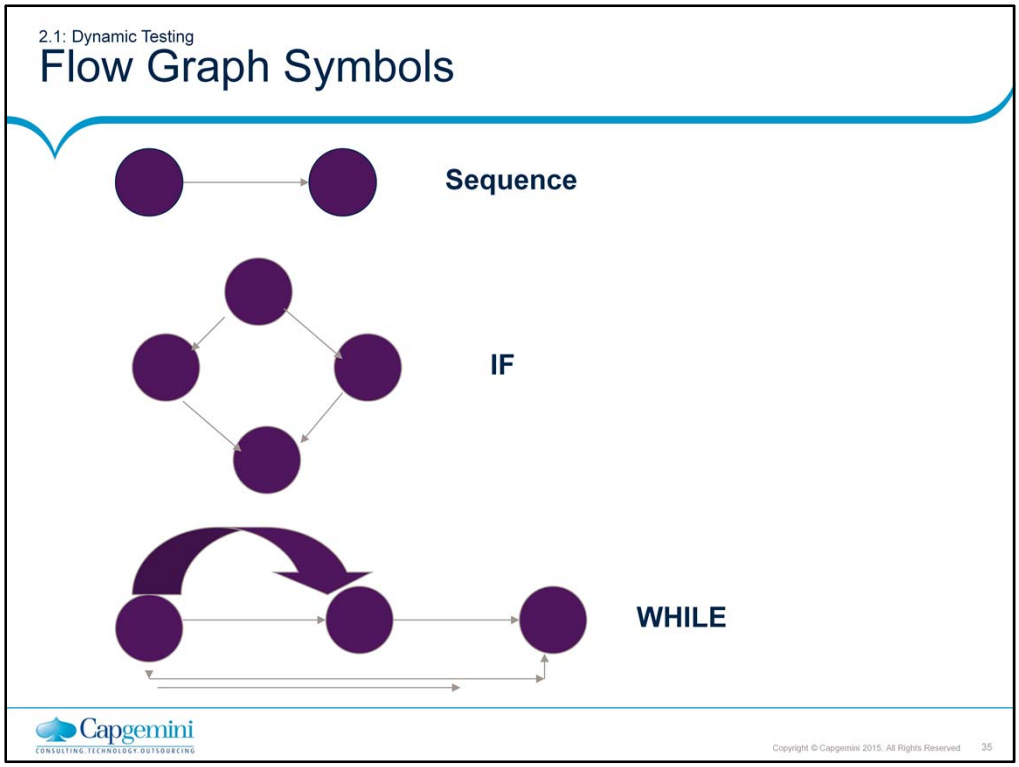


Sequence Flow – indicates the statements to be executed in a defined sequence

If – Sequence of statements will be executed depending on the condition match

While - Sequence of statements will be executed depending on the condition match, another way of achieving If flow.

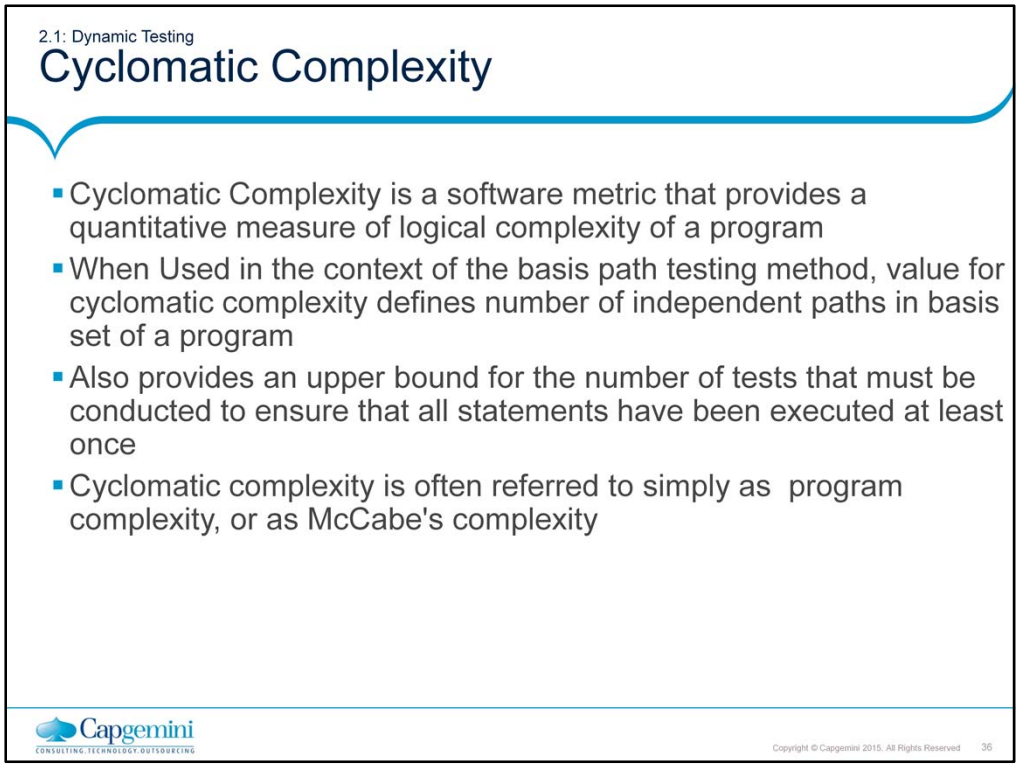
Flow graph is the notation for the representation of the control flow. It depicts logical control flow with the help of notations.

Each circle is called a flow graph node, represents one or more procedural statements. The arrows on the flow graph , called edges or links, represent flow of control and are analogous to flowchart arrows. An edge must terminate at a node, even if the node does not represent any procedural statements.

Areas bounded by edges and nodes are called regions. When counting regions, we include the area out-side the graph as a region.

When compound conditions are encountered in a procedural design, the generation of a flow graph becomes slightly more complicated. A compound condition occurs when one or more Boolean operators (logical OR, AND, NAND, NOR) is present in a conditional statement.

Each node containing a condition called a predicate node. It is characterized by two or more edges emanating from it.



Introduced by Thomas McCabe in 1976:

1. Count the regions of the flow graph (including the exterior)
2. Or compute by e-n+2 This is called Cyclomatic Complexity
3. The number of paths to test , all decision options are tested

How many paths (McCabe's technique for units)?

Cyclomatic complexity defines the number of independent paths. This provides minimum number of tests to be conducted to ensure all the statements have been executed at least once.
An independent path is any path through the program that introduces at least one new set of processing statements or a new condition. When stated in terms of a flow graph, an independent path must move along at least one edge that has not been traversed before the path is defined.

Cyclomatic complexity is a useful metric for predicting those modules that are likely to be error prone. Use it for test planning as well as test case design.
Cyclomatic complexity is a software metric that provides a quantitative measure of the logical complexity of a program.
When used in context of the basis path testing method, the value computed for cyclomatic complexity defines the number of independent paths in the basis set of a program and provides us the upper bound of the number of tests that must be conducted to ensure that all statements have been executed at least once.

2.1: Dynamic Testing

Calculating Cyclomatic Complexity

- The cyclomatic complexity of a software module is calculated from a flow graph of the module , when used in context of the basis path testing method
- Cyclomatic Complexity V(G) is calculated one of the three ways:
  - V(G) = E - N + 2 , where E is the number of edges and N = the number of nodes of the graph
  - V(G) = P+1, where P is the number of predicate nodes
  - V(G) = R , where number of region in the graph

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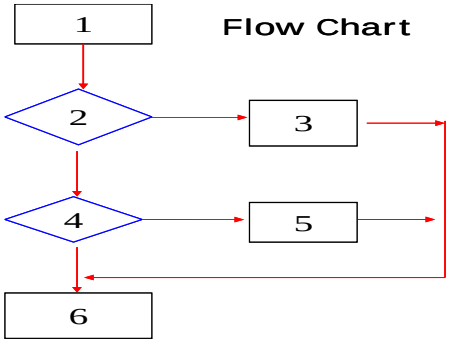
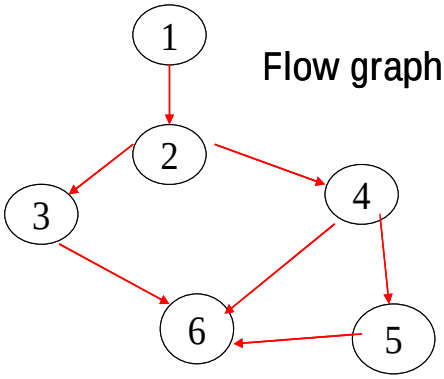
Here, a flow chart is used to depict program control structure. Flow chart is mapped into corresponding flow graph. Each circle is called as flow graph node, represents one or more procedural statements. A sequence of process boxes and a decision diamond can map into a single node.



A flow chart depicts program control structure.
Flow chart is mapped into flow graph.
A sequence of process boxes and a decision diamond are map into a single node.

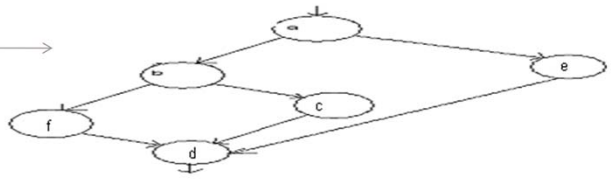


Each circle is called as graph node.
Arrows are called as edges.
The arrows on the flow graph is called edges, represents flow of control. An edge must be terminated at a node.

2.1: Dynamic Testing

Calculating Cyclomatic Complexity : Example

In the given figure a and b are predicate nodes



- Cyclomatic Complexity, V(G) for a flow Graph G is V(G) = E – N + 2
- E = Number of Edges in the graph (7 in the above figure)
- N = number of flow graph Nodes (6)
- R = number of Regions (3)
- Hence V(G) = 7-6+2 = 3
- V(G) can also be calculated as V(G) = P+1, where P is the number of predicate nodes. Here V(G) = 2+1 = 3
- Also V(G) can be calculated as V(G) = R hence V(G) = 3

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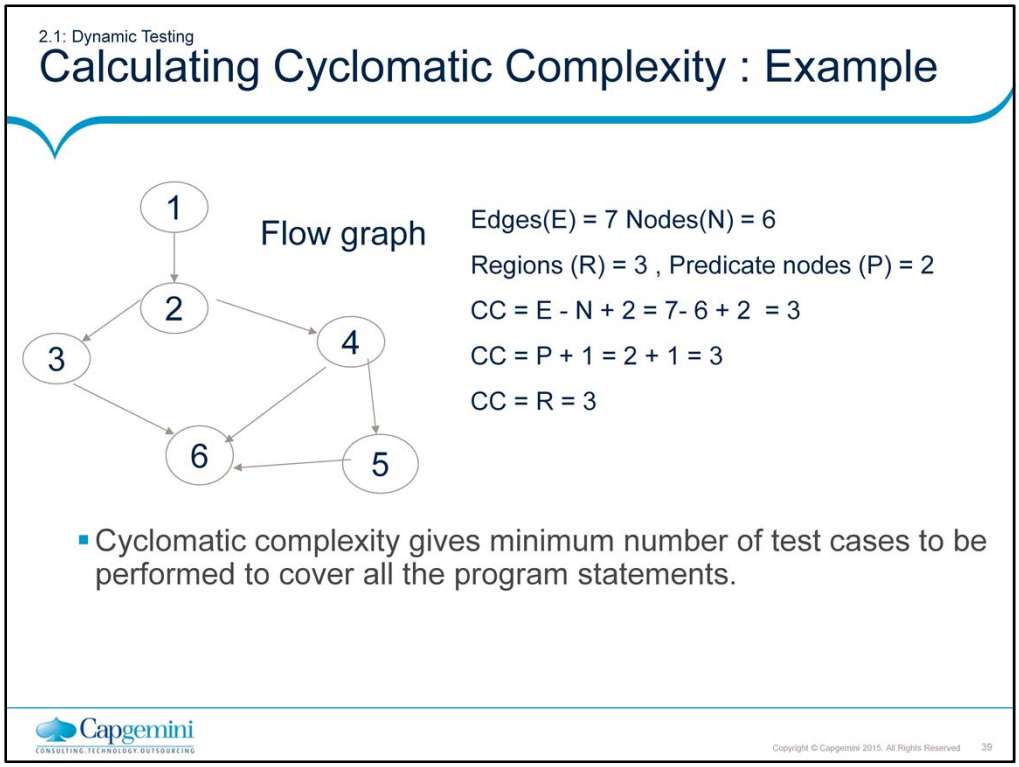
The value of V(G) provides the number of linearly independent paths through the program.

Here, in the above graph, value of V(G) is 3. That is, minimum 3 test cases must be designed to guarantee coverage of all program statements.



In the above graph, the cyclomatic complexity is 3. That means, there are 3 independent paths in this program. Independent path is any path through the program that has set of statements or a condition.

Path 1: 1-2-3-6

Path 2: 1-2-4-5-6

Path 3: 1-2-4-6

In order to have complete coverage of this code, there are minimum 3 test cases are required which traversed thorough the above paths.

2.1: Dynamic Testing

Memory Leak

- Memory leak is present whenever a program loses track of memory.
- Memory leaks are most common types of defect and difficult to detect
- Performance degradation or a deadlock condition occurs
- Memory leak detection tools help to identify
  - memory allocated but not deallocated
  - uninitialized memory locations

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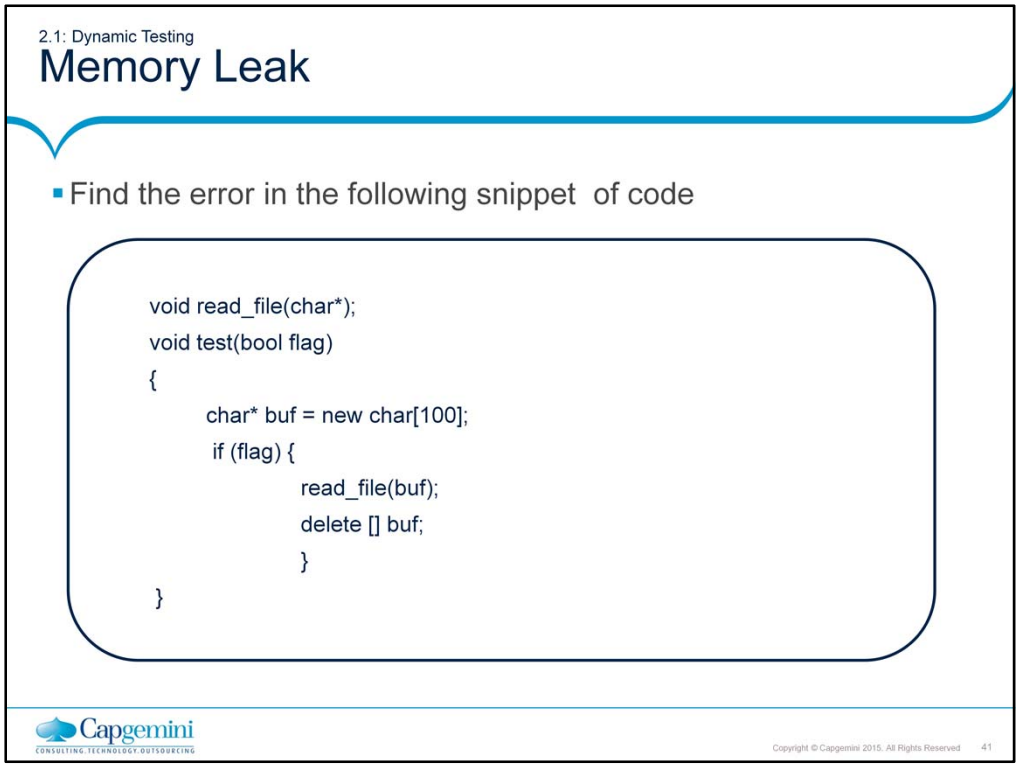
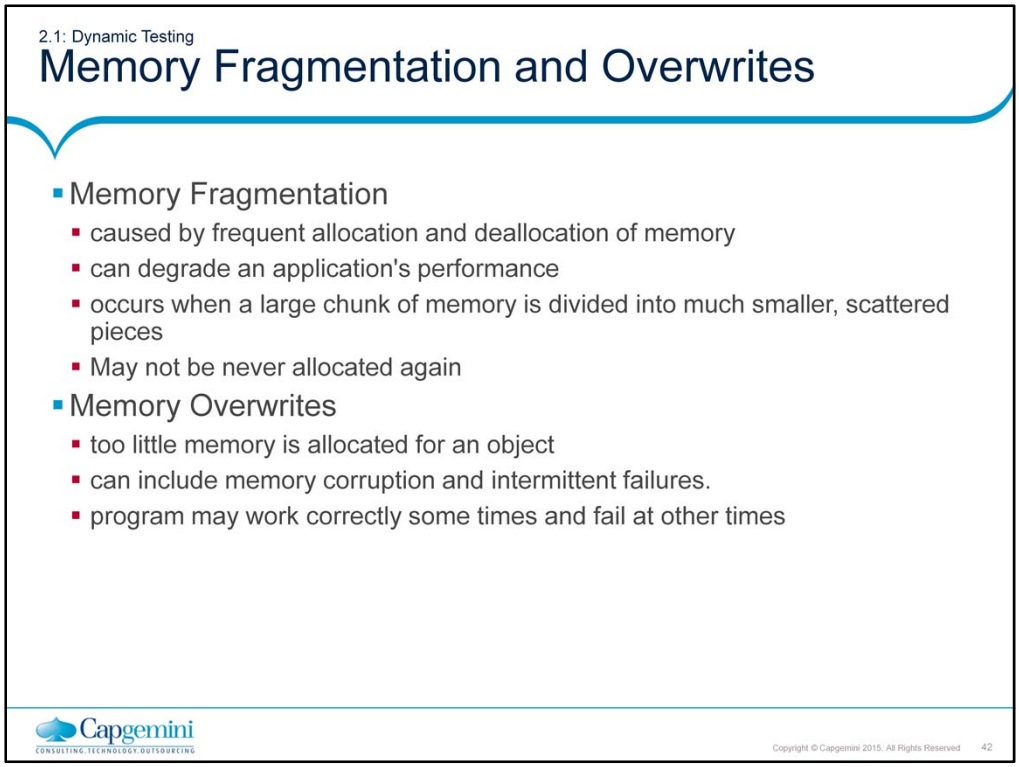


This problem occurs if a program fails to free objects that are no longer in use. The code leaks 100 bytes of memory every time the function test is called with the argument flag as false.
If a program continues to leak memory, its performance degrades. Its runtime memory footprint continues to increase and it spends more and more time in swapping and can eventually run out of memory.
You can use the garbage collection library to fix these errors.

Same memory pointer is deleted more than once:

```
void test3()
{
 int* p1 = new int;
 int* p2 = p1;
 delete p1;
 delete p2;  // deleting again!
}
```



Memory Fragmentation

This can be caused by frequent allocation and deallocation of memory and can degrade an application's performance. Memory fragmentation occurs when a large chunk of memory is divided into much smaller, scattered pieces. These smaller discontiguous chunks of memory may not be of much use to the program and may never be allocated again. This can result in the program consuming more memory than it actually allocates.

Memory Overwrites

This problem occurs when too little memory is allocated for an object. Consequences can include memory corruption and intermittent failures. The program may work correctly some times and fail erratically at other times.

Memory Overwrites: Once a block of memory has been allocated, it is important that the program does not attempt to write any data past the end of the block or write any data just before the beginning of the block. Even writing a single byte just beyond the end of an allocation or just before the beginning of an allocation can cause disaster. It is a possible candidate for turning on overflow buffers.

2.1: Dynamic Testing

Black Box Test Techniques

- Black box is data-driven, or input/output-driven testing
- The Test Engineer is completely unconcerned about the internal behavior and structure of program
- Black box testing is also known as behavioral, functional, opaque-box and closed-box

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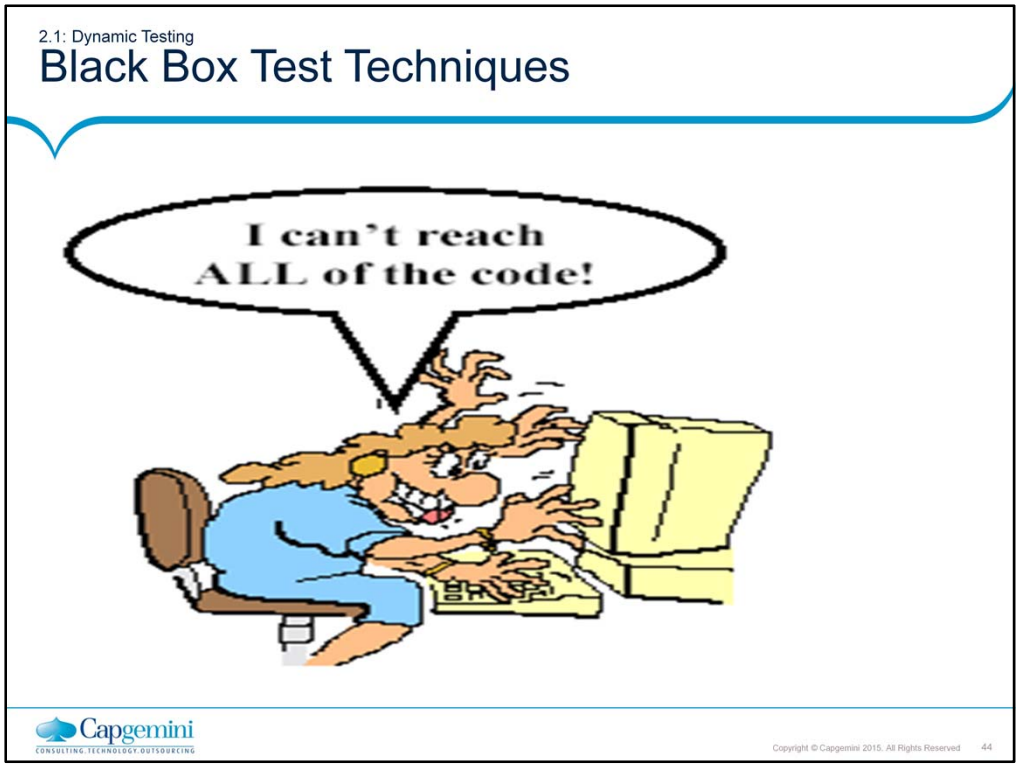
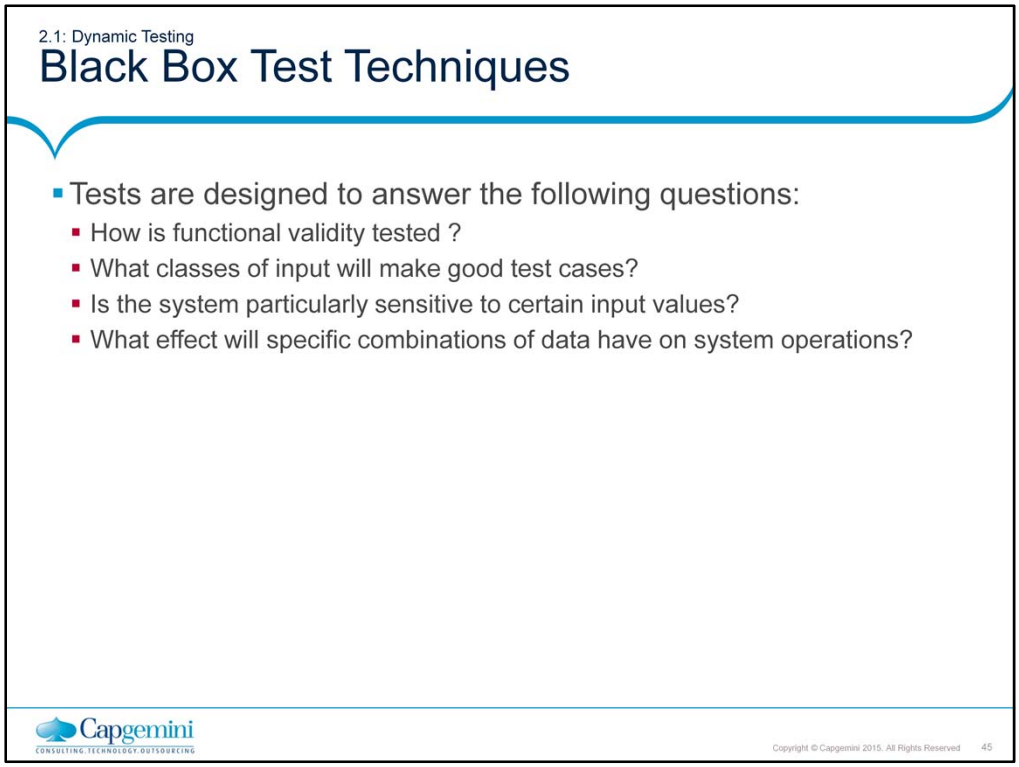
Black Box At Different Levels – Unit, Subsystem and System.

A black box is just a bigger box with more input, functionality, and output.

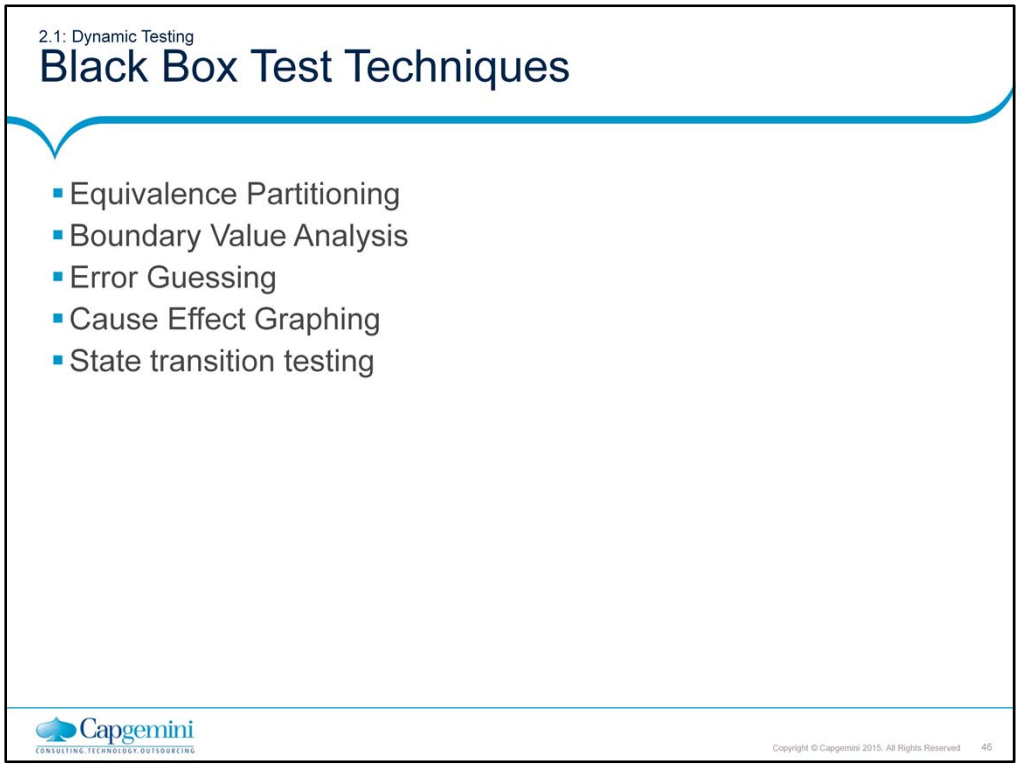


Trainer Notes

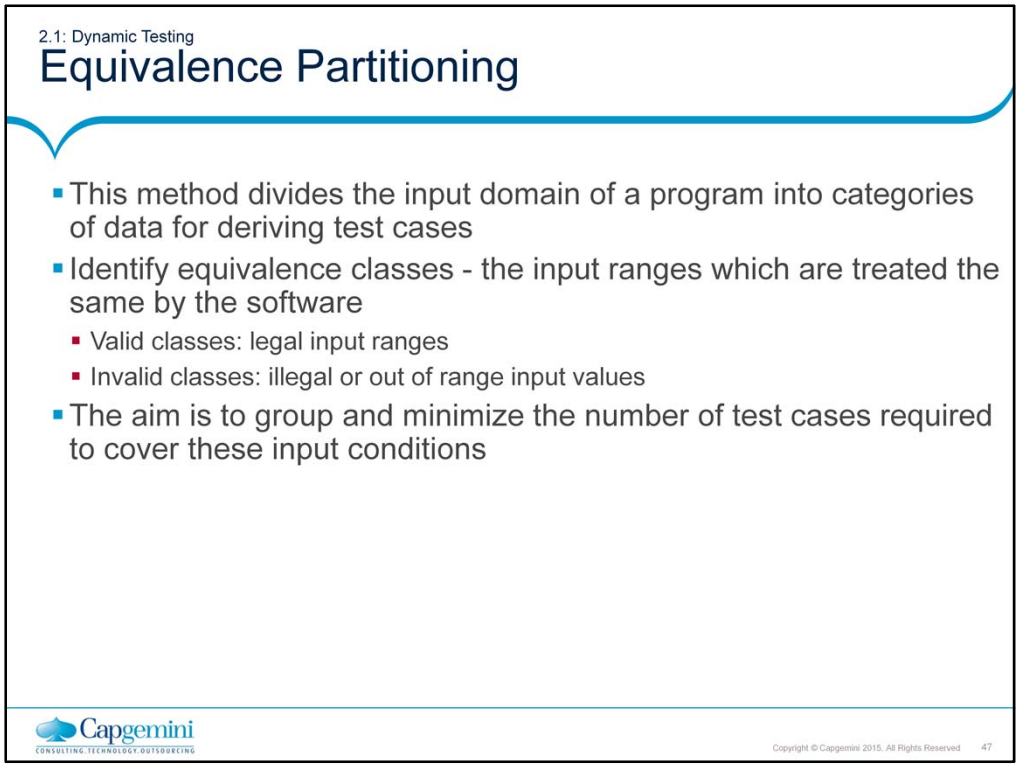


Black Box testing also called behavioral testing, focuses on the functional requirements of the software. Black box testing is not an alternative to white box techniques. Rather it is complementary approach that is likely to uncover a different class of errors than white box methods.

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
(5) initialization errors.



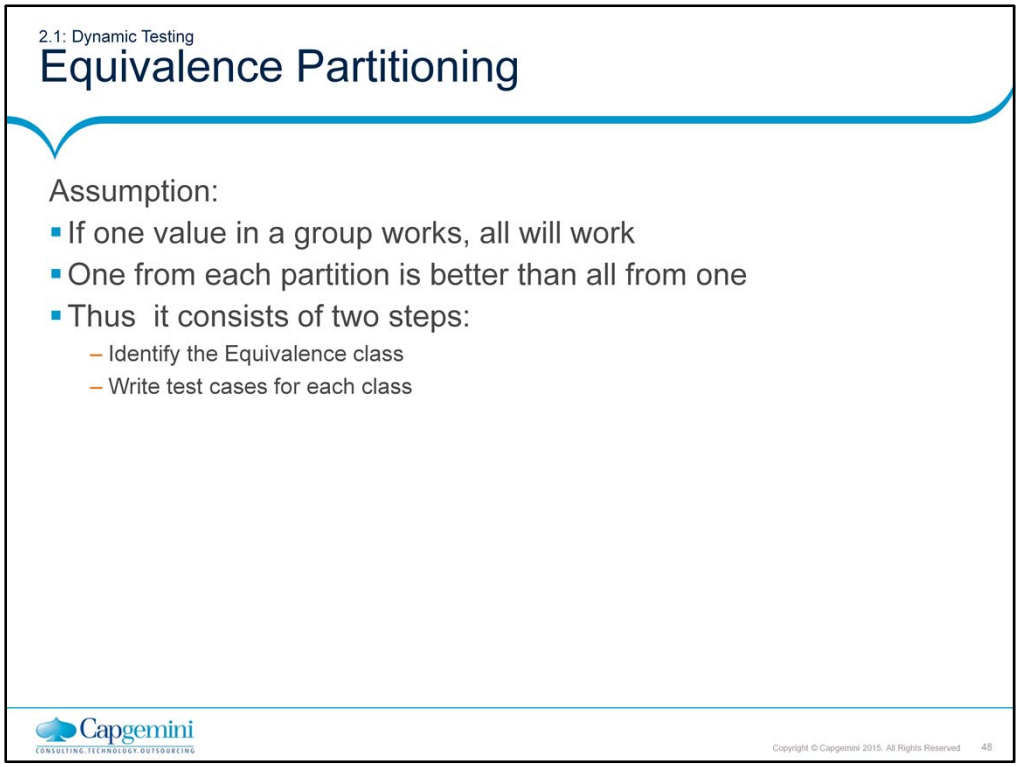
Programmers are logical thinkers, so they catch many of the “logical’ defects. Real users are NOT necessarily logical.
Real environmental circumstances are often illogical.



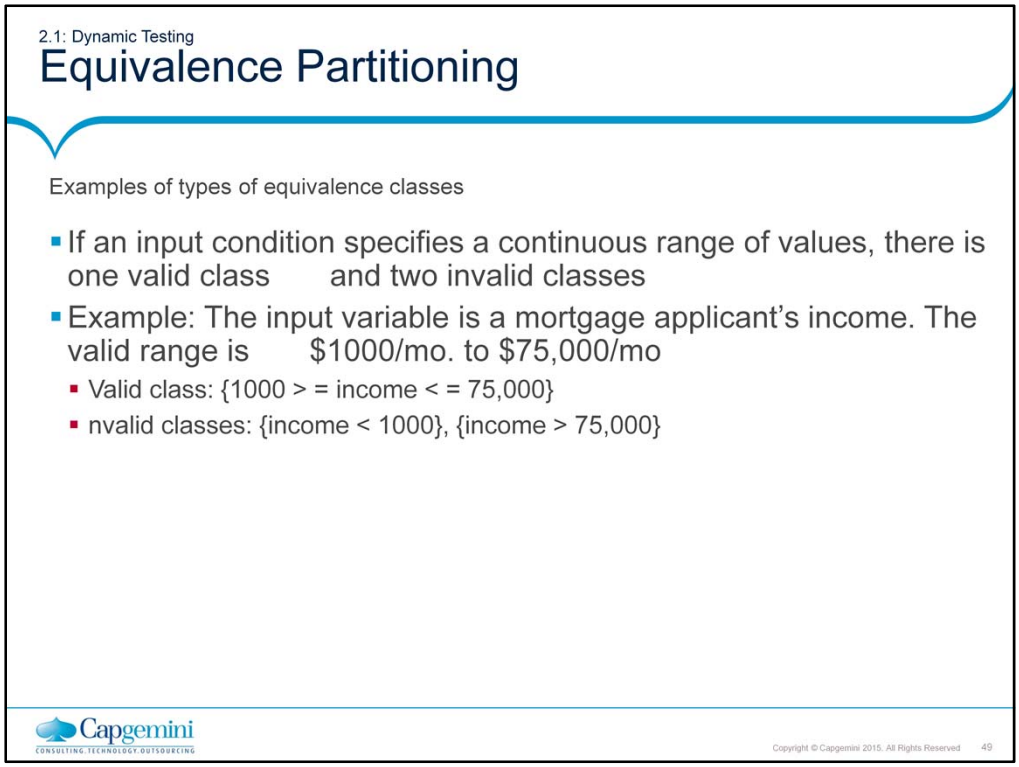
For those familiar with elementary statistical techniques, EP is very much similar to **class intervals** and **tally marks analysis**.

An ideal test case single handedly uncovers a class of errors (e.g. incorrect processing of all character data) that might require many cases to be executed before general error is observed. EP strives to define a test case that uncovers classes of errors, thereby reducing the total number of test cases that must be developed.

An equivalence class represents a set of valid or invalid states for input condition. An input condition is either a specific numeric value , a range of values , a set of related values or a Boolean condition.

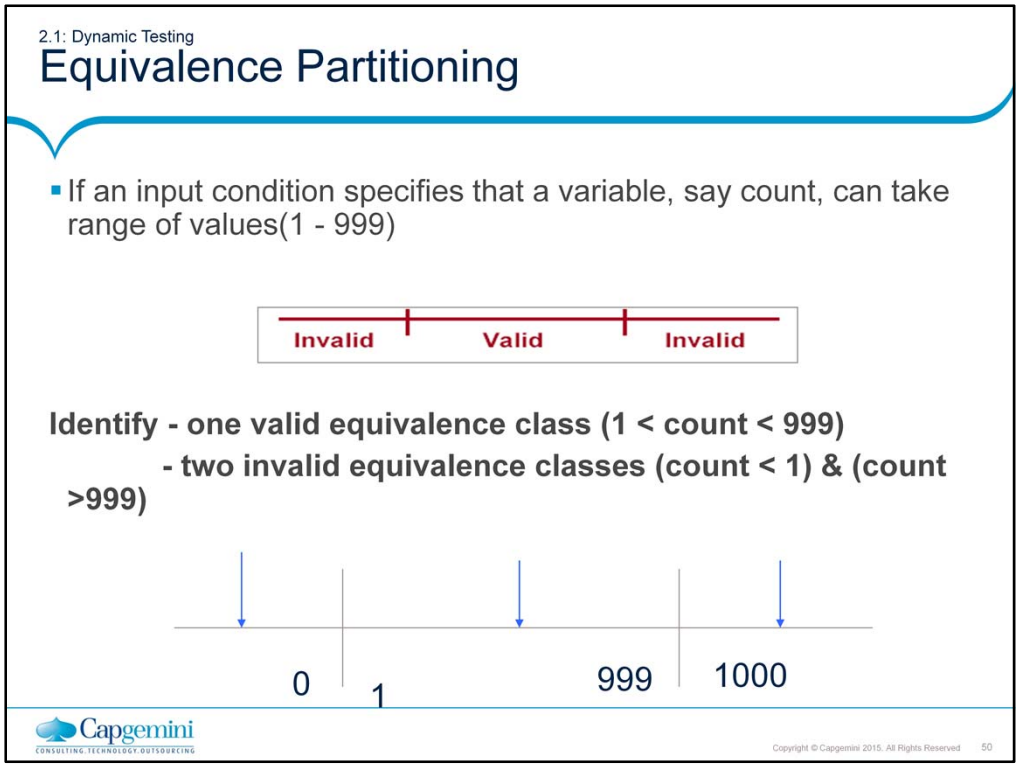


For those familiar with elementary statistical techniques, EP is very much similar to **class intervals** and **tally marks analysis**.



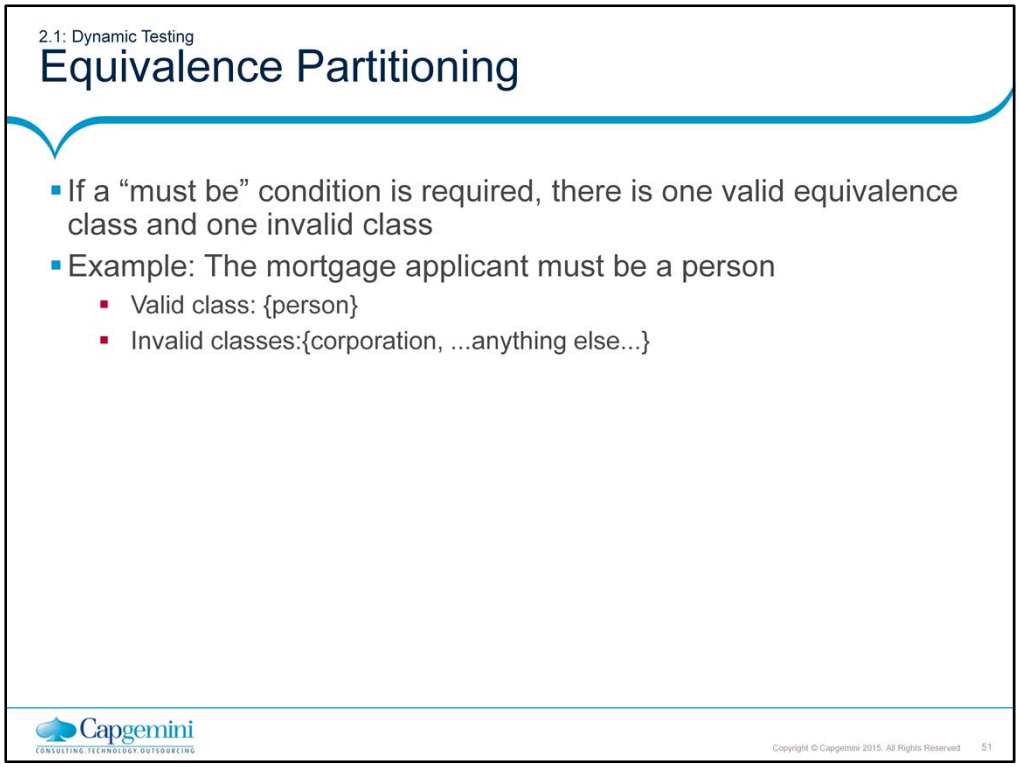
If an input condition specifies a set of values, there is reason to believe that each is handled differently in the program.

e.g., Type of Vehicle must be Bus, Truck, Taxi). A valid equivalence class would be any one of the values and invalid class would be say Trailer or Van.



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 EC are defined.
3. If an input condition specifies a member of a set, one valid and one invalid EC are defined.
4. In an input condition is Boolean, one valid and one invalid class are defined.



If we have to test function **int Max (int a , int b)** the Equivalence Classes for the arguments of the functions will be

Arguments	Valid Values	Invalid Values
A	-32768 <= Value <= 32767	< - 32768 , >32767
B	-32768 <= Value <= 32767	< - 32768 , >32767

2.1: Dynamic Testing

Equivalence Partitioning

Example

- If we have to test function int Max(int a , int b) the Equivalence Classes for the arguments of the functions will be

Arguments	Valid Values	Invalid Values
A	-32768 <= Value <= 32767	< - 32768 , >32767
B	-32768 <= Value <= 32767	< - 32768 , >32767

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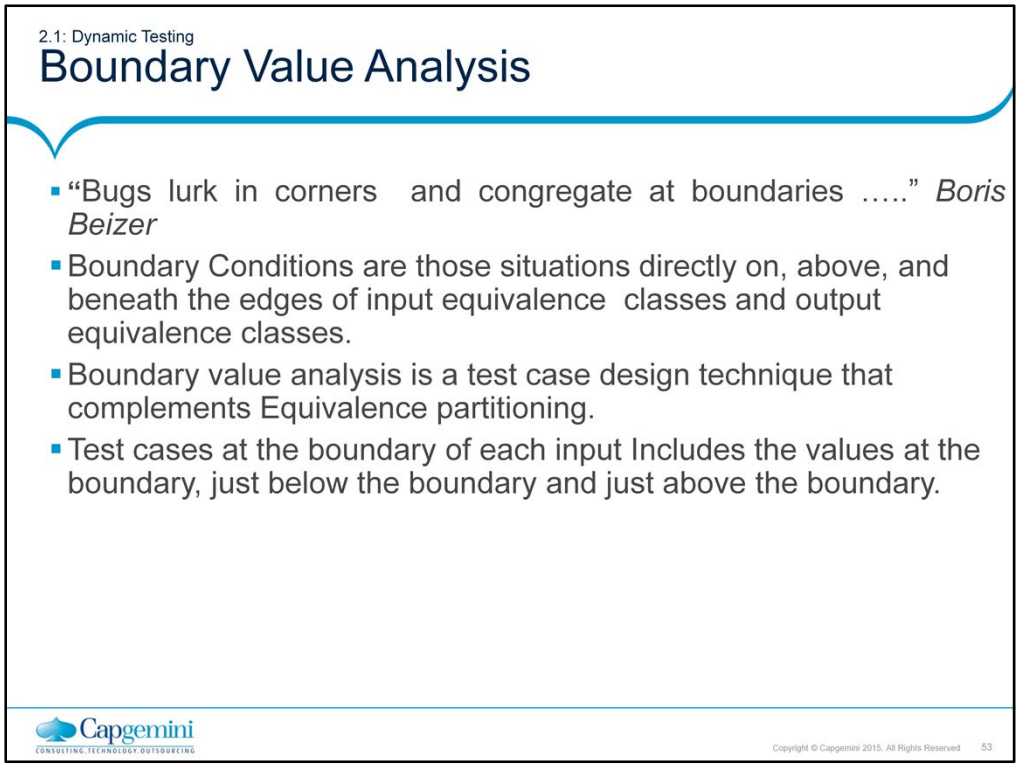
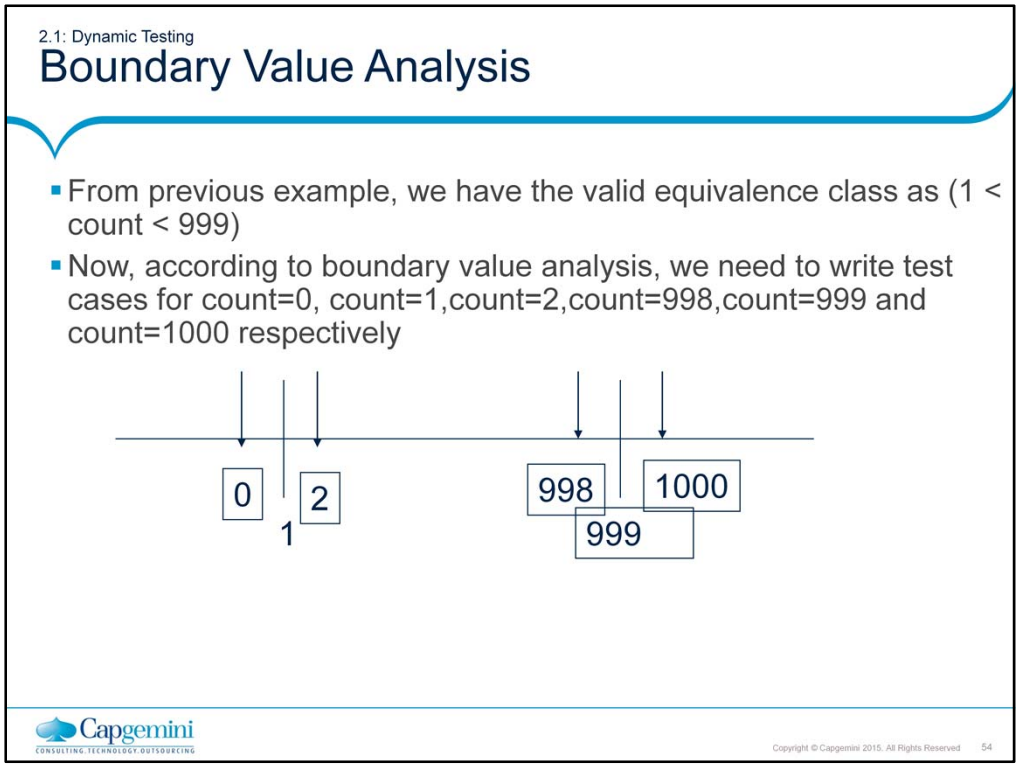
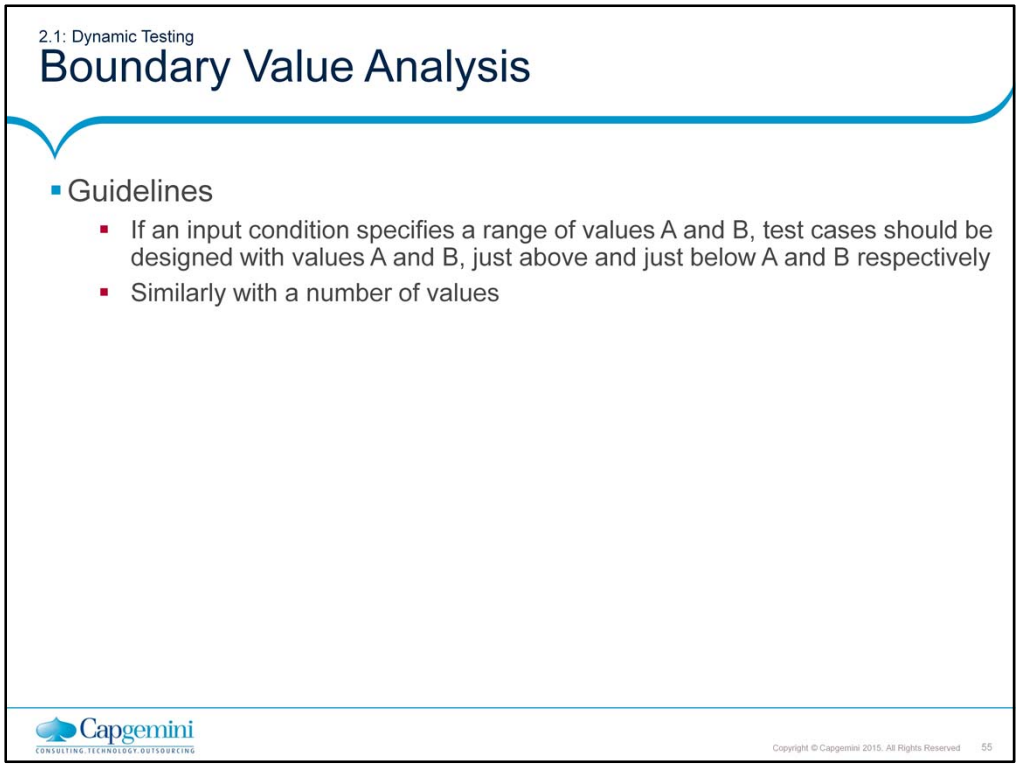


BVA is not as simple as it sounds, because boundary conditions may be subtle and difficult to identify.
The method does not test combinations of input conditions.



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

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



If we have to test function **int Max (int a , int b)** the Equivalence Classes for the arguments of the functions will be

Arguments	Valid Values	Invalid Values
A	-32768 <= Value <= 32767	< - 32768 , >32767
B	-32768 <= Value <= 32767	< - 32768 , >32767

2.1: Dynamic Testing

Boundary Value Analysis

- Example :
- If we have to test function int Max(int a , int b) the Boundary Values for the arguments of the functions will be

Arguments	Valid Values	Invalid Values
A	-32768, -32767, 32767, 32766	-32769,32768
B	-32768, -32767, 32767, 32766	-32769,32768

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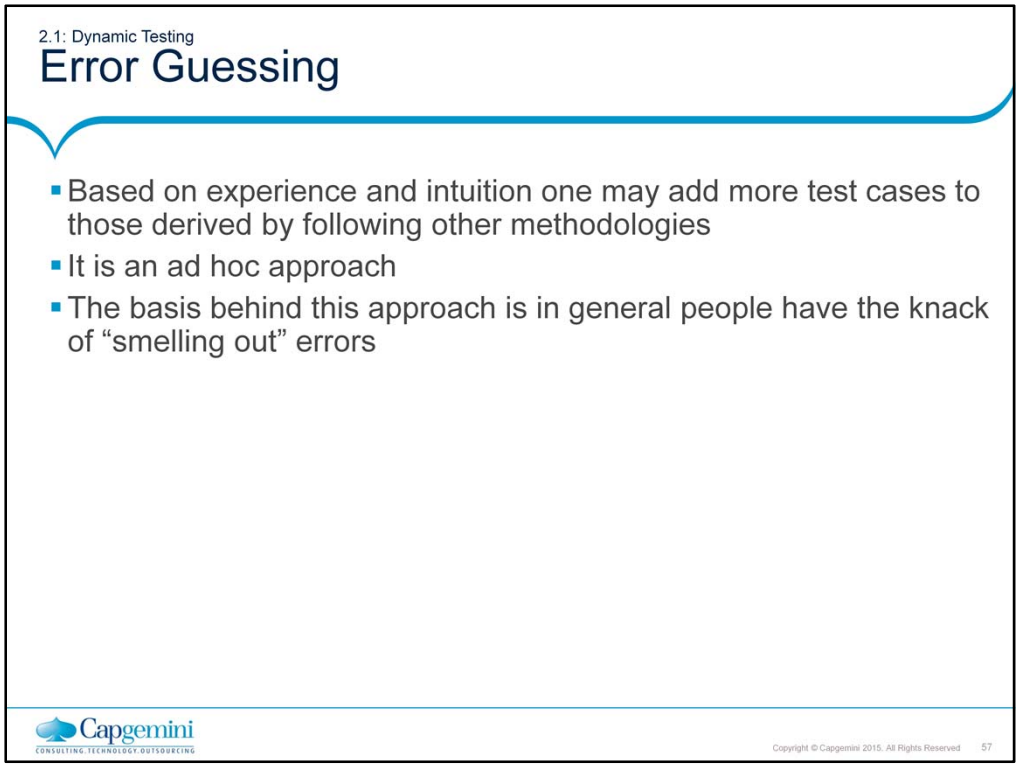
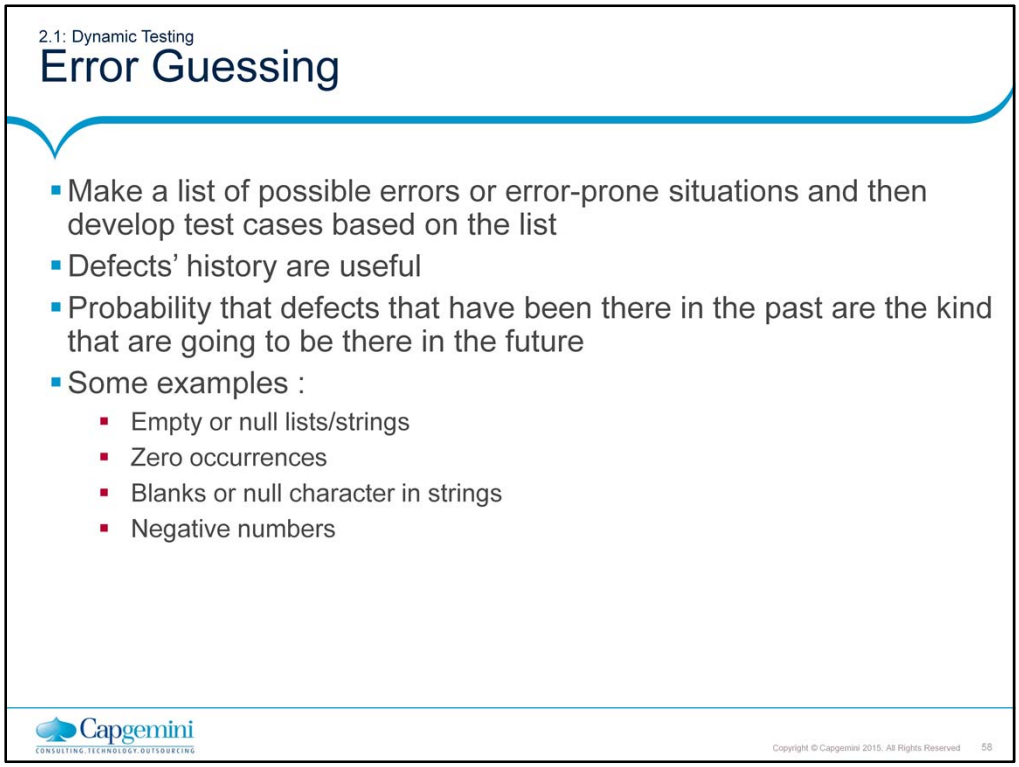
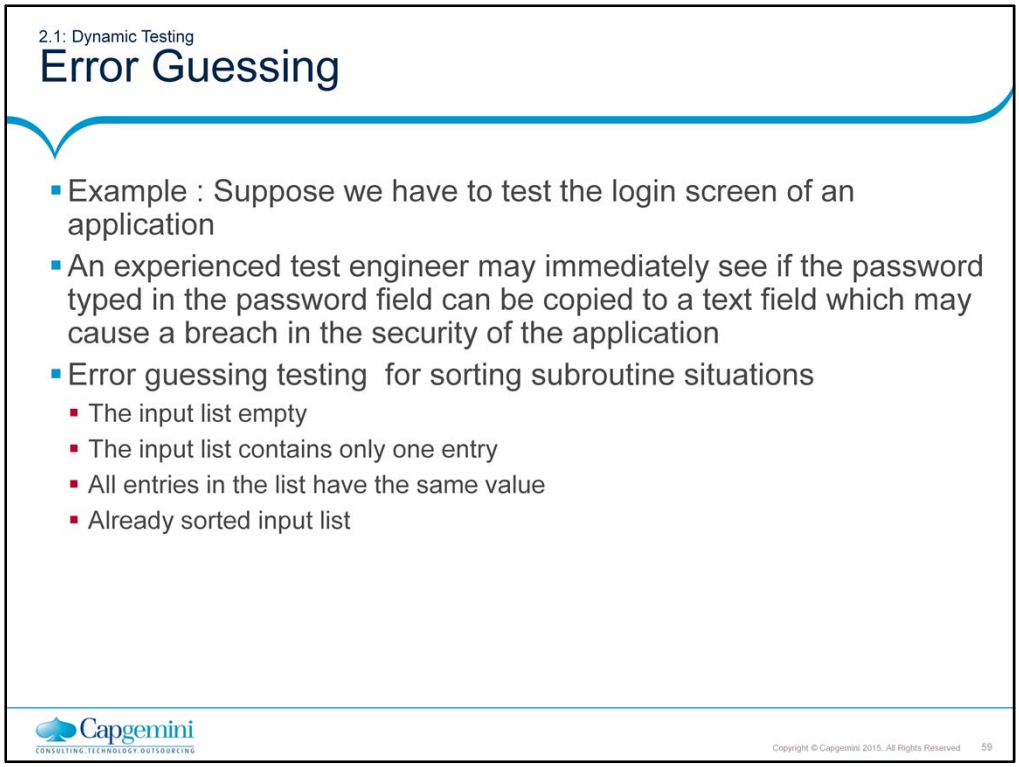


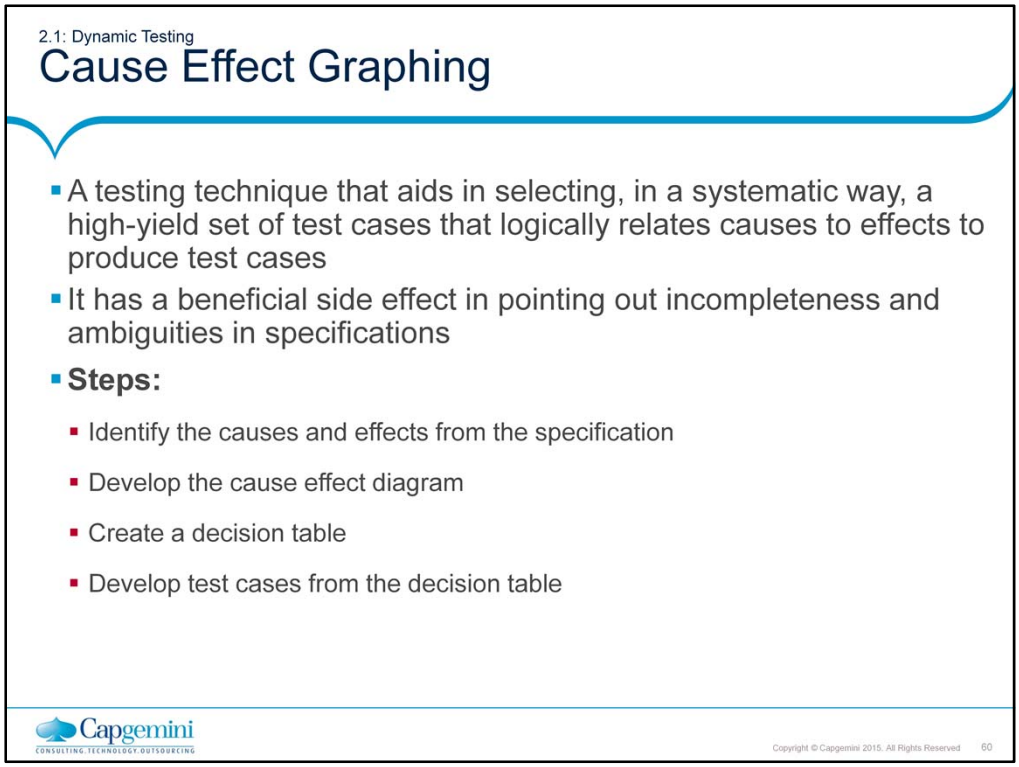
Here mention about Myers Probability study that the probability of errors remaining in the program is proportional to the number of errors that have been found so far, which provides a rich source for productive error guessing.



Trainer Notes

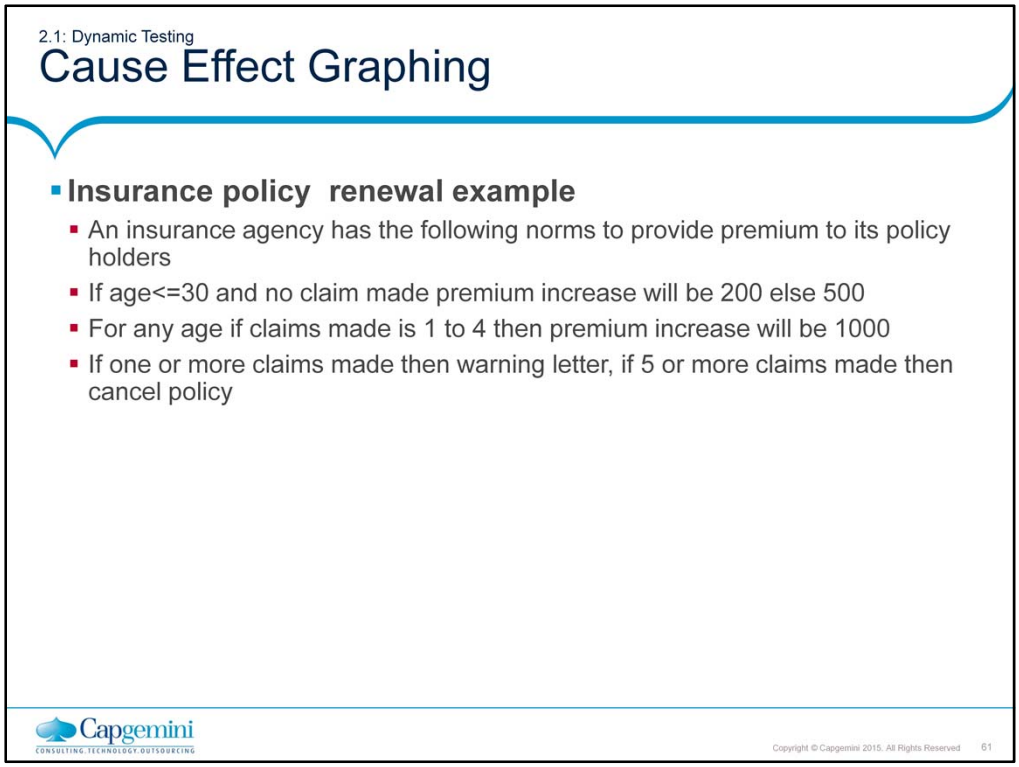


Trainer Notes

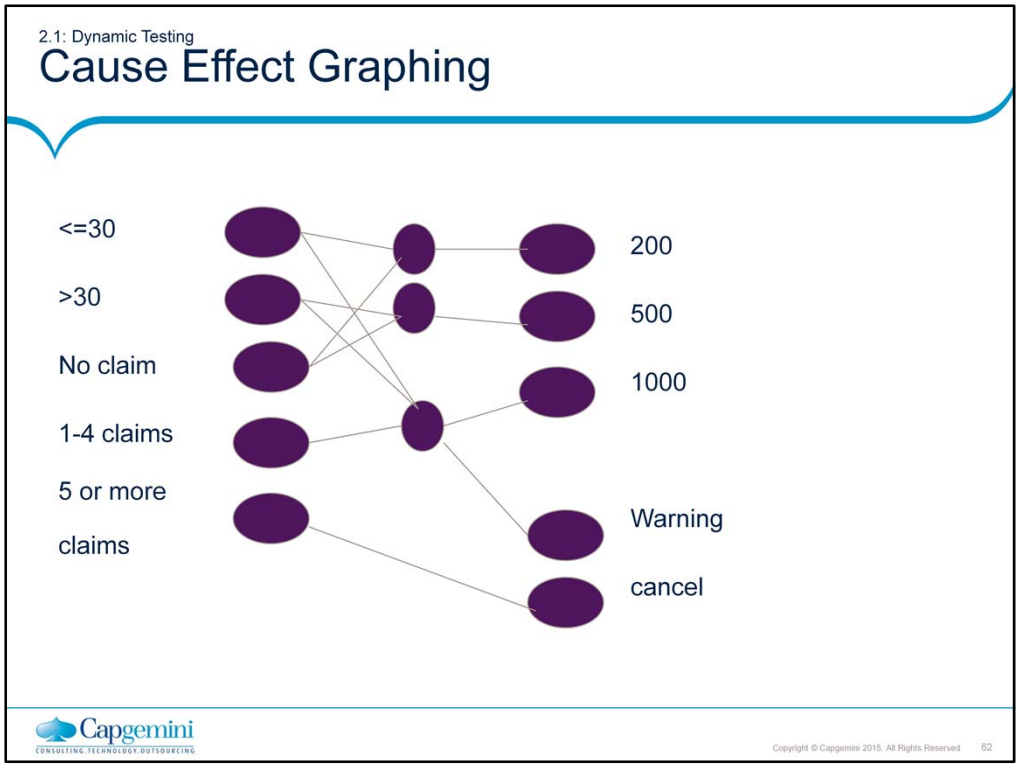


BVA and Equivalence partitioning do not explore combinations of input circumstances.
In Cause effect graphing, causes and effects are identified.
Cause is a distinct input condition. Effect is a distinct output condition.

Cause and Effect - Simple example
E.g. 1
Cause: Got caught in rain
Effect: Cold and cough
E.g. 2
Cause: Hours of Dance practice
Effect: First Prize in the competition

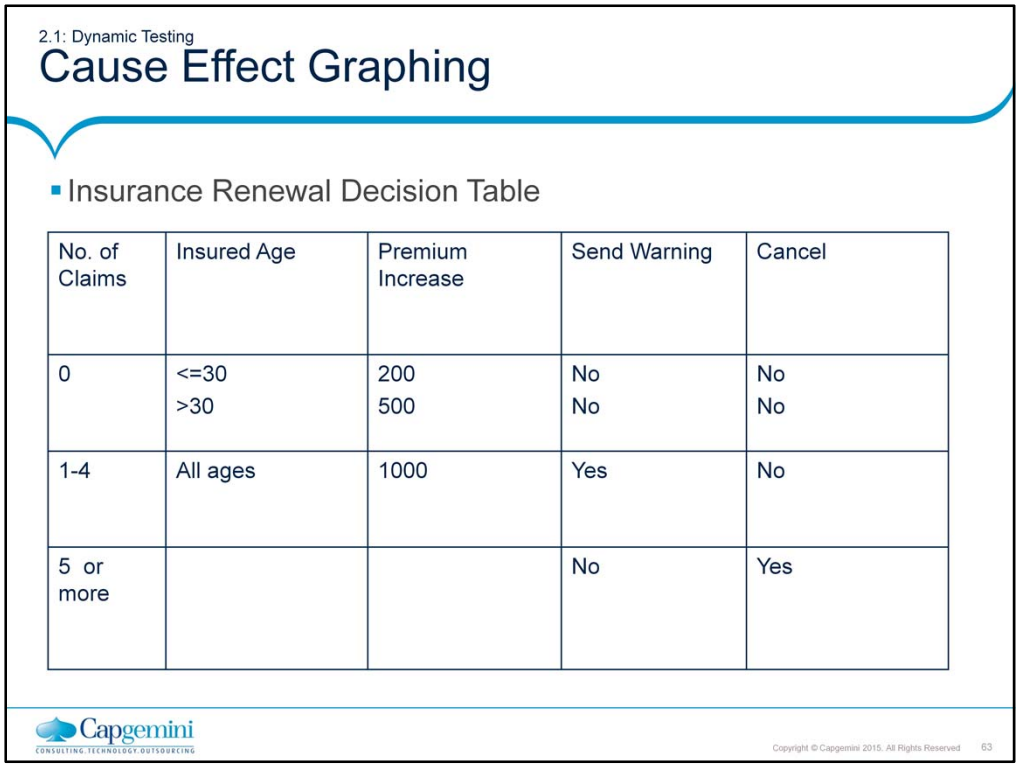


It helps to create the cause and effect diagram through the decision table.



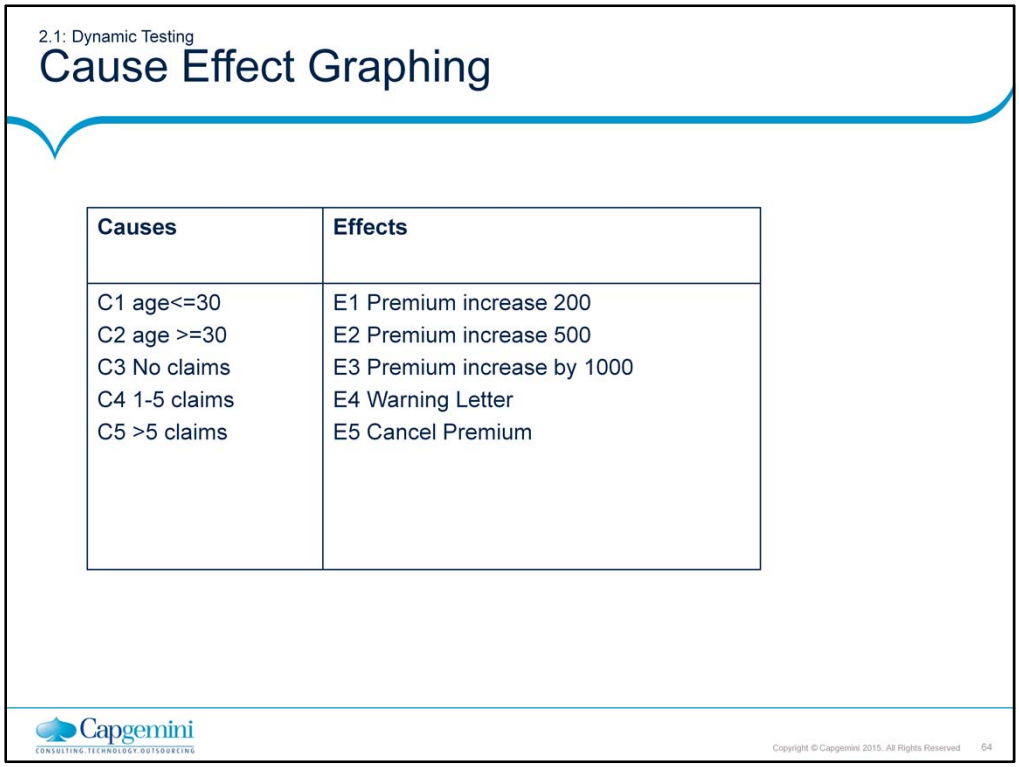
The above graph covers all the combinations of the scenarios where

1. If age<=30 and no claim made premium increase will be 200 else 500
2. For any age if claims made is 1 to 4 then premium increase will be 1000
3. If one or more claims made then warning letter, if 5 or more claims made then cancel policy

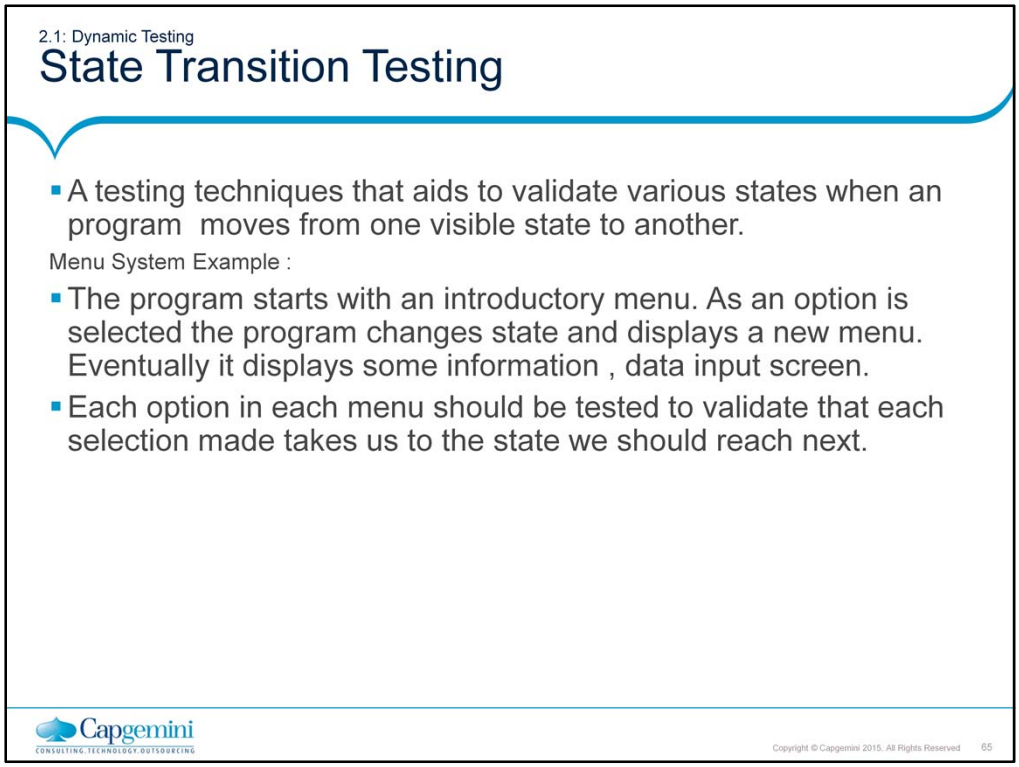


The cause effect graph is converted into decision table. The entire policy terms get transformed into tabular format in more easier way.

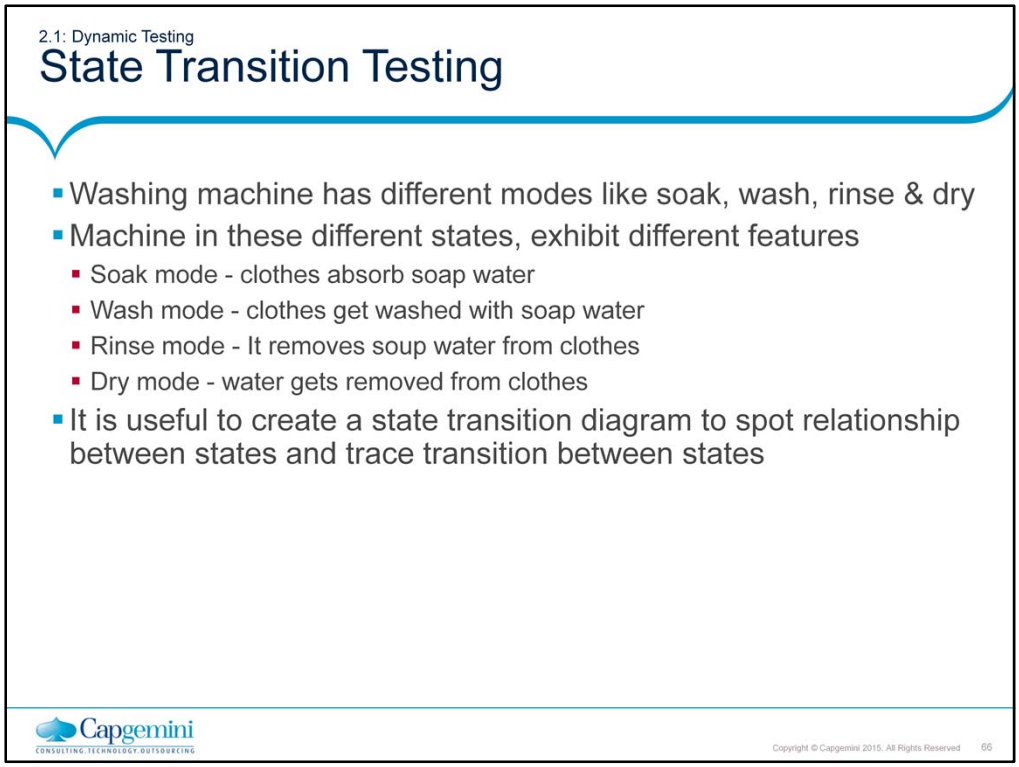
1. If age<=30 and no claim made premium increase will be 200 else 500. No warning will be sent and no cancellation is done.
2. For any age if claims made is 1 to 4 then premium increase will be 1000. Warning will be sent but no cancellation is done
3. If 5 or more claims made then cancel policy



Policy terms are mentioned in the cause and effect manner. All the conditions are termed as causes and its result is reflected as effects in the above table.



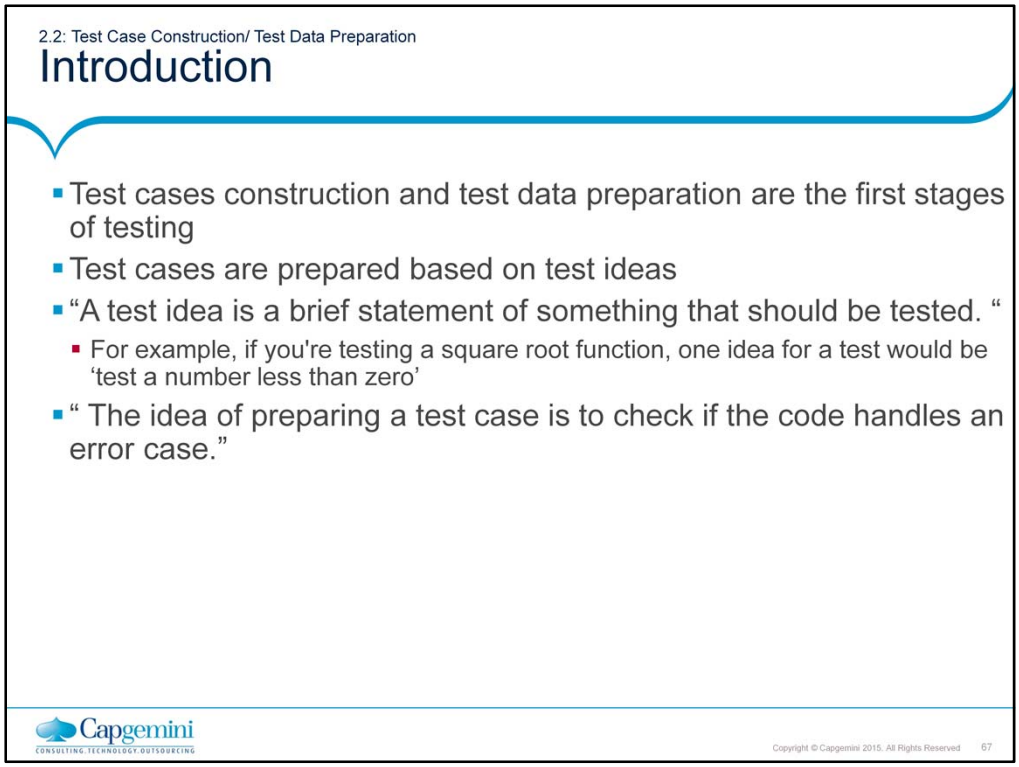
For Example:
A registration form as two buttons, viz. OK and CANCEL. After filling up the entire application, OK button changes to SAVE caption to save the filled data.
So the single button is acting in two different ways depending on its state transition, which has to be tested.



Example :

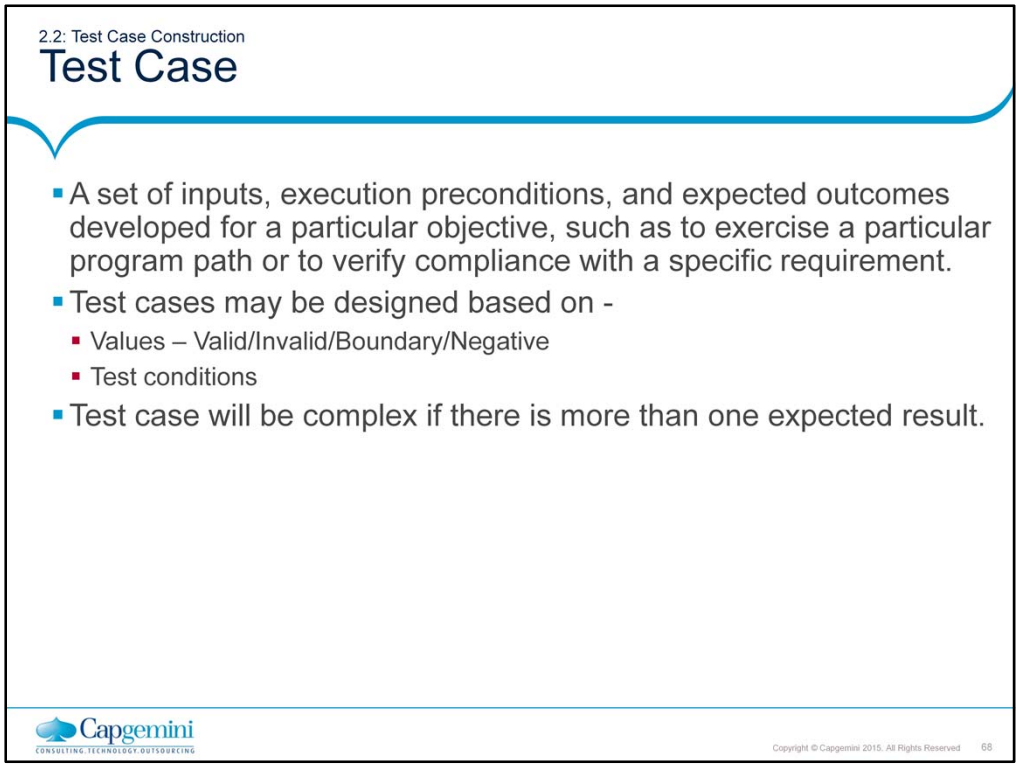
Drawn above is a classic example of State Transition testing. It depicts about the Stack implementation.

1. Initially Stack is in **Empty** state.
2. As soon as, some elements get added to it with push() method, its state changes to
   Loaded.
1. When the element reaches to the Stack's maximum capacity, its state changes from
   Loaded to **FULL.**
1. Similarly, while removing or accessing from the Stack with pop() method, it gets the
   element into **Loaded** state. It extracts the topmost element.



Designing good test cases is a complex art. The complexity comes from three sources:

- Test cases help us discover information. Different types of tests are more effective for different classes of information.
- Test cases can be "good" in a variety of ways. No test case will be good in all of them.
- People tend to create test cases according to certain testing styles, such as domain testing or risk-based testing. Good domain tests are different from good risk-based tests.



A test case is a question that we ask the program. The point of running the test is to gain information, for example whether the program will pass or fail the test.

Characteristics of a Good Test:

They are: likely to catch bugs
not redundant
not too simple or too complex.

2.2.2: Test Case Construction

Test Case Terminologies

- Test Scenario
  - It is an end-to-end flow of a combination of test conditions & test cases integrated in a logical sequence, covering a business processes
- Test Condition / Pre Condition
  - Environmental and state which must be fulfilled before the component/unit can be executed with a particular input value.
  - It is a set of rules under which a tester will determine if a requirement is partially or fully satisfied
  - One test condition will have multiple test cases

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2.2.2: Test Case Construction

Test Case Terminologies

- Test Data/Input
  - Inputs & its combinations/variables used
- Test Procedure
  - A detailed description of steps to execute the test
- Test Result/Output
  - Pass / Fail – If the program works as given in the specification, it is said to Pass otherwise Fail.
  - Failed test cases may lead to code rework

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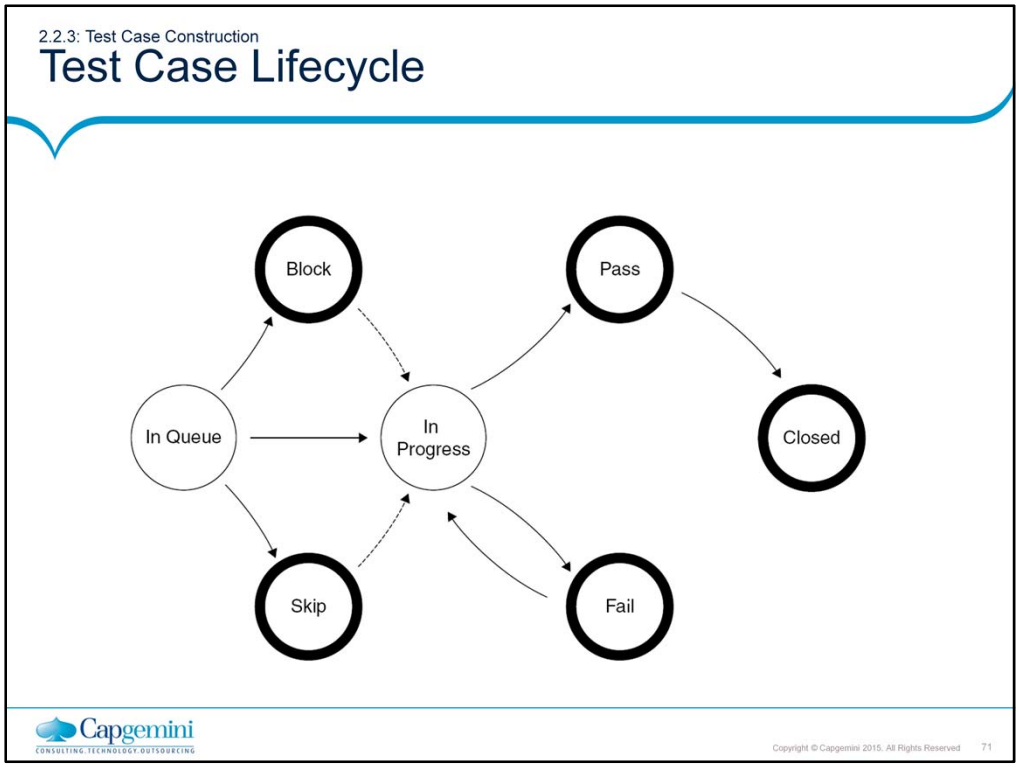
2.2.3: Test Case Construction
Test Case Lifecycle
Block
Pass
In Queue
In Progress
Closed
Skip
Fail
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2.2.3: Test Case Construction

Test Case Lifecycle

- Write an effective and efficient set of test cases.
- The set of tests should find common bugs.
- The set of tests finds those bugs with a reasonable amount of effort.
- Test case incorporated tester action, data, and expected result. The action is usually to input some data, but it might be other actions as well.
- A template is usually followed for writing test cases.

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2.2.3.2: Test Case Construction

Test Case Design Technique

- Test cases are designed based on the following techniques
  - Specification-based - Black Box testing techniques
    - Boundary value analysis, Equivalence partitioning, decision table
  - Structure – based – White Box testing techniques
    - Code coverage, decision coverage, statement coverage
  - Experience based techniques
    - Exploratory testing, fault attack

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2.2.3.2: Test Case Construction

Test Case Template

A	B	C	D	E	F	G	H	I
	Test Cases							
Assumption								
	Test Case Id	PreCondition	Test Scenario / Test Condition	est Case / Test Ste	Test Data	Expected Result	Remarks	Req: Reference
	<Sequence number>	<Identify test scenarios>	<This cell describes **what** to test for i.e. the condition which is being tested for>	<This cell describes **how** to test i.e. the detailed testing procedure>	<Mention test data to be used>	<Describe the expected test result>		

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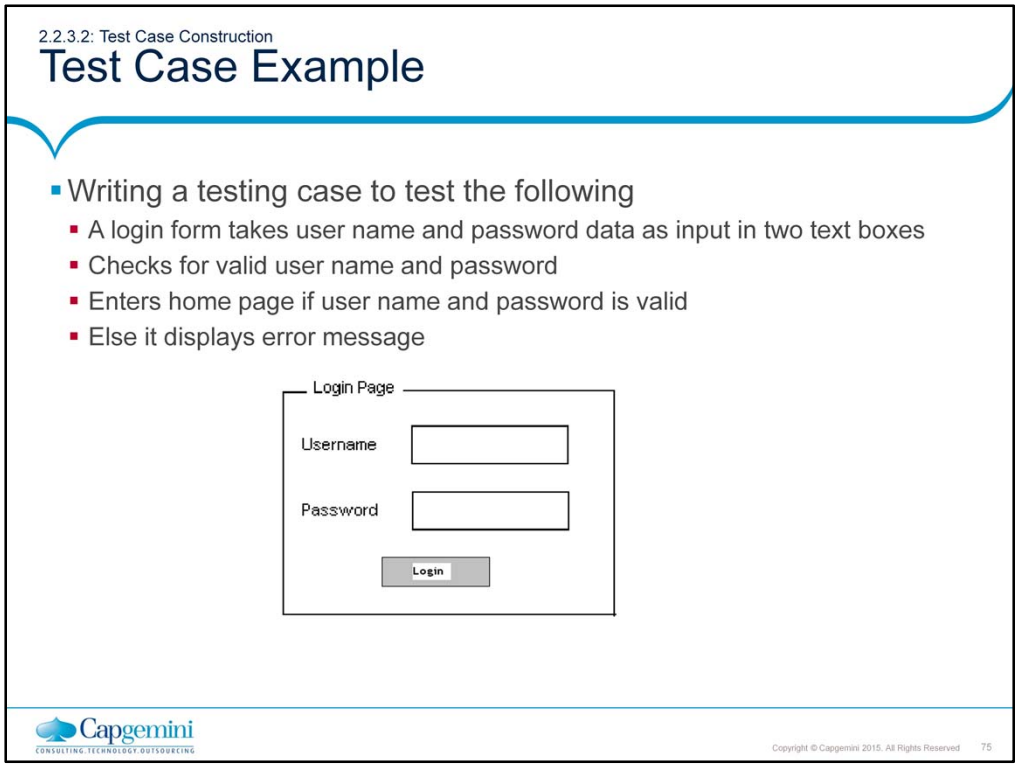
Note: Test case template may vary from project to project. Based on project and client requirement few additional fields can be added in test case template like test environment, module/functionality column/test case type column etc.



The format of test case for login screen should contain :

1. +ve test cases for login.

The positive test case can test with valid user name and password as input data.

2. -ve test cases for login.

In the -ve scenario test case should cover all invalid combinations of input data such as

- User name is null
- Password is null
- Both username and password are null
- Invalid username
- Invalid password

2.2.3.2: Test Case Construction

Test Case Example

- Test Preconditions:
  - User should have valid username and password
  - All the fields must be enabled
  - Application should have proper connection with the database
- Assumptions:
- If there any assumptions while writing the test cases that can be written in the assumption field or column.
- Example:
  - Username: Jim
  - Password: pass123
  - Username: Harry
  - Password:mypass123

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2.2.3.2: Test Case Construction

Test Case Example

- Test Post Conditions:
  - The user is either logged in and home page is displayed
  - Error message is displayed if either the username or password is incorrect
- Test Objective:
  - To check whether the entered username and password are valid or invalid
    - Home page is displayed for valid inputs
    - Error message is displayed for invalid inputs

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2.2.3.2: Test Case Construction

Test Case Design Technique

Assumptions: Valid UserName and password are available in database

	Test Case ID	Preconditions (If any)	Test Condition / Scenario	Test Steps	Input /Test Data	Expected Result	Actual Result
The application is invoked and login page is displayed	TC_01	User name and password field in the login form are enabled	To validate the login page with null password	Enter User Name	Jim		
				Enter password			
				Press LOGIN Button		Should Display Warning Message Box "Please Enter User name and Password"	
The application is invoked and login page is displayed	TC_02	User name and password field in the login form are enabled	To validate the login page with null username	Enter User Name			
				Enter password	igate123		
				Press LOGIN Button		Should Display Warning Message Box "Please Enter User name and Password"	
The application is invoked and login page is displayed	TC_03	User name and password field in the login form are enabled	To validate the login page with valid username and invalid password	Enter User Name	Harry		
				Enter password	mypass123		
				Press LOGIN Button		Should Display Warning Message Box "Please Enter User name and Password"	

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2.2.3.2: Test Case Construction

Test Case Design Technique

The application is invoked and login page is displayed	TC_04	User name and password field in the login form are enabled	To validate the login page with invalid username and valid password	Enter User Name	XYZ		
				Enter password	pass123		
				Press LOGIN Button		Should Display Warning Message Box "Please Enter User name and Password"	
The application is invoked and login page is displayed	TC_05	User name and password field in the login form are enabled	To validate the login page with invalid username and invalid password	Enter User Name	XYZ		
				Enter password	XYZ		
				Press LOGIN Button		Should Display Warning Message Box "Please Enter User name and Password"	
The application is invoked and login page is displayed	TC_06	User name and password field in the login form are enabled	To validate the login page with null username and null password	Enter User Name			
				Enter password			
				Press LOGIN Button		Should Display Warning Message Box "Please Enter User name and Password"	
The application is invoked and login page is displayed	TC_07	User name and password field in the login form are enabled	To validate the login page with valid username and password	Enter User Name	Jim		
				Enter password	pass123		
				Press LOGIN Button		Should navigate to the Home page	

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2.2.4: Test Data Preparation

What is test data?

- Test Data
  - An application is built for a business purpose. We input data and there is a corresponding output. While an application is being tested we need to use dummy data to simulate the business workflows. This is called test data.
  - A test scenario will always have an associated test data.Tester may provide test data at the time of executing the test cases or application may pick the required input data from the predefined data locations.
  - The test data may be any kind of input to application, any kind of file that is loaded by the application or entries read from the database tables. It may be in any format like xml test data, stand alone variables, SQL test data etc.
- If you are testing with bad or unstable data, how can you be sure your test results are accurate!!!

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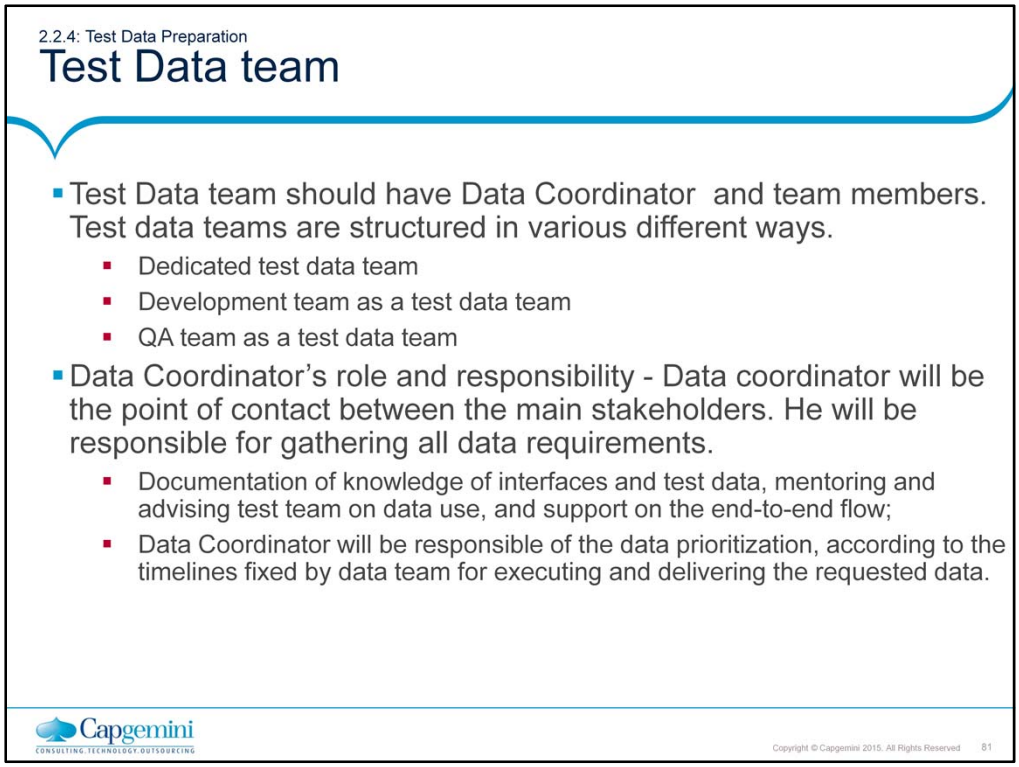
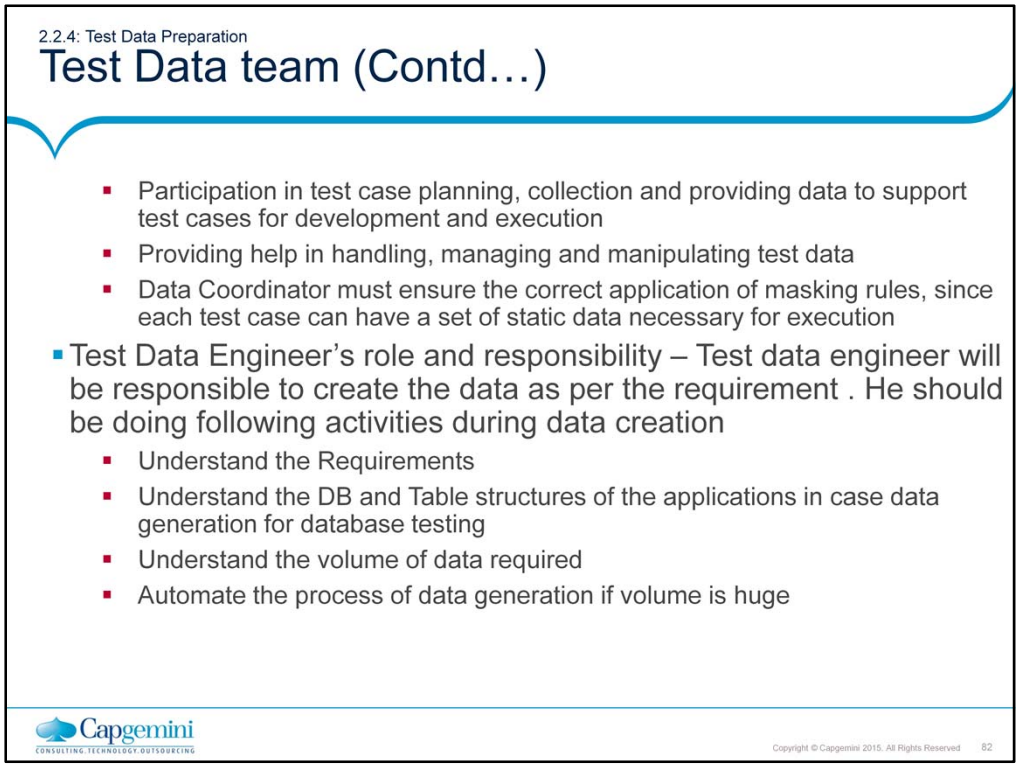


Self explanatory



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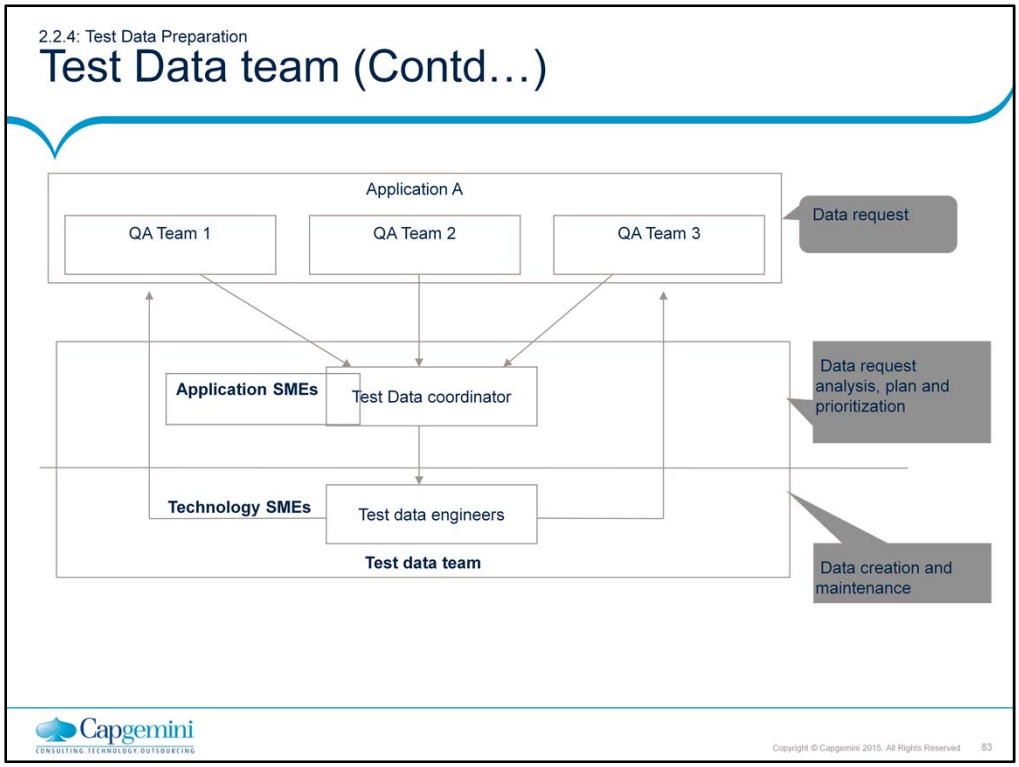

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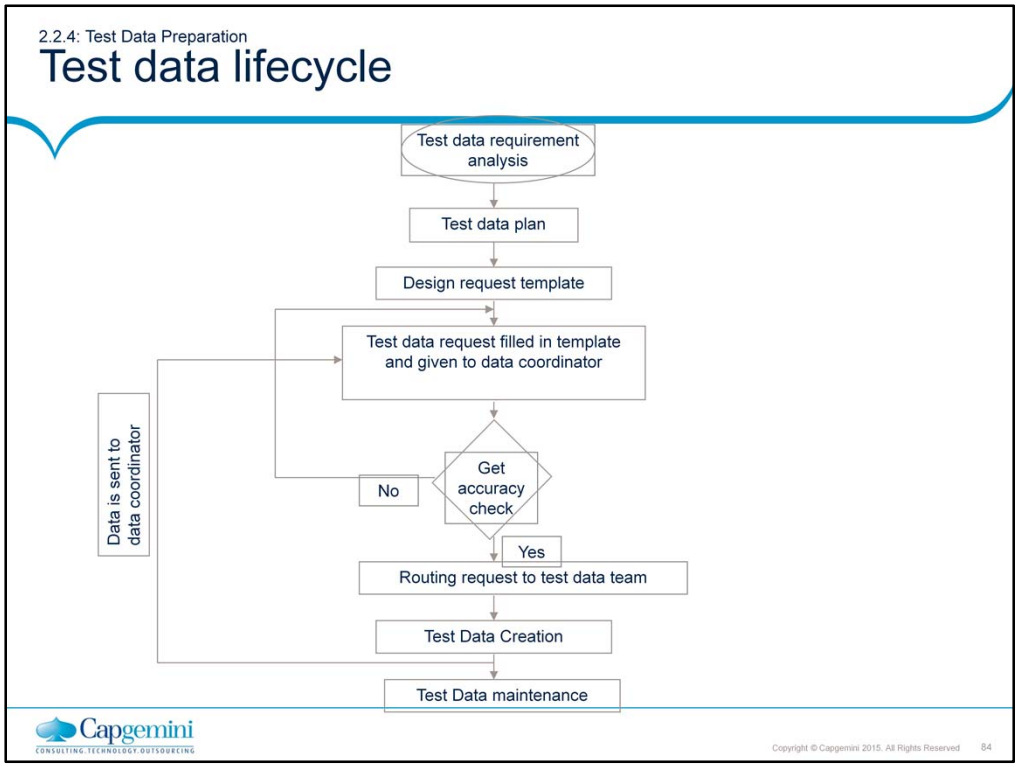
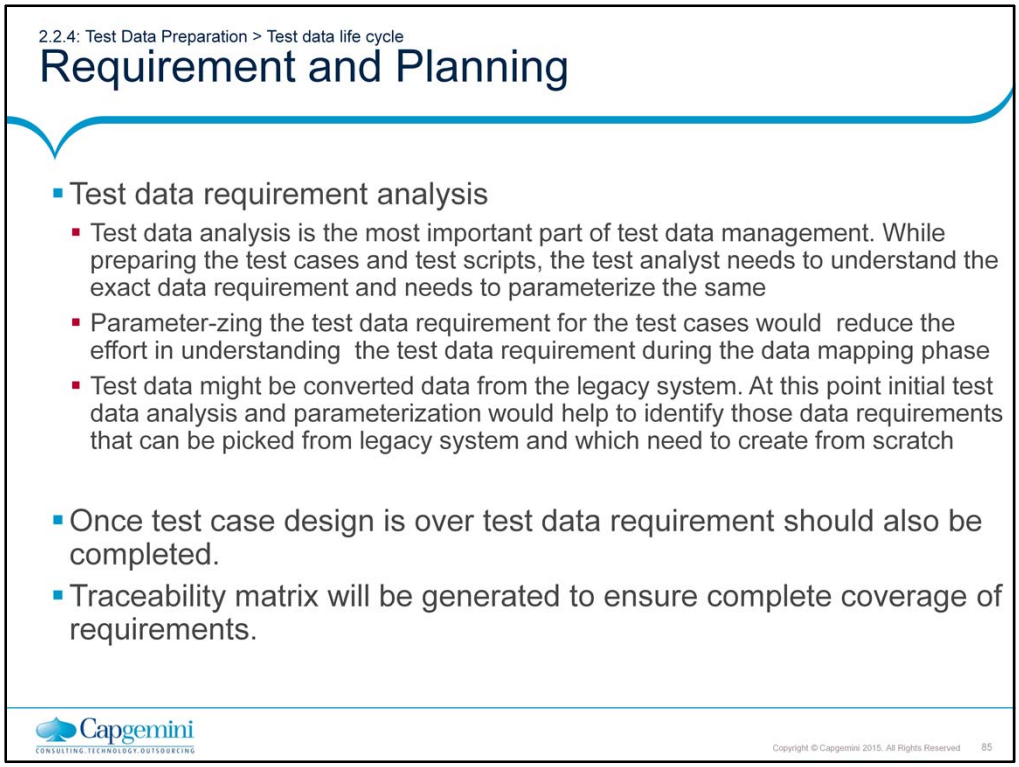


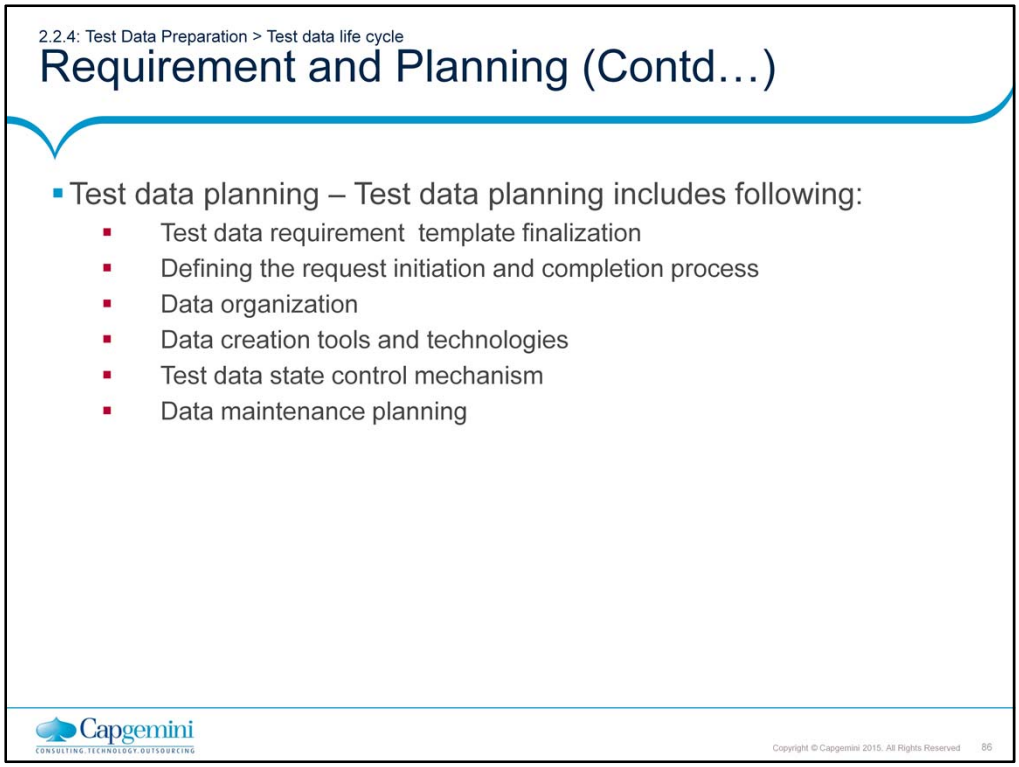
The way we have SDLC and STLC for software, the same way test data has to follow a defined path.

It having similar phases as STLC:

1. Requirement
2. Plan
3. Creation
4. Usage and maintenance



Parameterzing means a value or a symbolic reference to a value.
Give some value for each data requirement. So If sample is available then its easy to understand the exact data requirements.



Planning - > A standard template will always be helpful during requirement gathering as all the users have the common understanding of the fields in template.
By looking at the requirements need to plan if there is any tool is require to generate the data. For example any kind of database testing will be required millions of records that are not possible to create manually.
Once data is created it might required for subsequent iterations or releases, in that case data need to maintain.
For maintenance it's required to know the data state after the execution and the required state for next iteration. So proper data state control mechanism should be in place.

2.2.4: Test Data Preparation > Test data life cycle

Request Process

- The communication between data coordinator and QA Testing Team must follow certain standards in terms of requests template. The data coordinator will act as a single entry point for the QA Team and will be able to retrieve data for testing.
  - Data request Template
    - The Testing Team will address their requests to the data coordinator through a standard template
    - The template includes fields to fulfil with detailed information's for each kind of requested data. The tester has to describe very precisely the needs of required data for execution of test cases to ensure quick and consistent delivery of data from the data team
    - The fields integrated in the request template are grouped for each kind of data
    - The QA Testers have to fill the template and when it's possible add a sample of required data
    - The data coordinator will be in charge of the data request template from QA team

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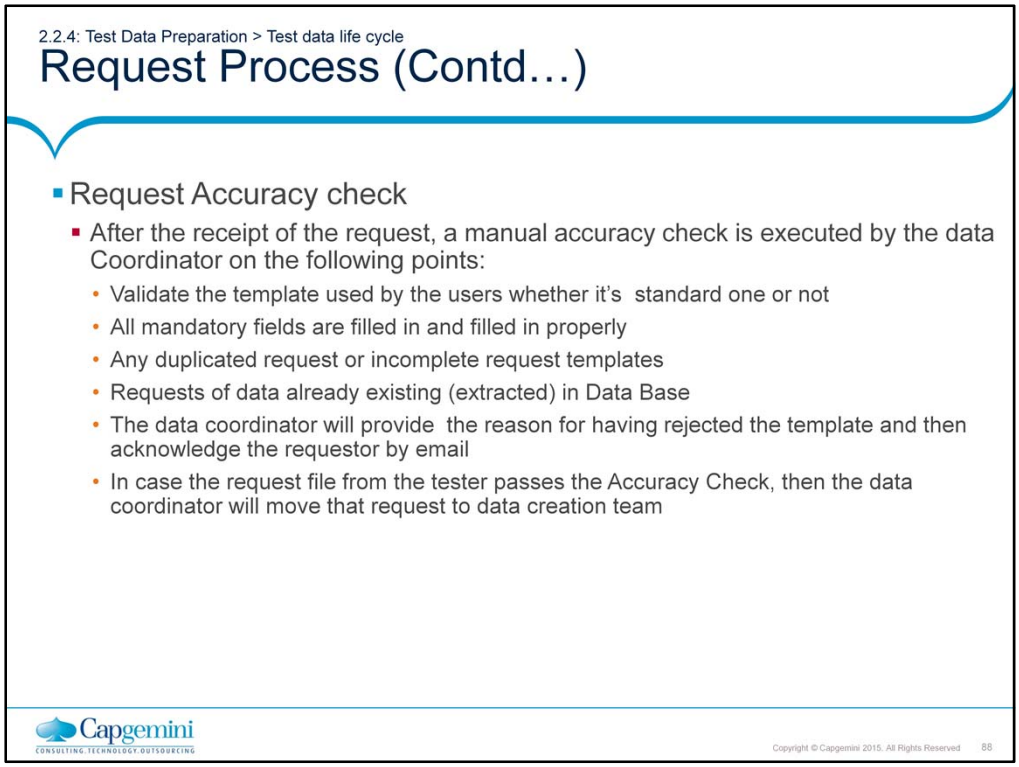
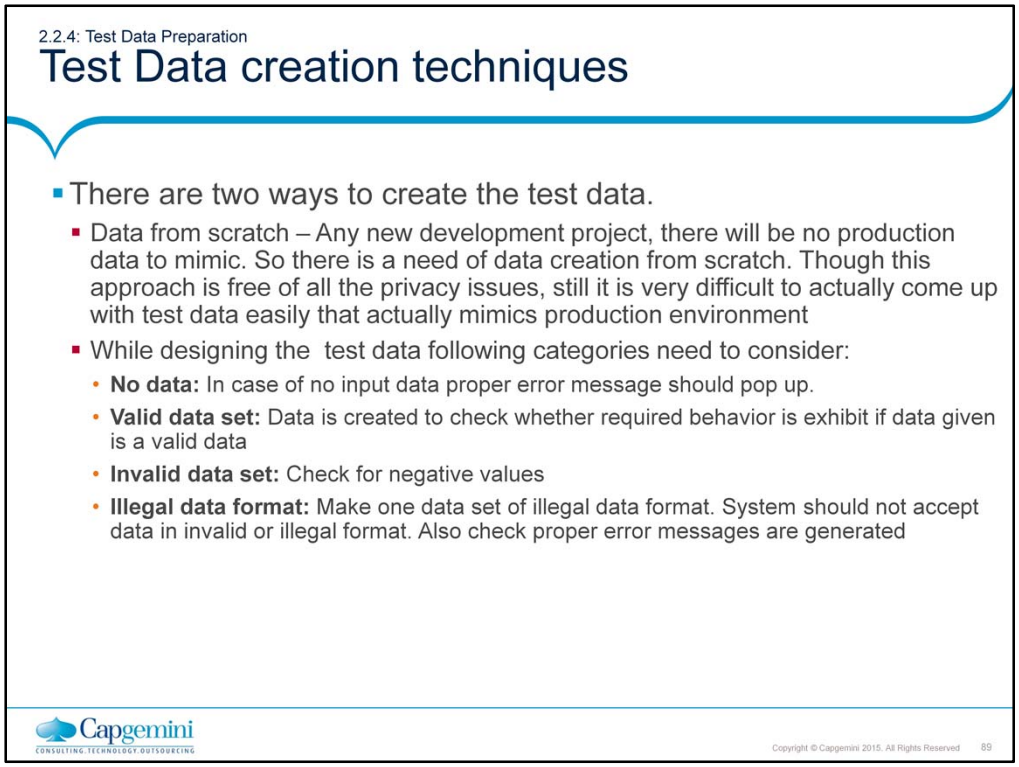


Give example of existing project.



An application accepting integer values (that is whole number values) between -10,000 to +10,000 can be expected to be able to handle negative integers, zero and positive integers. Therefore, the set of input values can be divided into three partitions:
From -10,000 to -1, 0 and from 1 to 10,000

2.2.4: Test Data Preparation

Test Data creation techniques (Contd…)

- Boundary Condition data set: Data set containing out of range data. Identify application boundary cases and prepare data set that will cover lower as well as upper boundary conditions
- Equivalent partition: Set of data to an input condition that give the same result when executing a program and partitioning them from another equivalent set of data for the same condition
- Decision Tree: This model is used to visually represent the paths from input to all possible outputs of a given system. Data is created for each node and corresponding branches
- State transition: State-Transition testing is identifying the states, events, actions, and transitions that should be tested. It also define how a system interacts with the outside world, the events it processes

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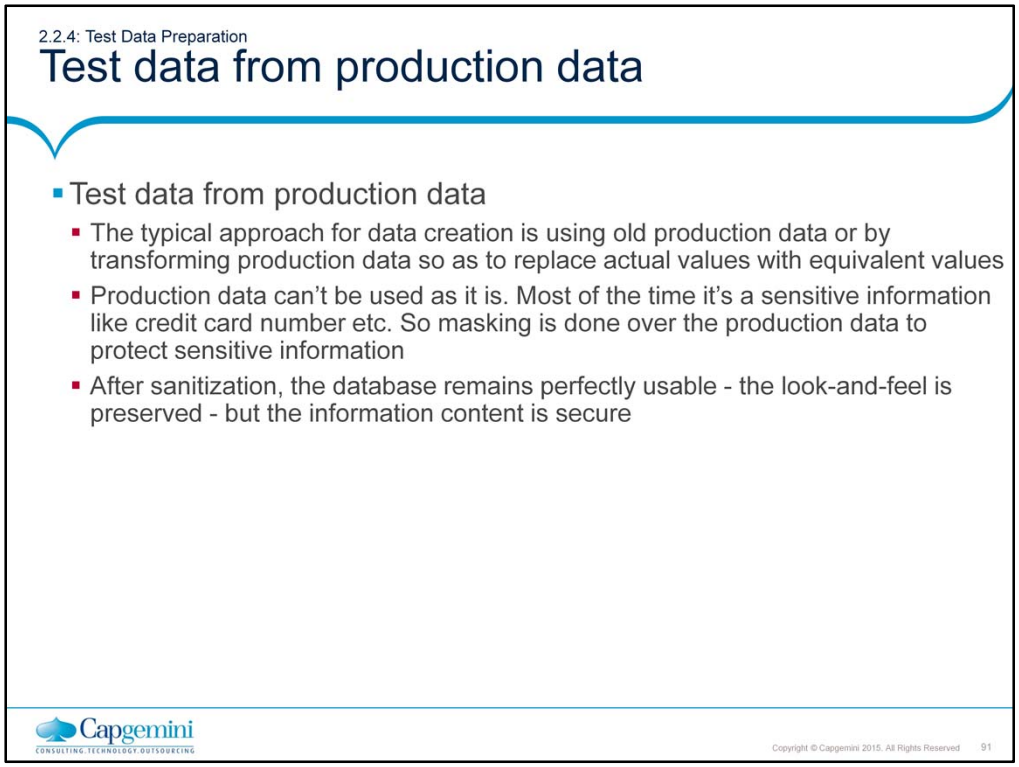

For example any search engine project 'statistics testing'. To check history of user searches and clicks on advertiser campaigns large data was processed for several years which is practically impossible to manipulate manually for several dates spread over many years. So there is no other option than using live server data backup for testing.

2.2.4: Test Data Preparation

Test data life cycle - Maintenance

- Data maintenance
  - Data maintenance is a sizeable task, and it is be substantial fraction of overall test maintenance costs
- Activities
  - Data maintenance team should closely with the execution team to monitor any data related defects that are raised during the execution phase
  - In case of data corruption due to defect fixes or due to major deployment, the test data management team should take the lead and analyze the extent of data corruption and start data mapping activity as a part of maintenance

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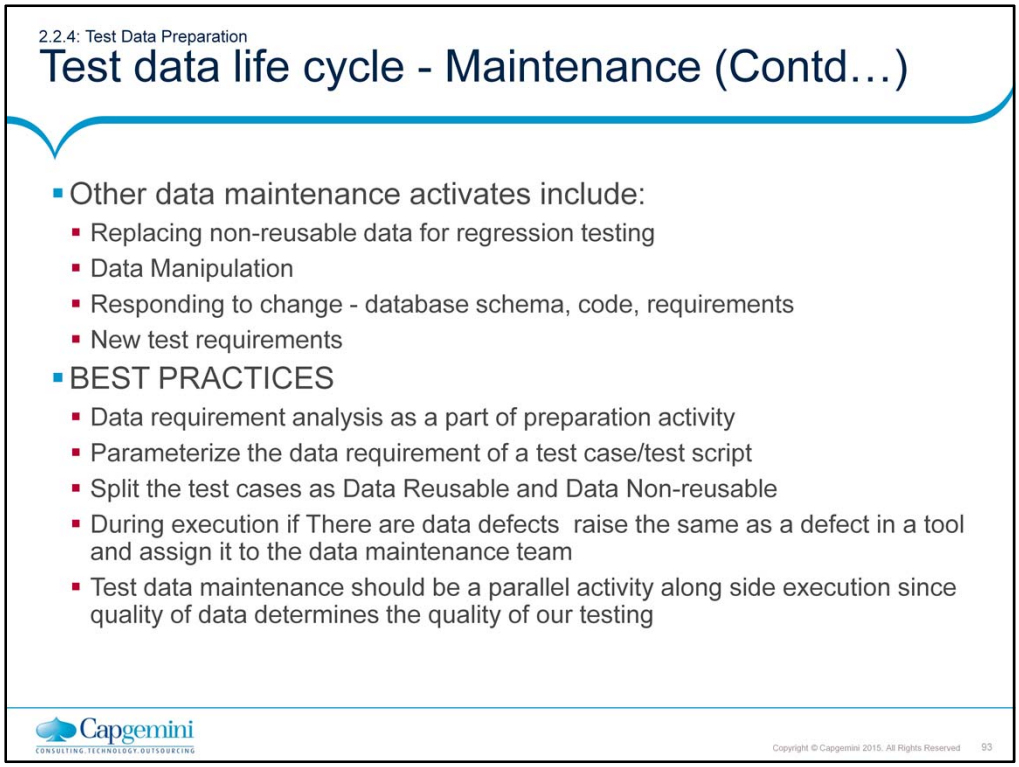


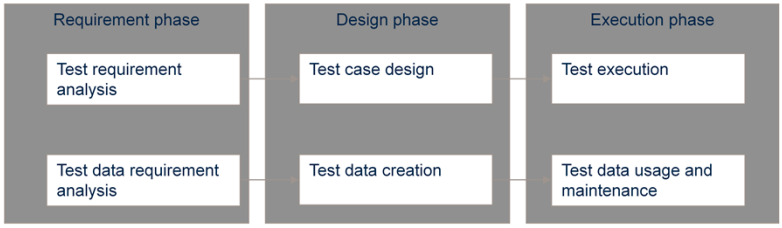
Data-Reusable Test case: A test case or a test script that does not change the nature of the test data that has been mapped to it. An example would be customer enquiry test cases, where customer identification number (CIN) or an account number (A/c) is mapped to the test case. While executing the test case, the data does not get corrupt. Hence this data can be reused. Such test cases are classified as Data-Reusable test cases.

Data-Non-Reusable: A test case or a test script that changes the nature of the test data that has been mapped to it comes under this category. An example would be a case where a customer is marked as deceased. Once data is modified after the execution of the test script, the same data cannot be reused across another test case.

2.2.4: Test Data Preparation

Test data in STLC - Staggered with test case Design

+ve	-ve
•All Test data will be ready before Test Execution phase. •As Test cases are designed and signed-off, data creation will happen almost concurrently.	•There are issues such as Resource overloading, idle time due to lesser test case inputs or not having logical test cases, which may lead to load balancing challenges



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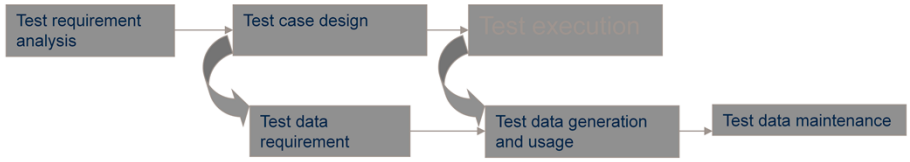
Self explanatory

2.2.4: Test Data Preparation

Test data in STLC - Staggered with test case Execution



+ve	-ve
•Test data creation will happen as per Test Execution Priority •Minimizes rework as all Test Cases will be designed and signed-off prior to Test Data creation	•Test data dependencies between different areas to be tested might be overlooked •Some of the Test data creation can be redundant

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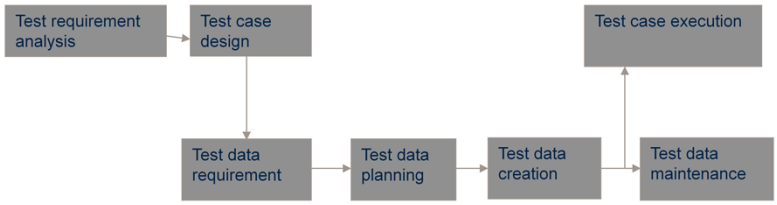
2.2.4: Test Data Preparation

Test data in STLC -Standalone phase between Test Case Design and Test Case Execution

+ve	-ve
•Test data creation happens with clear exit criteria from Test design phase and with clear entry criteria for the Test Execution phase •Data creation will be completed so There will be no or minimal resource load balancing problems	• If not planned in advance, Test Data creation activities can delay the start of Test execution activities



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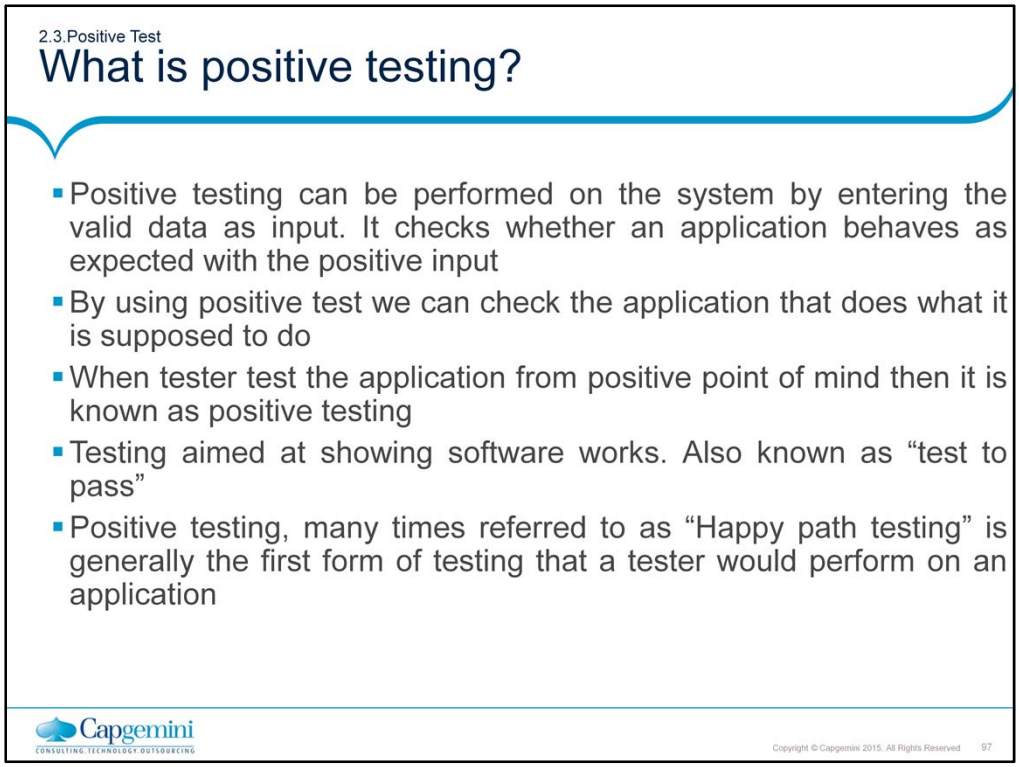

Note: Equivalence Partitioning and boundary value analysis are test case design techniques used for writing positive test cases.

2.3.Positive Test

Example of positive testing

- Example of positive testing
- Consider a scenario where you want to test an voting application which contains a simple textbox to enter age and requirement is that it should take only integers values and the value should be greater than 18. So here provide only positive integer values which are greater than 18 to check whether it is working as expected or not is the Positive Testing. Most of the applications developers are implement Positive scenarios. Testing point of view testers get less defects count around positive testing.

Age: Enter only integer values

> 18 19

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2.3.Positive Test

Advantages/Limitations of positive testing

- Advantages of positive testing
  - Positive testing proves that a given product and project always meets the requirements and specifications
  - Positive testing is useful in the normal day to day life scenarios as it checks the expected behavior of application
  - Positive testing ensures that the business use case is validated
- Limitations of Positive testing:
  - Positive tests check for only valid set of values

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2.3.Positive Test

Positive test scenarios

- Let's take example of Positive testing scenarios:
  - If the requirement is saying that password text field should accepts 5 – 15 characters and only alphanumeric characters.
- Positive Test Scenarios:
  - Password textbox should accept 5 characters
  - Password textbox should accept upto 15 characters
  - Password textbox should accepts any value in between 5-15 chars length
  - Password textbox should accepts all numeric & alphabets values

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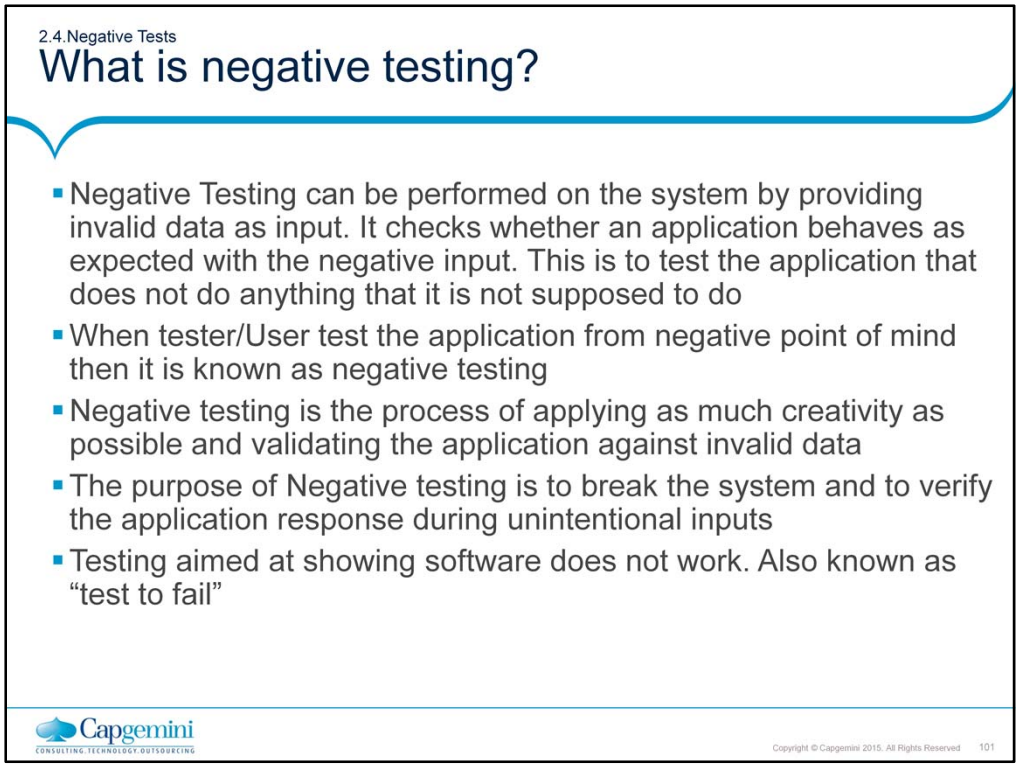

Note: Equivalence Partitioning and boundary value analysis are test case design techniques used for writing negative test cases.

2.4.Negative Tests

Example of negative testing

- Example of Negative testing:
  - In the voting application scenario, Negative testing can be performed by testing by entering alphabets characters from A to Z or from a to z. Age text box should not accept the values or it should throw an error message for these invalid data inputs.

Age: Daya223 Enter only integer values > 18

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2.4.Negative Tests

Advantages/Limitations of negative testing

- Advantages of Negative Testing:
  - Negative testing helps to improve the testing coverage of your software application under test
  - Negative testing discovers 'hidden' errors from application under test
  - Negative testing help to find more defects & improve the quality of the software application under test
  - negative testing ensures that the delivered software has no flaws
- Limitation of Negative Testing
  - Negative tests check for only invalid set of values

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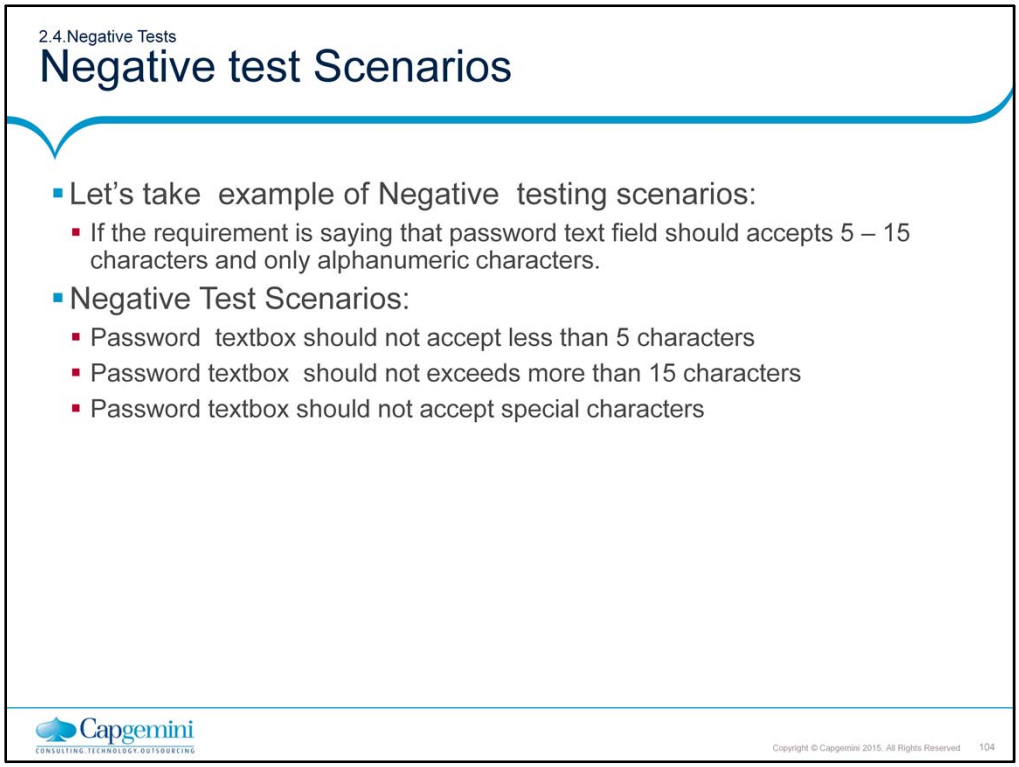

Note:**Requirements:**
The ID has to be a number between 1- 200
The ID is mandatory.
Write some positive and negative test scenarios for this particular pane.

2.5.Basic Tests

What is basic test?

- Basic tests are used to test very basic functionality of software
- The basic tests also verifies end to end builds
- Basic test are always positive tests
- Basic test can be smoke test or sanity test

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2.5.Basic Tests

Example on Basic test

- Customer Relationship Management (CRM) application is business philosophy towards customers. To focus on their needs and improve customer relationships, with view to maximize customer satisfaction. So, in CRM application customer creation is basic functionality that should work. So the basic test focus is on Login and then customer creation. The basic test for this CRM application is Customer login and then customer creation with mandatory fields.

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2.6.Alternate Tests

What is alternate test?

- Sometimes there maybe more than one way of performing a particular function or task with an intent to give the end user more flexibility or for general product consistency
- This is called alternate testing
- Alternate test is a kind of positive testing
- In alternate path testing the test is again performed to meet its requirements but using different route than the obvious path
- The test scenario would even consume the same kind of data to achieve the same result

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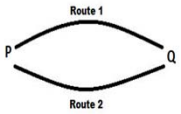
2.6.Alternate Tests

Example on alternate test

- Alternate test



- P is a starting point and Q is the end point. There are two ways to go from P to Q. Route 1 is the generally taken route and Route 2 is an alternative route. Therefore in such a case, happy path testing would be traversing from point P to Q using Route 1 and the alternate test would comprise taking Route 2 to go from P to Q. Observe that the result in both the cases is the same.

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2.7.Importance of writing positive,negative,basic,alternate test while designing test cases.

Importance of writing positive, negative, basic, alternate test while designing test cases

- Approach of writing positive, negative, basic, alternate test are useful to design effective test cases which help to improve quality of software
- These approach to test case design are help to improve the test case design coverage
- By using these approach test cases are written for real life scenarios. It ensures real life scenarios are tested before moving software live
- By designing positive and negative test cases ensures that the application works as per the requirements and specifications
- By executing effective test cases, helps to find more defects before releasing software, so it builds confidence in system

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Summary

- In this lesson, you have learnt:
  - The test case techniques discussed so far need to be combined to form overall strategy
  - Each technique contributes a set of useful test cases, but none of them by itself contributes a thorough set of test cases

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Review Question

- Question 1: _____ testing can discover dead codes
- Question 2: The objective of walkthrough is to find errors but not solutions
  - Option: True / False
- Question 3: For calculating cyclomatic complexity, flow graph is mapped into corresponding flow chart
  - Option: True / False
- Question 4: How many minimum test cases required to test a simple loop?

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Review Question

- Question 5: One test condition will have _____ test cases
- Question 6: For Agile development model conventional testing approach is followed
  - Option: True / False
- Question 7: A test case is a set of _____, _____, and _____ developed for a particular objective

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Review Question: Match the Following

1. Code coverage	A. Flow graph
2. Interface errors	B. Loop testing
3. Code complexity	C. Black box testing
	D. Flow chart
	E. Condition testing
	F. White box testing

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Testing Concepts for V&V Automation Testing

Lesson 3: Types of System Testing

Lesson Objectives

- To understand the following topics:
  - Verification and Validation
  - SDLC & V Model
  - Testing phases
  - Types of system testing
  - Acceptance testing- Alpha testing, Beta testing
  - Exploratory testing
  - Test strategy

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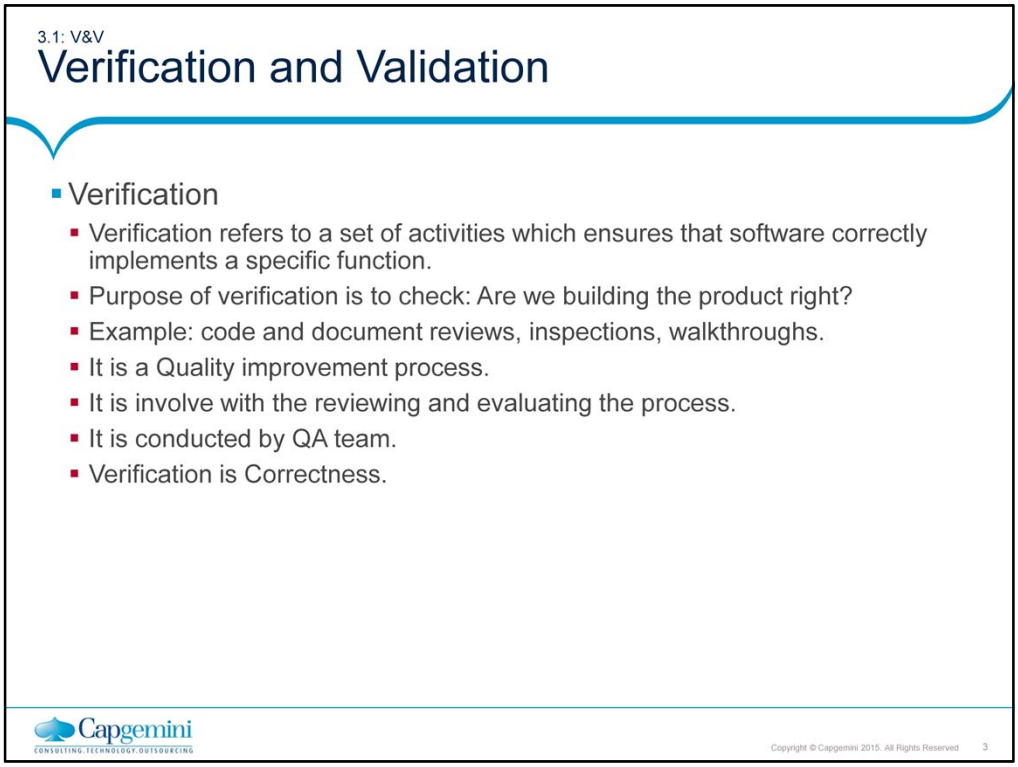
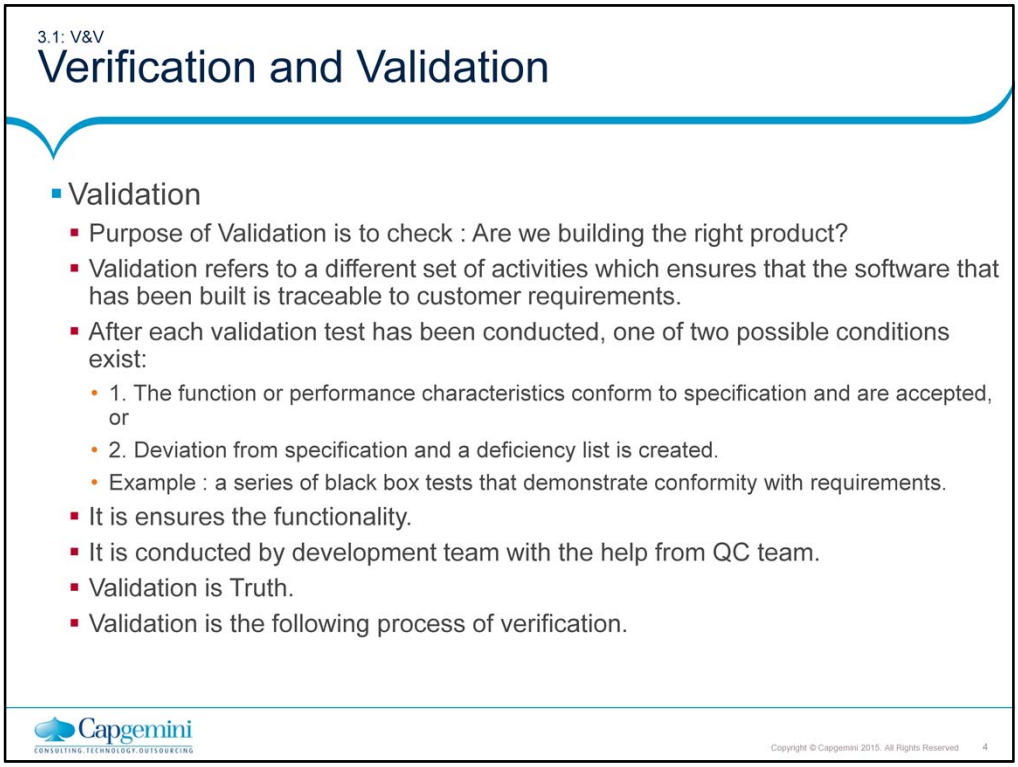
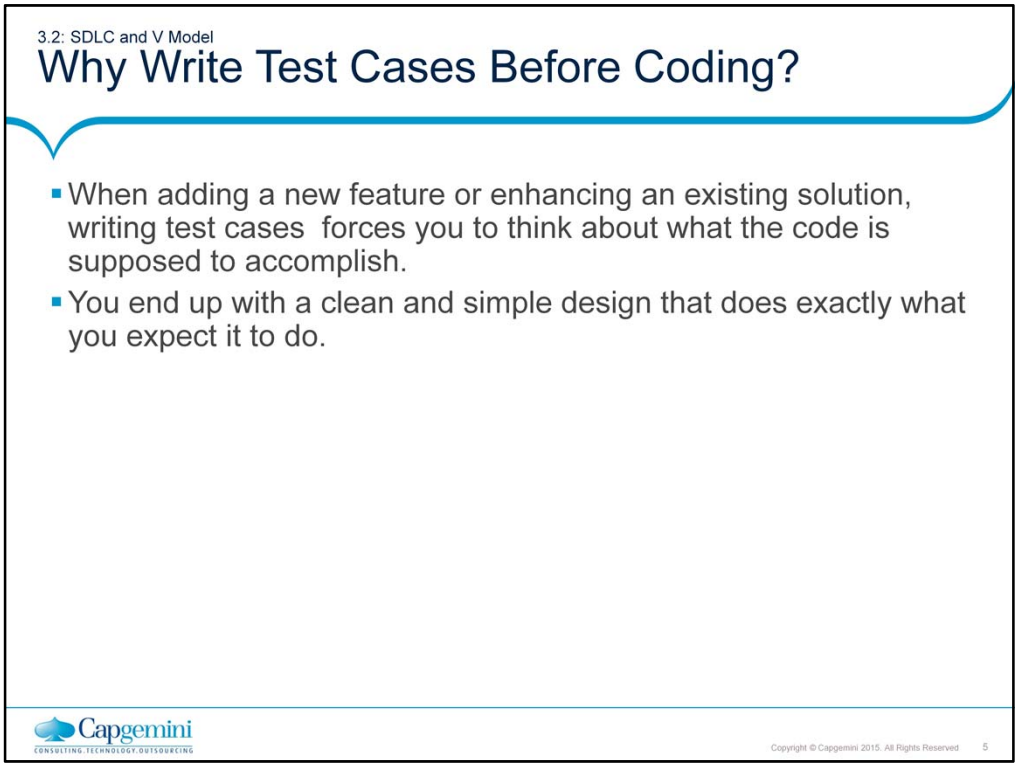


V&V encompasses many of the activities that are encompassed by S/w quality assurance that include formal technical reviews, quality and configuration audits, performance monitoring, simulation, feasibility study, documentation review, database review, algorithm analysis, development testing, usability testing, installation testing.
Example of Verification : code and document inspections, walkthroughs, and other techniques. unit testing , integration testing , system testing

If we are in a shopping centre and buy a thing with a code number 2342 and when we go to till and they check the number of that item and find it wrong then system will check all product number of the relevant number but don't find any number of this kind then we can say that the verify thing is wrong.
Verification is a process, which performs testing to ensure implemented functions meeting to designed functions.



Validation of software typically includes evidence that all software requirements have been implemented correctly and completely and are traceable to system requirements.


3.2: SDLC and V Model
Why Write Test Cases Before Coding?
When adding a new feature or enhancing an existing solution, writing test cases forces you to think about what the code is supposed to accomplish.
You end up with a clean and simple design that does exactly what you expect it to do.
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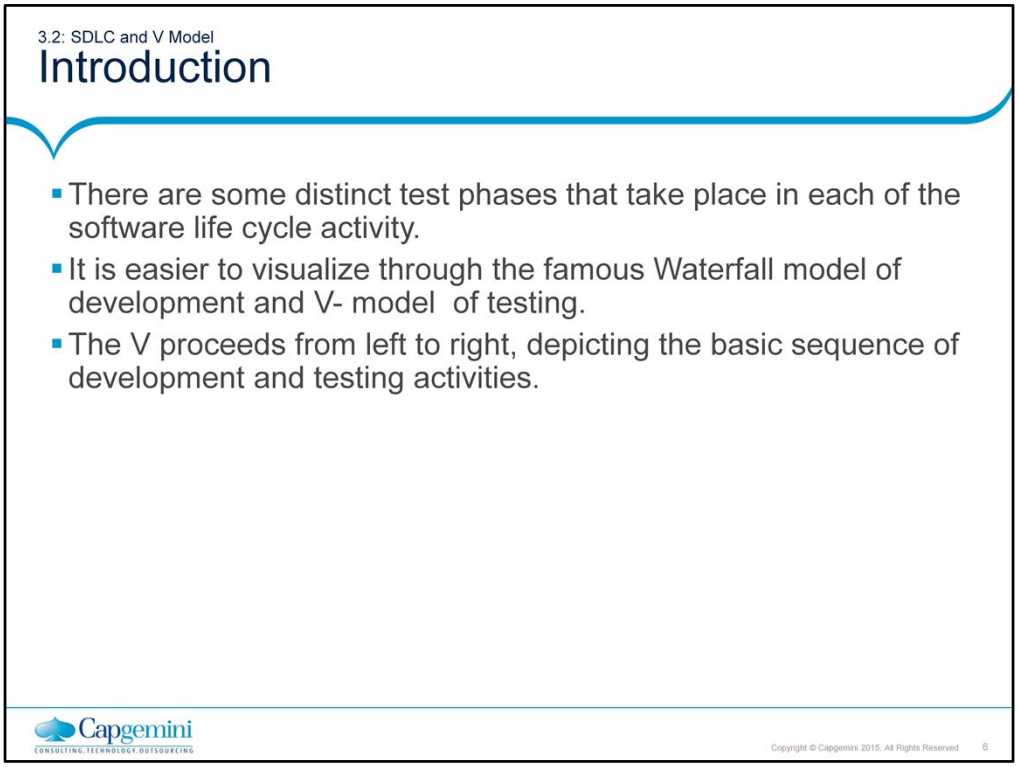
3.2: SDLC and V Model
Introduction
There are some distinct test phases that take place in each of the software life cycle activity.
It is easier to visualize through the famous Waterfall model of development and V- model of testing.
The V proceeds from left to right, depicting the basic sequence of development and testing activities.
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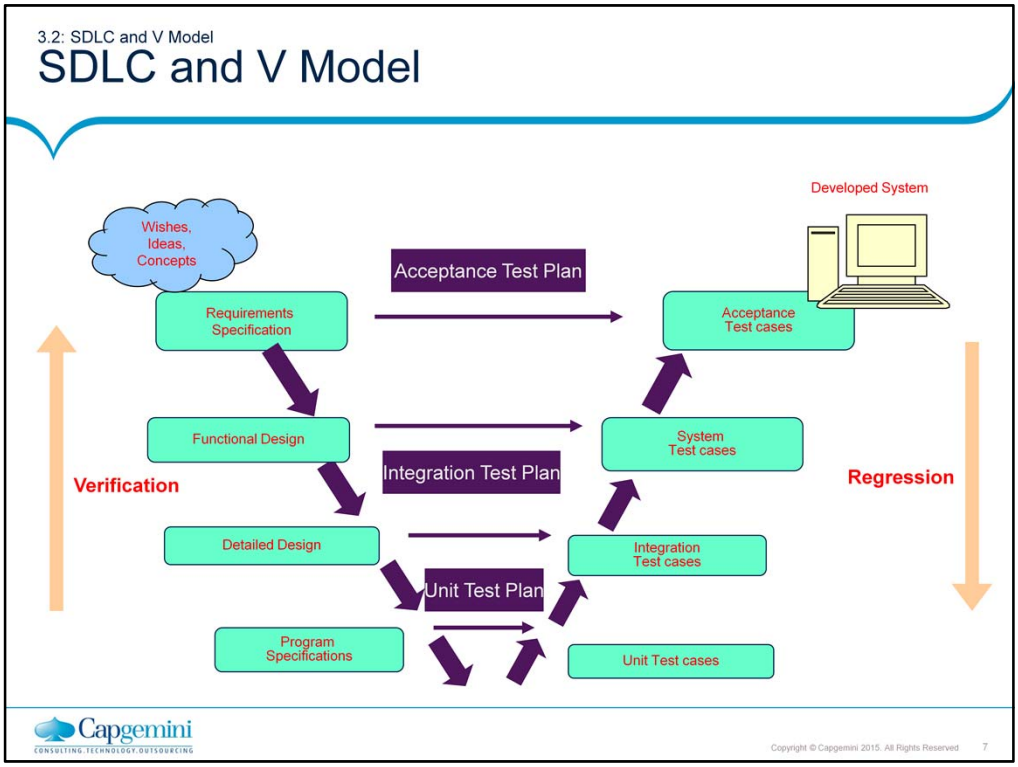


Briefly discuss the Software Development Life cycle activities and the various Models that are used like the Waterfall, RAD, Spiral ,XP etc

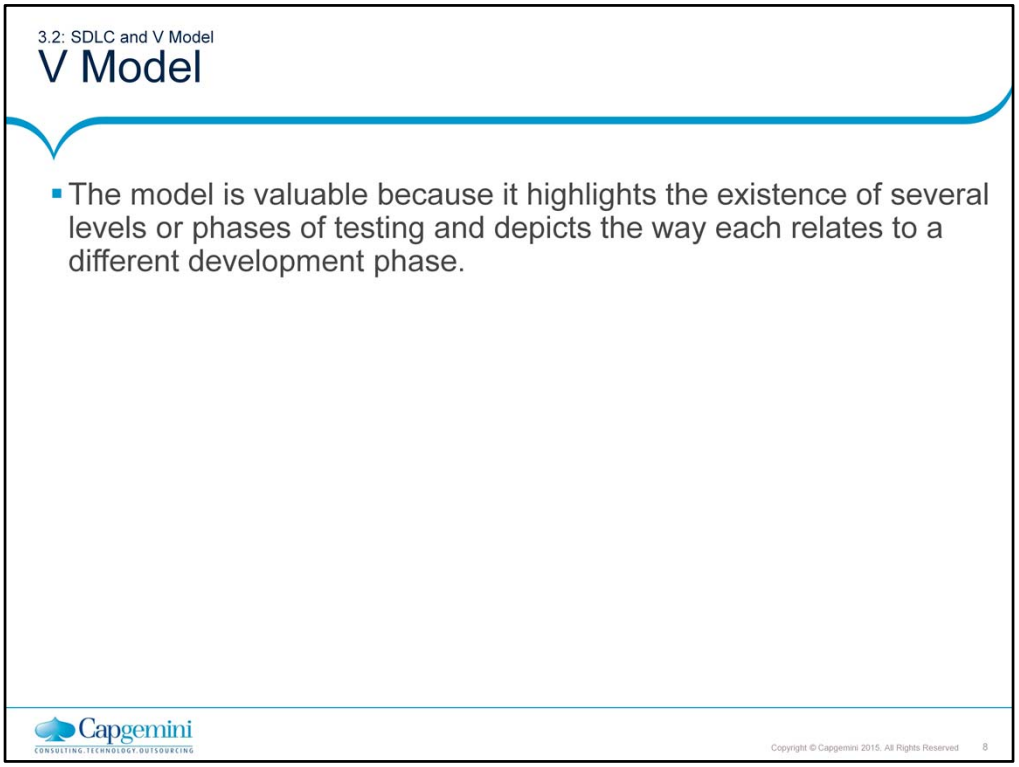
Then concentrate on the waterfall model above.

The four main process phases – **requirements, specification, design and implementation**

- They have a corresponding **verification and validation testing** phase
- **Implementation** of modules is tested by **unit testing**.
- **System design** is tested by **integration testing**.
- **System specifications** are tested by **system testing.**
- **Acceptance testing** verifies the **requirements specification.**
- Starting from the requirements, the system is developed one phase at a time

  until the lowest phase, the implementation phase, is finished.
- At this stage testing begins, starting from unit testing and moving up one test

  level at a time until the acceptance testing phase is completed


3.2: SDLC and V Model
V Model
The model is valuable because it highlights the existence of several levels or phases of testing and depicts the way each relates to a different development phase.
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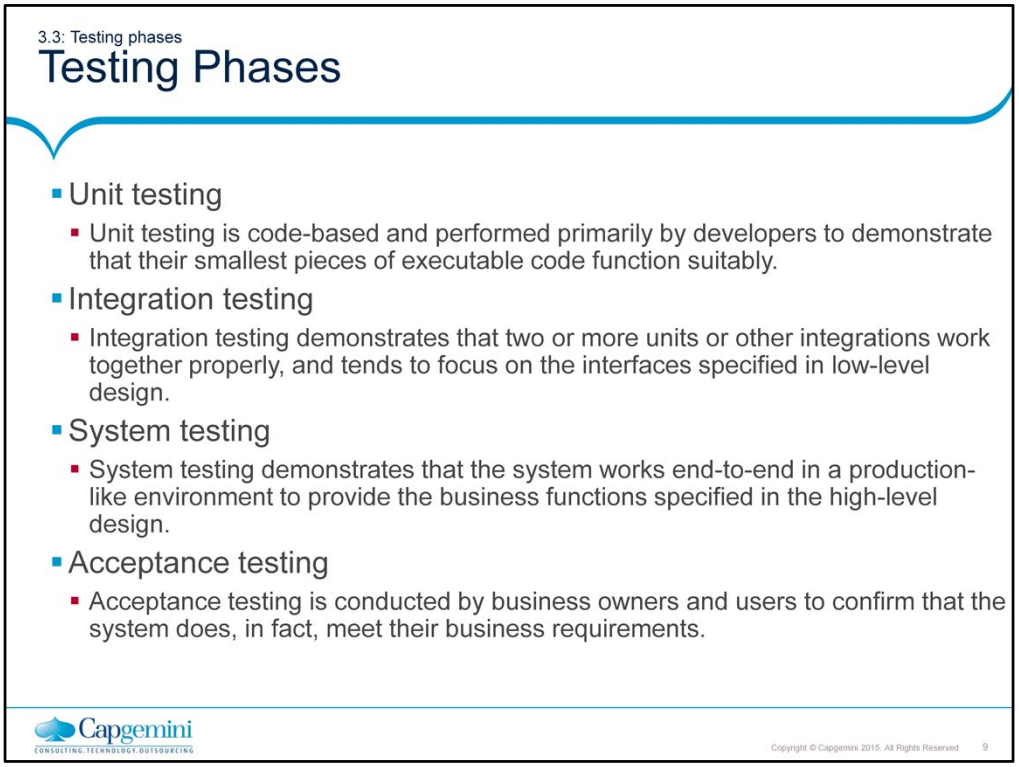
3.3: Testing phases
Testing Phases
Unit testing
Unit testing is code-based and performed primarily by developers to demonstrate that their smallest pieces of executable code function suitably.
Integration testing
Integration testing demonstrates that two or more units or other integrations work together properly, and tends to focus on the interfaces specified in low-level design.
System testing
System testing demonstrates that the system works end-to-end in a production-like environment to provide the business functions specified in the high-level design.
Acceptance testing
Acceptance testing is conducted by business owners and users to confirm that the system does, in fact, meet their business requirements.
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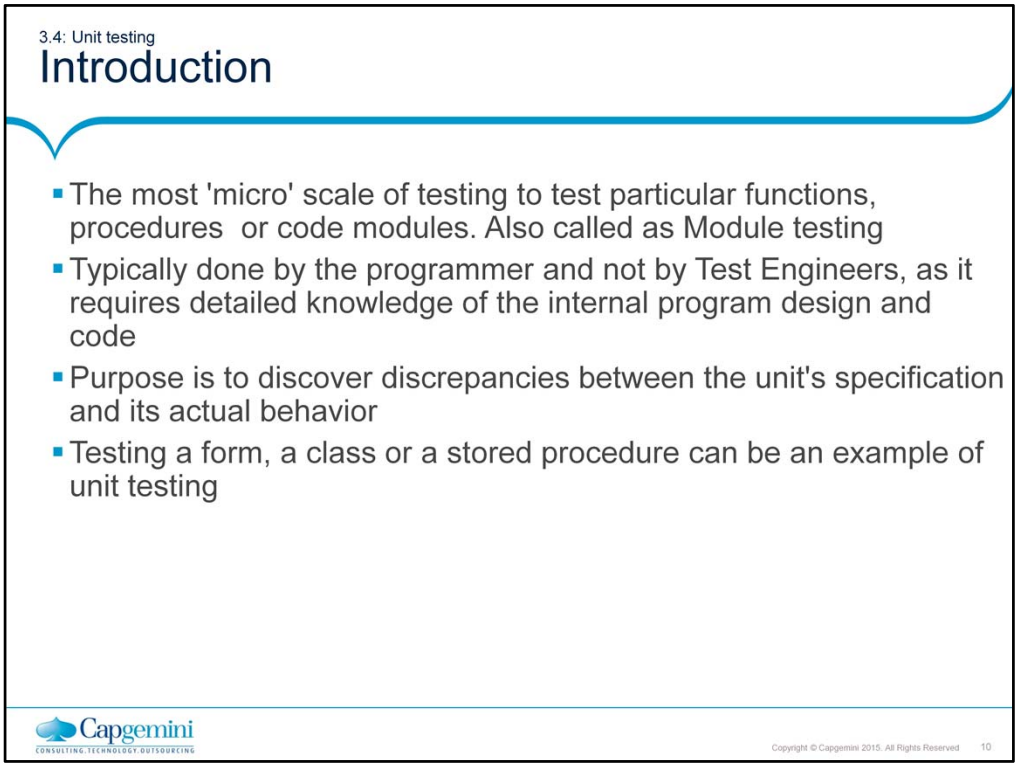


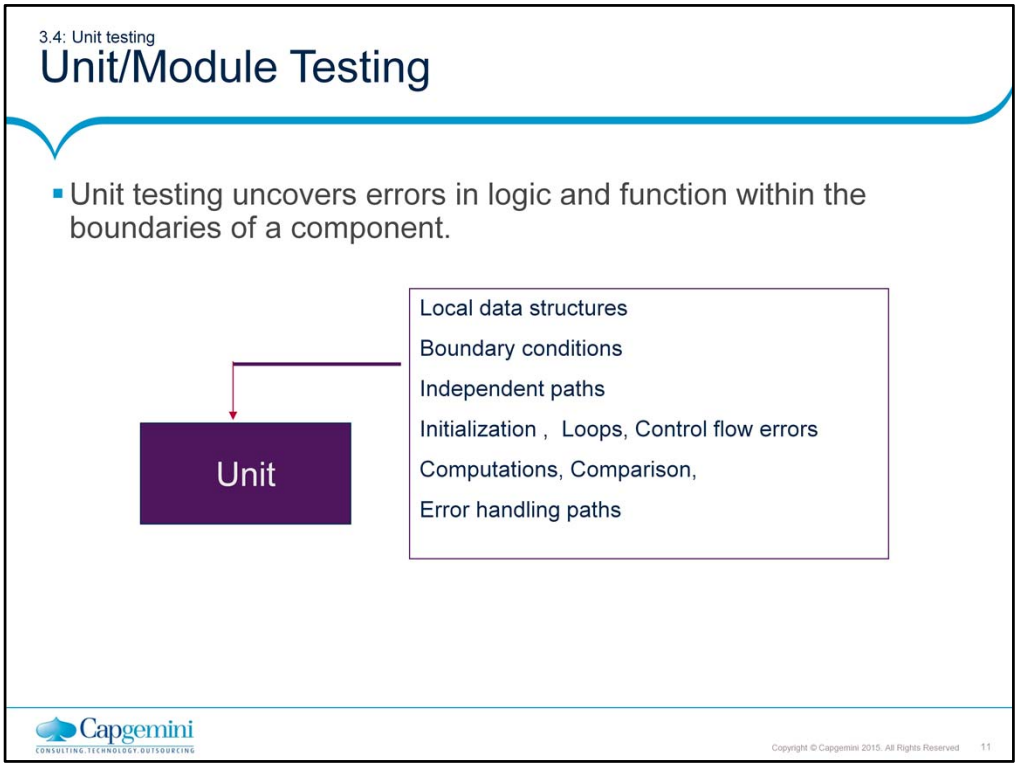
What is a Unit?

Synonyms are “component” and “module.”

The IEEE glossary says (for module):

• A program unit that is discrete and identifiable with respect to compiling, combining with other units, and loading.

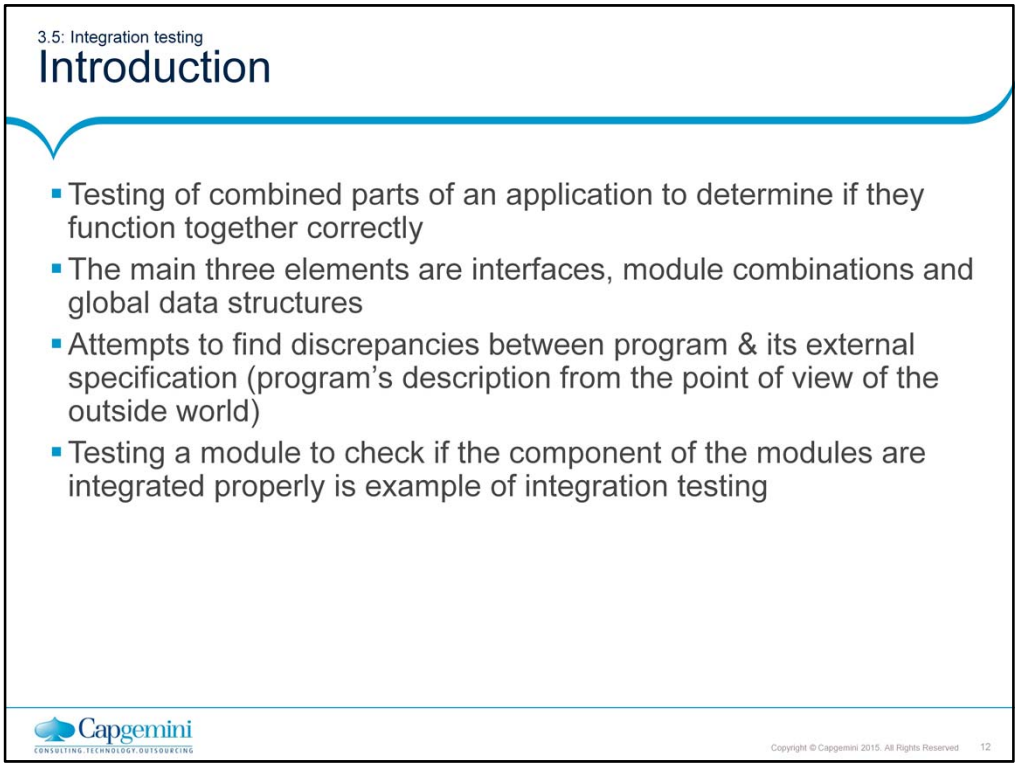
• A logically separable part of a program.



The module interface is tested to ensure that information properly flows into and out of the program under test. Local data structures are examined to ensure that data stored temporarily maintains its integrity during all steps in an algorithm's execution.

Test cases should uncover errors such as

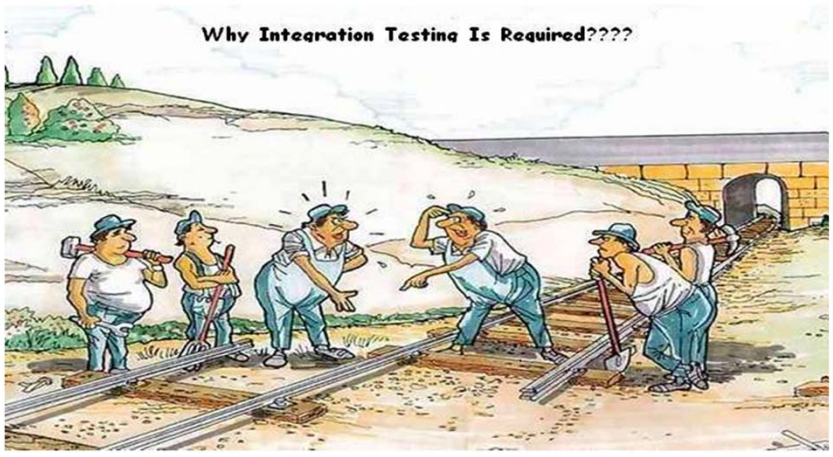
(1) comparison of different data types
(2) incorrect logical operators or precedence
(3) expectation of equality when precision error makes equality unlikely
(4) incorrect comparison of variables
(5) improper or nonexistent loop termination
(6) failure to exit when divergent iteration is encountered.



Interfaces are the means by which data is passed to and from modules.
"Interface integrity" – to ensure that when data is passed to another module, by way of a call, none of the data becomes lost or corrupted.
This loss or corruption can happen by number of ways- calling and receiving parameters may be of the wrong type and so the data appears in the receiving programs in a garbled form; there may be different number of calling and receiving parameters and so the data is lost; arrays may be of different lengths.
Global data structures are those pieces of data, maybe in the form of files, databases or variables, that are existing through out the entire system. Every module has access to global data structures and may alter the contents thereof. The effect of this again may create some unusual combination of data which reveals an error in another module.

3.5: Integration testing

Why Integration Testing is Required?



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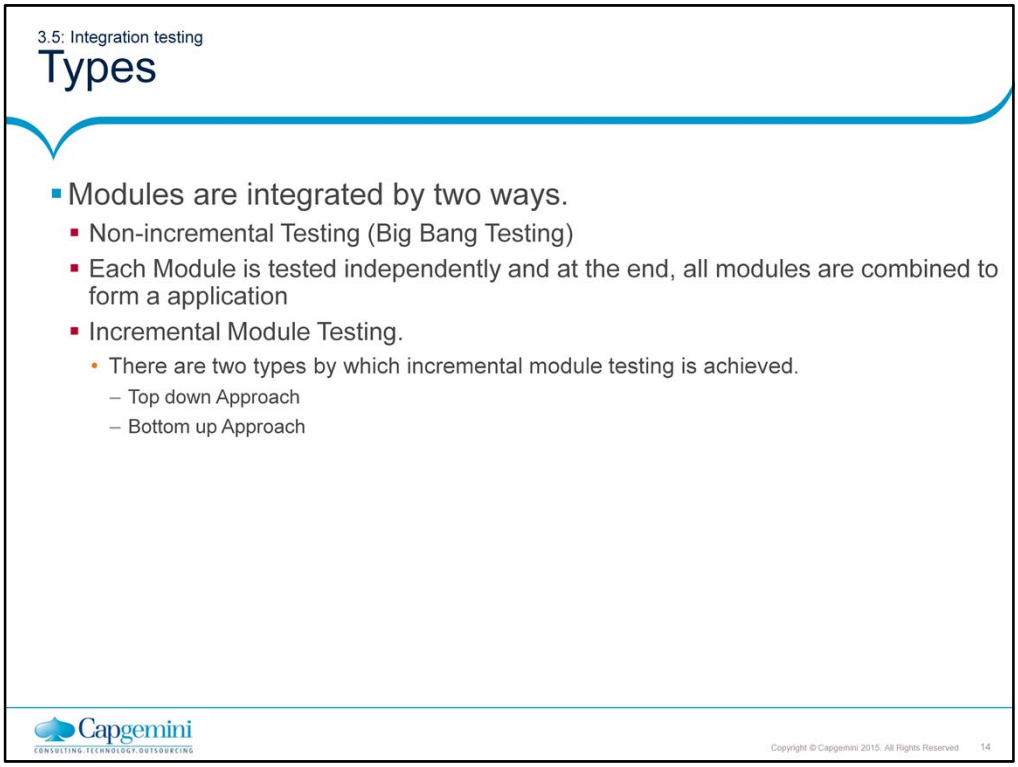
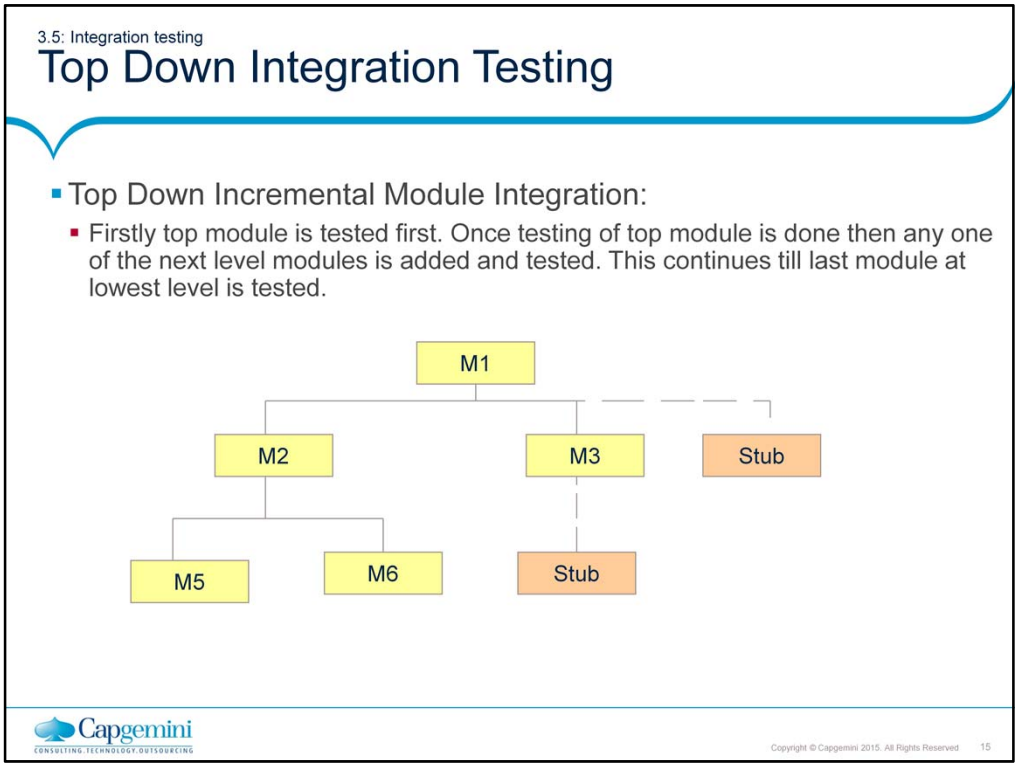
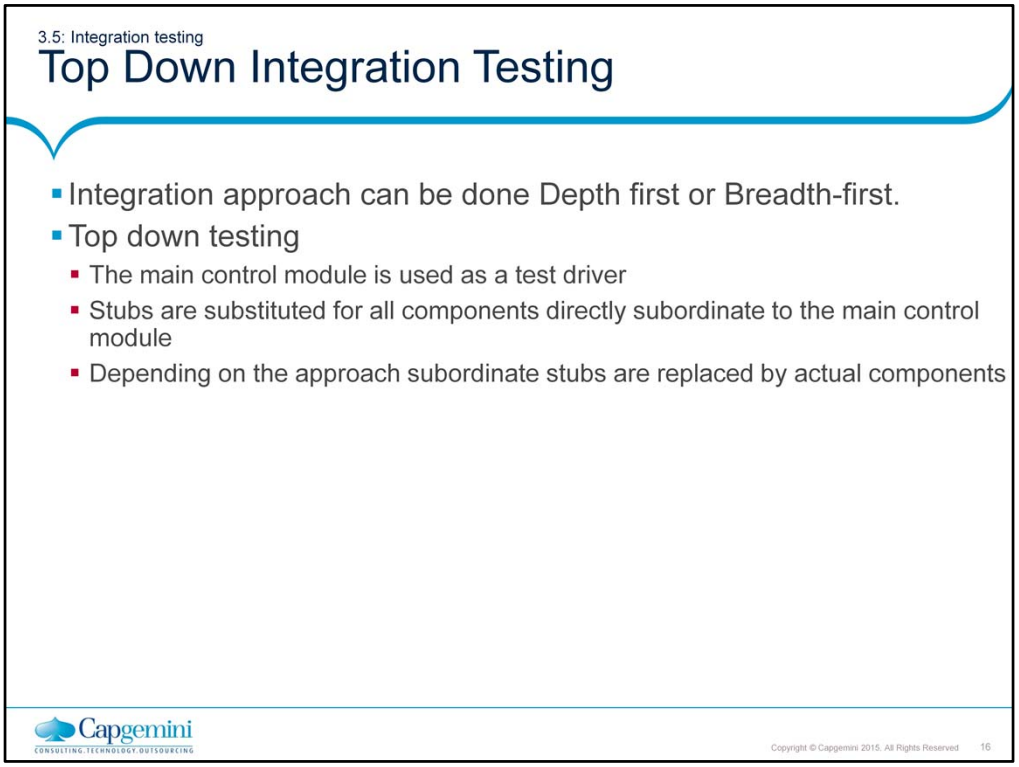


Discuss the advantages and disadvantages of the Non incremental testing and conclude that is more advantageous to do incremental testing



Disadvantages:
Many tests are delayed until stubs are replaced by actual modules.
Time taken to develop stubs to perform the functions of the actual modules.

Advantage :
Fast


3.5: Integration testing
Top Down Integration Testing
Integration approach can be done Depth first or Breadth-first.
Top down testing
The main control module is used as a test driver
Stubs are substituted for all components directly subordinate to the main control module
Depending on the approach subordinate stubs are replaced by actual components
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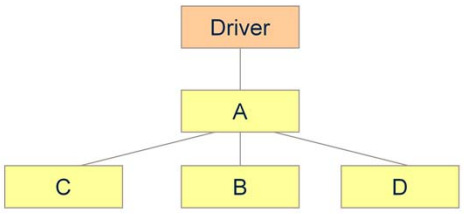
3.5: Integration testing

Bottom Up Integration Testing

- Bottom Up Incremental Module Integration:
  - Firstly module at the lowest level is tested first. Once testing of that module is done then any one of the next level modules is added to it and tested. This continues till top most module is added to rest all and tested



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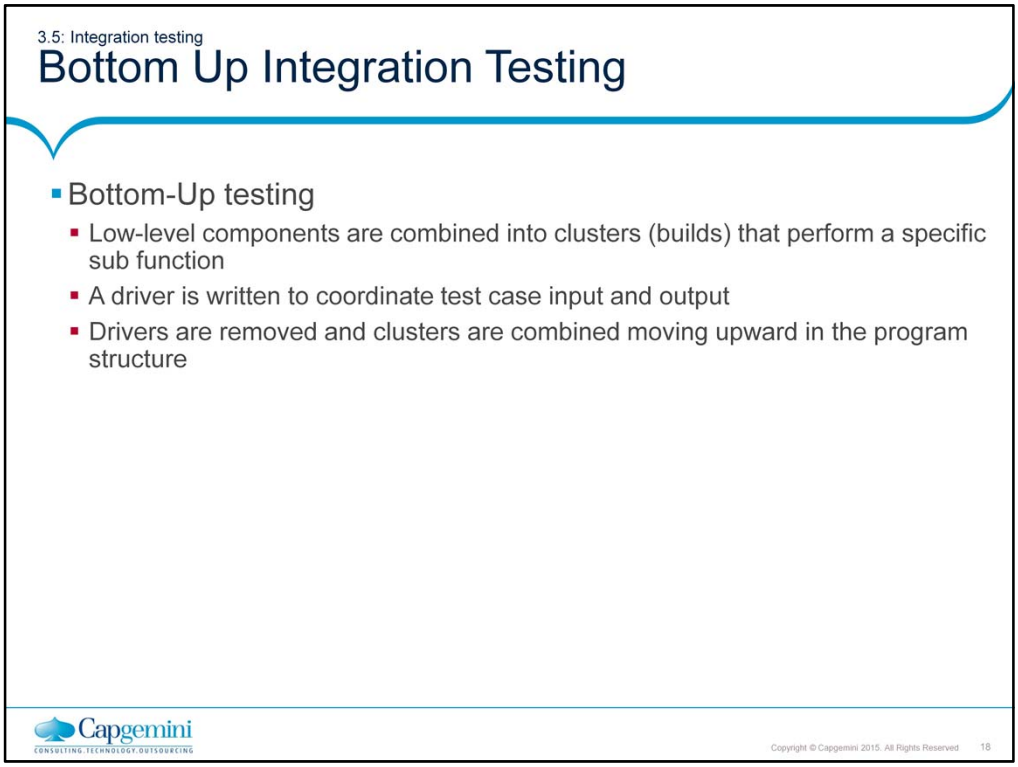
3.5: Integration testing
Bottom Up Integration Testing
Bottom-Up testing
Low-level components are combined into clusters (builds) that perform a specific sub function
A driver is written to coordinate test case input and output
Drivers are removed and clusters are combined moving upward in the program structure
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3.5: Integration testing

Top Down vs Bottom Up Testing

Top Down Testing	
Advantages	**Disadvantages**
Advantageous if major flaws occur toward the top of the program	Stub modules must be produced
Once the I/O functions are added, representation of test cases are easier	Stub Modules are often more complicated than they first appear to be.
Early skeletal Program allows demonstrations and boosts morale	Before the I/O functions are added, representation of test cases in stubs can be difficult
	Test conditions may be impossible, or very difficult, to create
	Observation of test output is more difficult
	Allows one to think that design and testing can be overlapped
	Induces one to defer completion of the testing of certain modules.

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3.5: Integration testing

Top Down vs Bottom Up Testing

Bottom Up testing	
Advantages	**Disadvantages**
Advantageous if major flaws occur toward the bottom of the program	Driver Modules must be produced
Test conditions are easier to create	The program as an entity does not exist until the last module is added
Observation of test results is easier	

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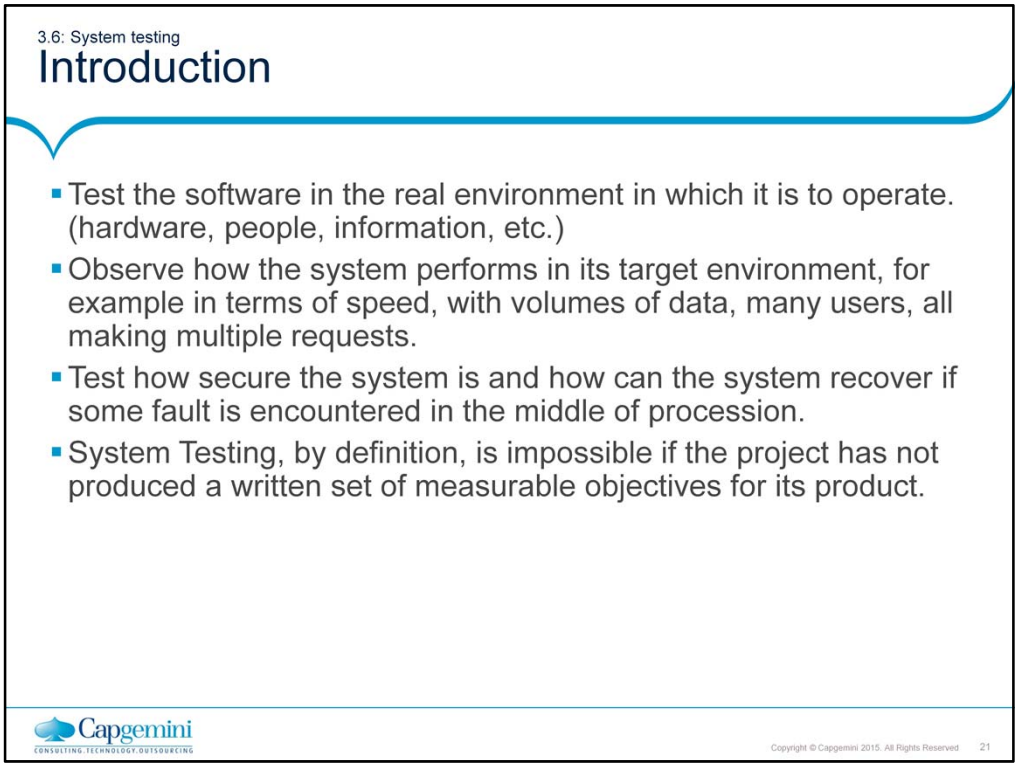
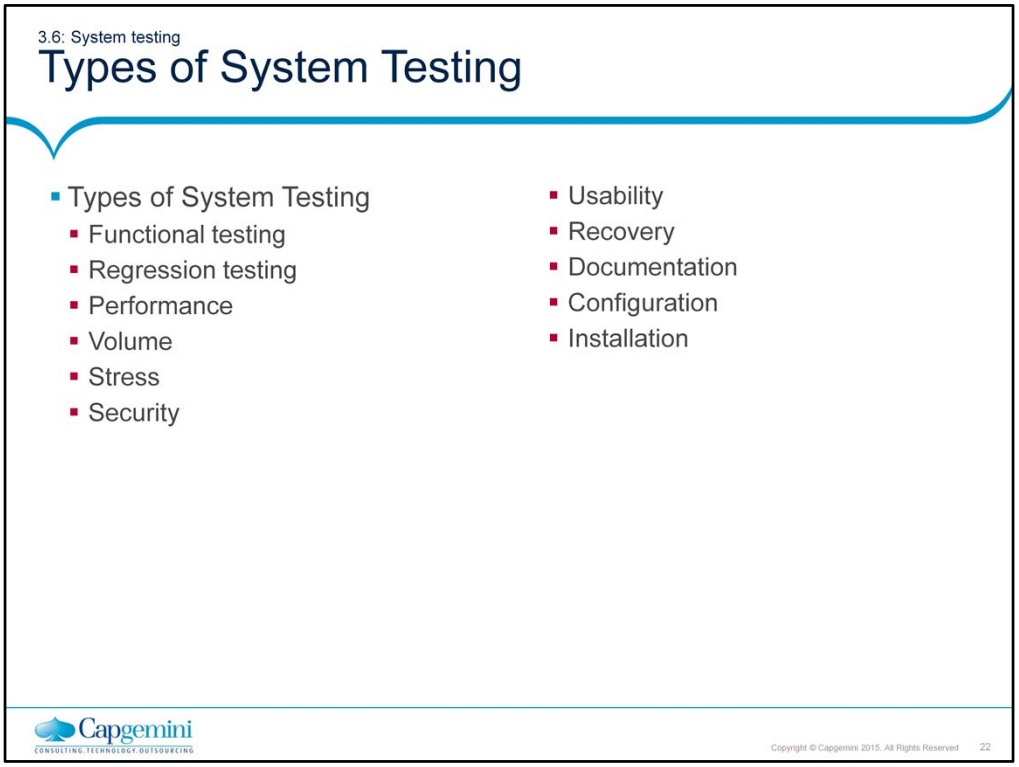


Discuss Airline Reservation Case Study and relate each test case with the System Tests that we are going to deal with in the next few slides and also the ones that were previously discussed


3.6: System testing
Types of System Testing
Types of System Testing
Functional testing
Regression testing
Performance
Volume
Stress
Security
Usability
Recovery
Documentation
Configuration
Installation
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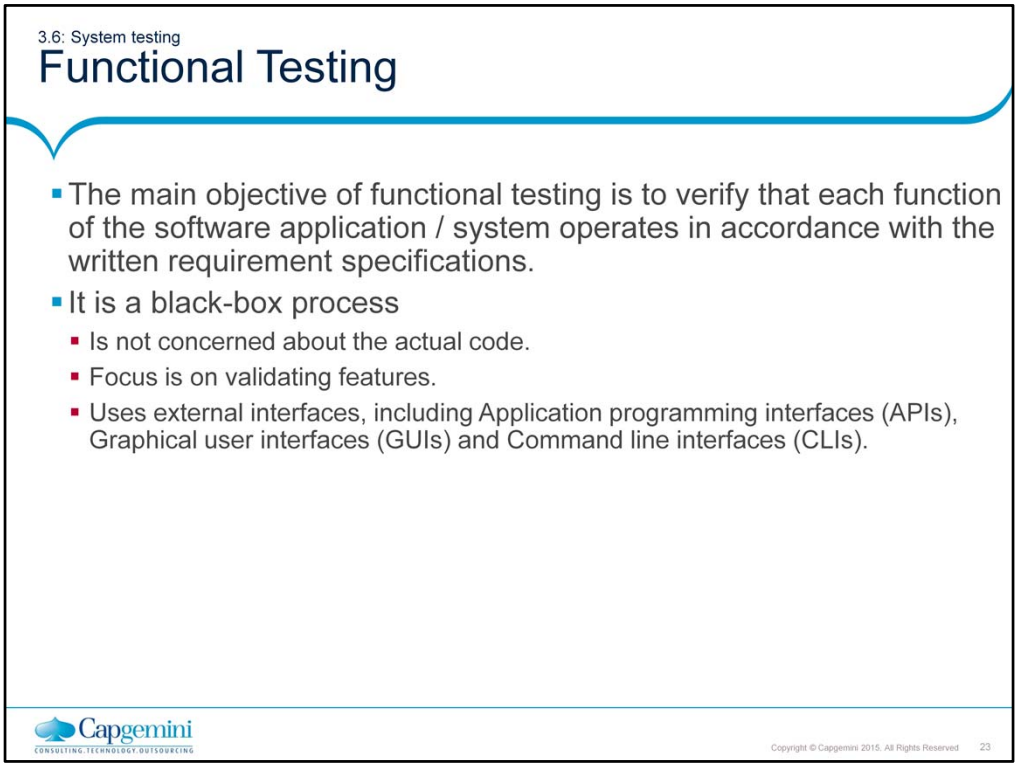
3.6: System testing
Functional Testing
The main objective of functional testing is to verify that each function of the software application / system operates in accordance with the written requirement specifications.
It is a black-box process
Is not concerned about the actual code.
Focus is on validating features.
Uses external interfaces, including Application programming interfaces (APIs), Graphical user interfaces (GUIs) and Command line interfaces (CLIs).
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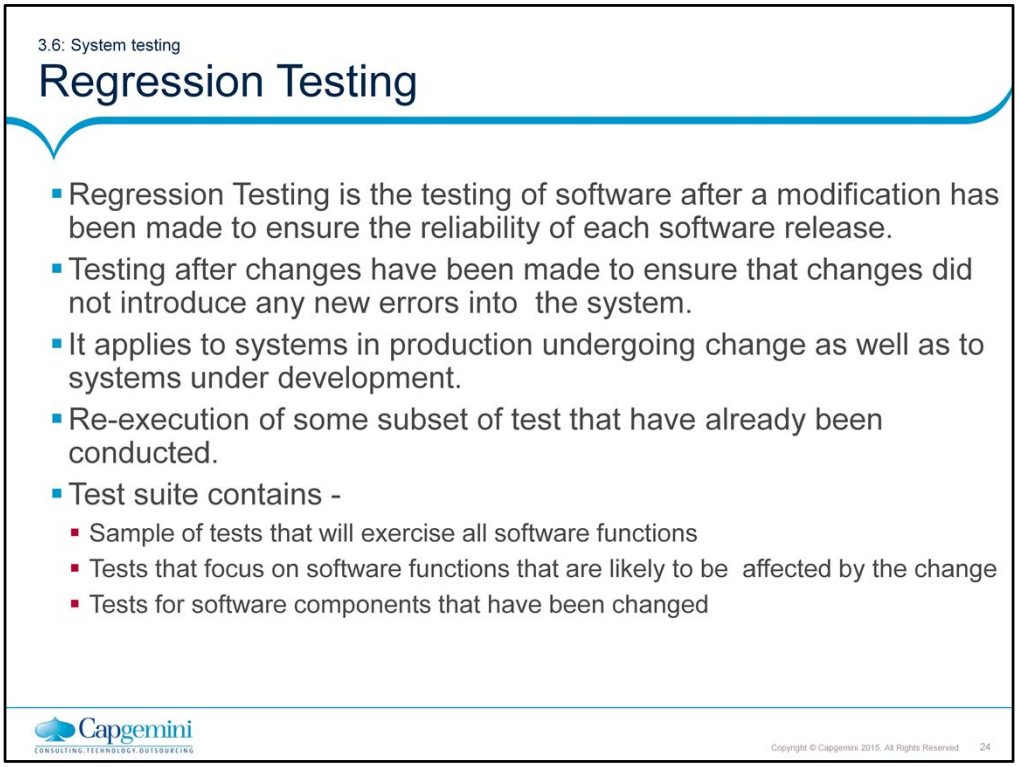
3.6: System testing
Regression Testing
Regression Testing is the testing of software after a modification has been made to ensure the reliability of each software release.
Testing after changes have been made to ensure that changes did not introduce any new errors into the system.
It applies to systems in production undergoing change as well as to systems under development.
Re-execution of some subset of test that have already been conducted.
Test suite contains -
Sample of tests that will exercise all software functions
Tests that focus on software functions that are likely to be affected by the change
Tests for software components that have been changed
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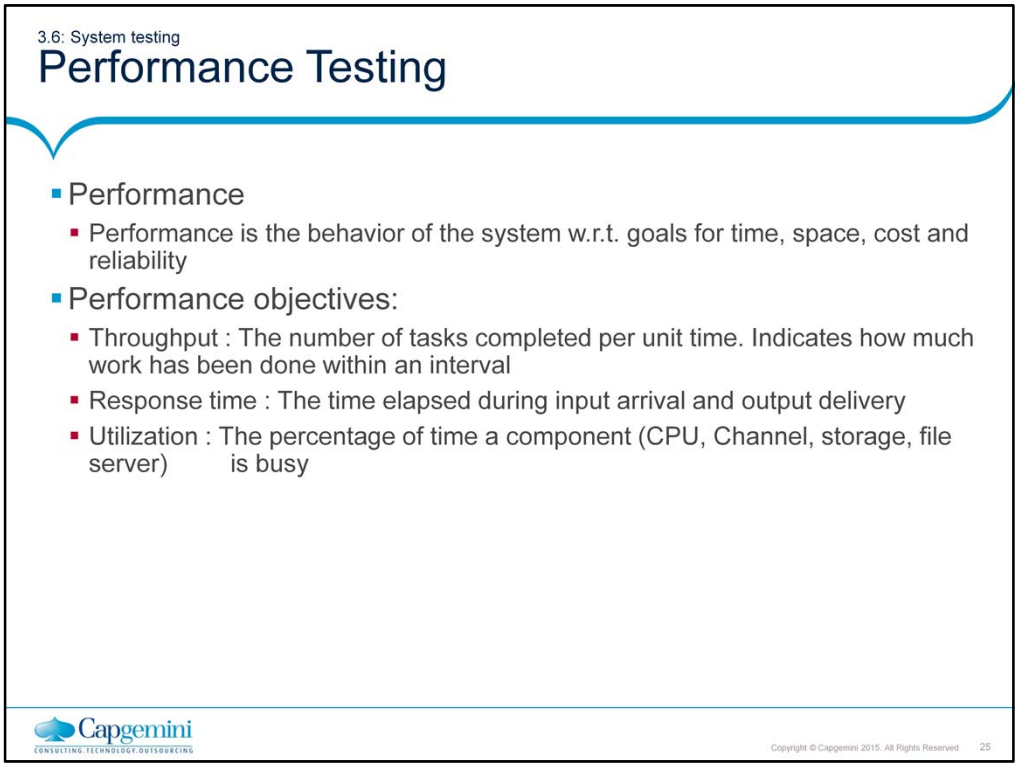
3.6: System testing
Performance Testing
Performance
Performance is the behavior of the system w.r.t. goals for time, space, cost and reliability
Performance objectives:
Throughput : The number of tasks completed per unit time. Indicates how much work has been done within an interval
Response time : The time elapsed during input arrival and output delivery
Utilization : The percentage of time a component (CPU, Channel, storage, file server) is busy
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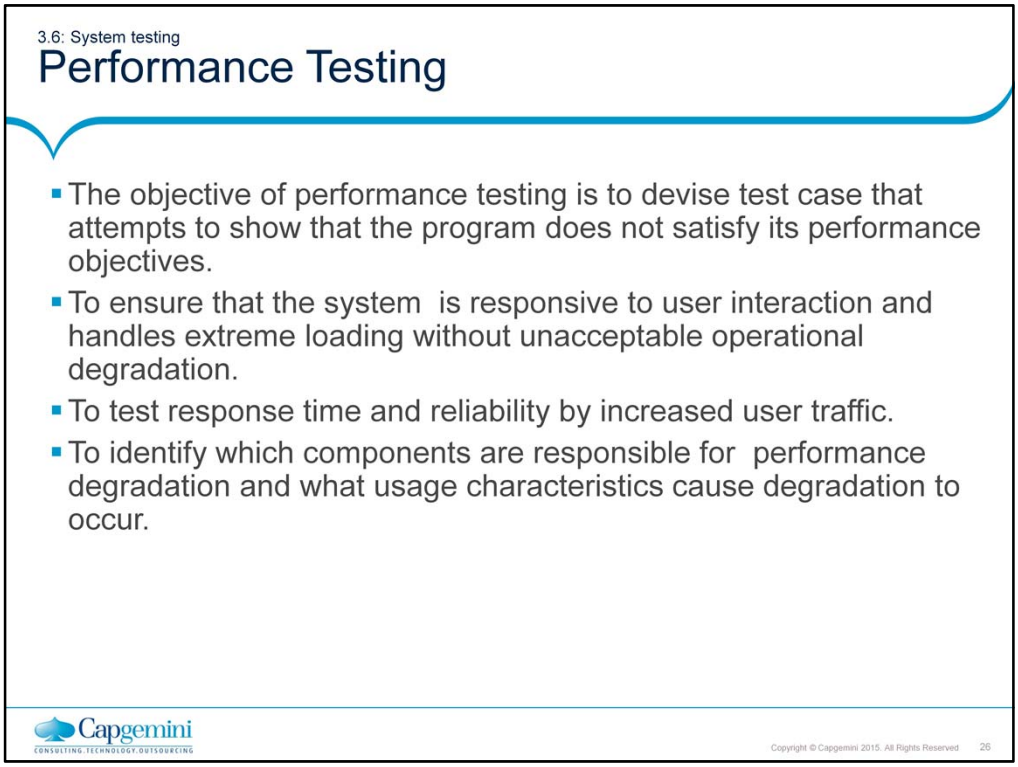
3.6: System testing
Performance Testing
The objective of performance testing is to devise test case that attempts to show that the program does not satisfy its performance objectives.
To ensure that the system is responsive to user interaction and handles extreme loading without unacceptable operational degradation.
To test response time and reliability by increased user traffic.
To identify which components are responsible for performance degradation and what usage characteristics cause degradation to occur.
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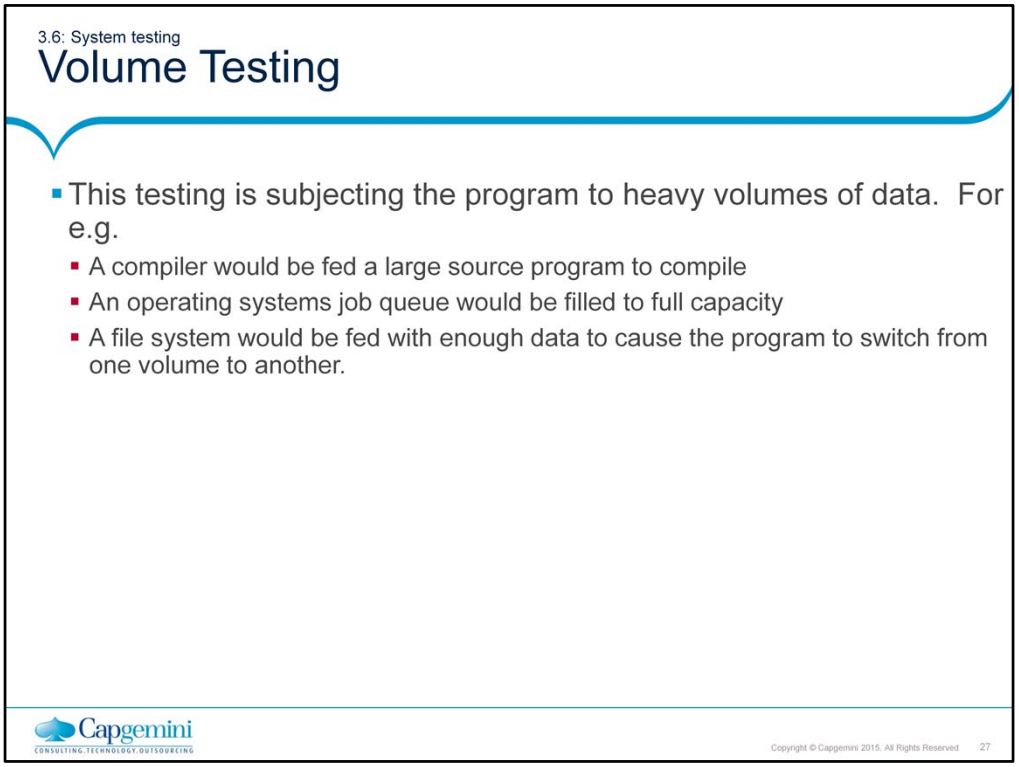
3.6: System testing
Volume Testing
This testing is subjecting the program to heavy volumes of data. For e.g.
A compiler would be fed a large source program to compile
An operating systems job queue would be filled to full capacity
A file system would be fed with enough data to cause the program to switch from one volume to another.
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3.6: System testing

Stress Testing

- Stress testing involves subjecting the program to heavy loads or stresses.
- The idea is to try to “break” the system.
- That is, we want to see what happens when the system is pushed beyond design limits.
- It is not same as volume testing.
- A heavy stress is a peak volume of data encounters over a short time.
- In Stress testing a considerable load is generated as quickly as possible in order to stress the application and analyze the maximum limit of concurrent users the application can support.

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3.6: System testing

Stress Testing

- Stress tests executes a system in a manner that demands resources in abnormal quantity, frequency, or volume
- Example :
  - Generate 5 interrupts when the average rate is 2 or 3
  - Increase input data rate
  - Test cases that require max. memory
- Stress Tests should answer the following questions
  - Does the system degrade gently or does the server shut down
  - Are appropriate messages displayed ? E.g. Server not available
  - Are transactions lost as capacity is exceeded
  - Are certain functions discontinued as capacity reaches the 80 or 90 percent level

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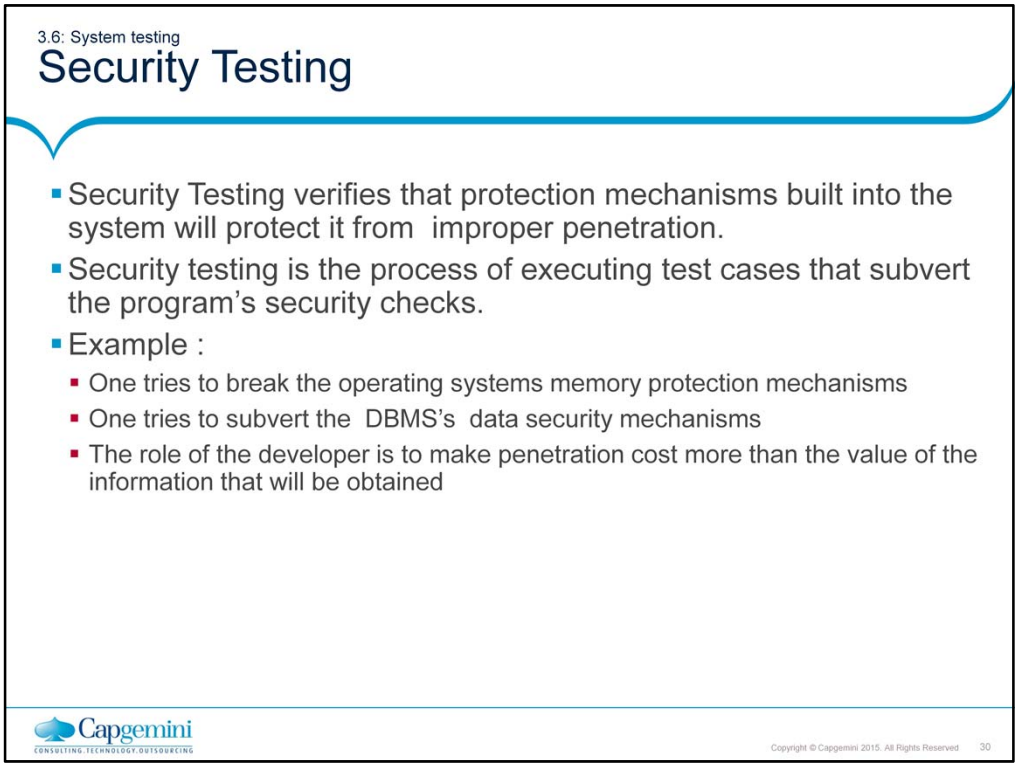


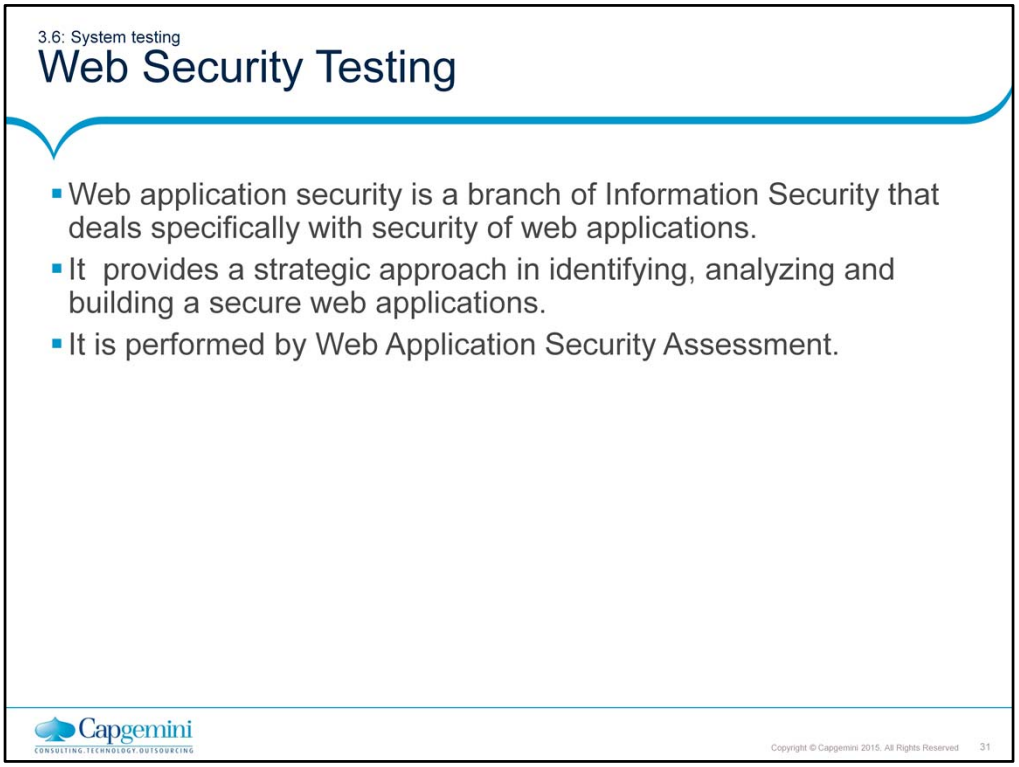
Any computer based system that manages sensitive information or causes actions that can improperly harm (or benefit) individuals is a target for improper or illegal penetration. Penetration spans a broad range of activities : hackers who attempt to penetrate systems for sport, disgruntled employees who attempt to penetrate for revenge, dishonest individuals who attempt to penetrate for illicit personal gain.

Firewalls – a filtering mechanism that is a combination of hardware and software that examines each incoming packet of information to ensure that it is coming from a legitimate source, blocking any data that are suspect.

Authentication – a verification mechanism that validates the identity of all clients and servers, allowing communication to occur only when both sides are verified.

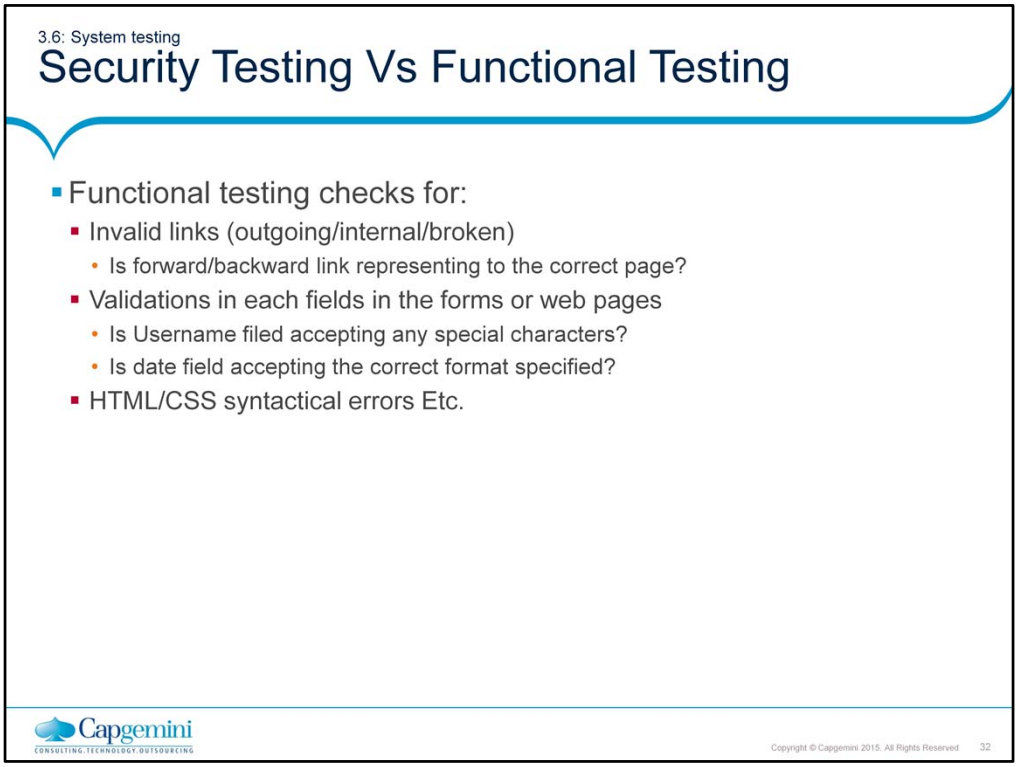
Encryption – Protect sensitive data by modifying it in a way that makes it impossible to read by those with malicious intent.

Authorization – a filtering mechanism that allows access to the client or server environment only by those individuals with appropriate authorization codes. (e.g. Userid , Passwords)

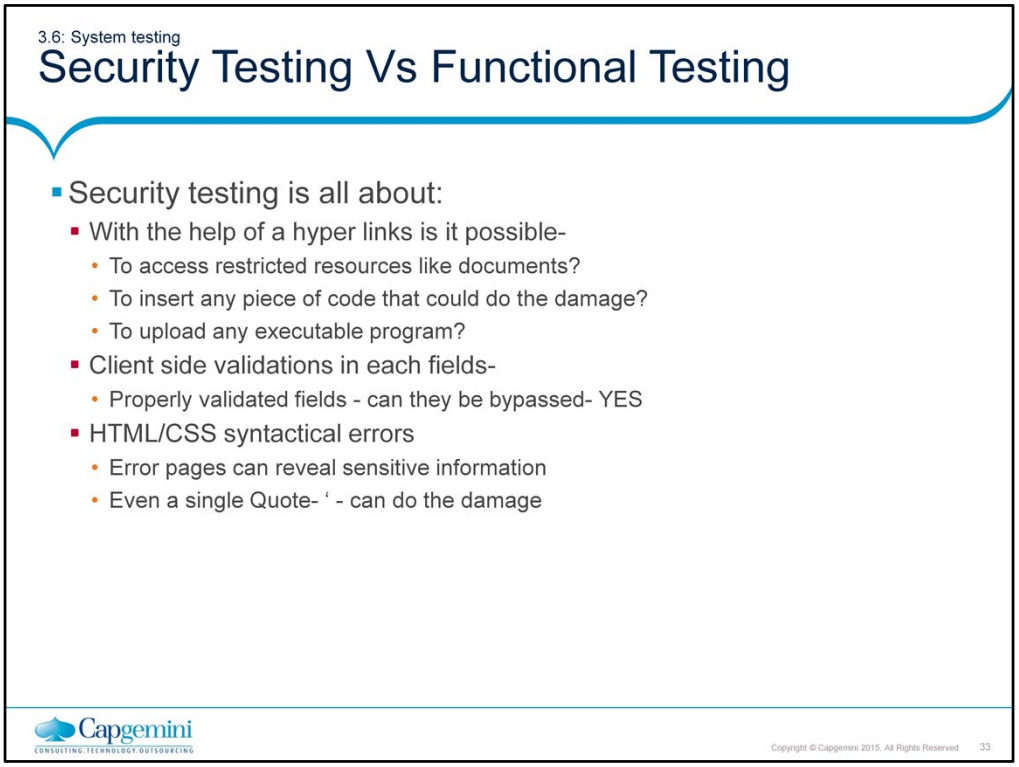


Why, Web Application Security?

1. Top breaches/fraud in recent times
2. Heartland Payment Systems - In January 2009 attackers were able to steal more than 130,000,000 credit card records
3. Virginia State Prescription Monitoring Program Records - Hackers stole 8.3 million records, erased the originals and created an encrypted backup of VPMP's database
4. Terrorists intercept US Drone unencrypted Video Feeds - Islamic terrorists have been able to hack into CIA state-of-the-art Predator drones with the help of just a 25.95 dollar off-the-shelf software, raising fears of remote control operated unmanned crafts being taken over and used against British and American targets.
5. Phishing attacks on banking sites – ICICI, SBI etc.,



Functional testing alone is not a primary defense against the real world attacks.



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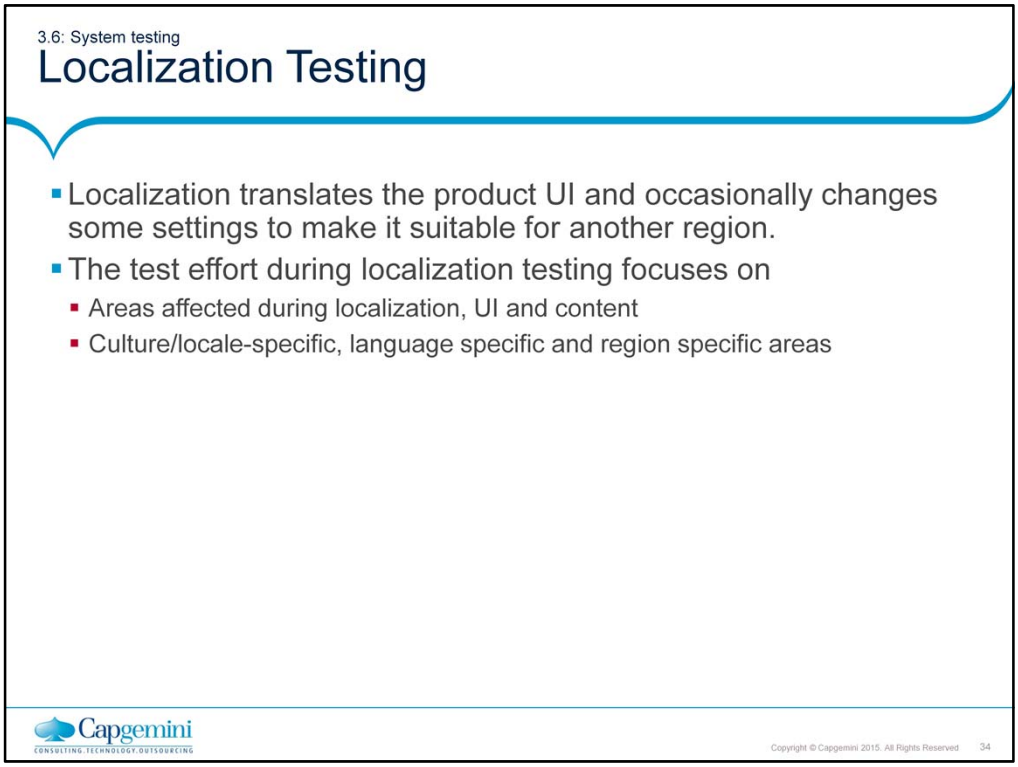

The goal of globalization testing is to detect potential problems in application design that could inhibit globalization. It makes sure that the code can handle all international support without breaking the functionality that would cause either data loss or display problems.

Automated testing is not an effective solution for localization/globalization testing because the default mouse click position changes with the language and also the text in the recordings don’t obviously match for all languages.

3.6: System testing

Usability Testing

- Usability is
  - The effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in a particular environment ISO 9241-11
  - Effective–- Accomplishes user's goal
  - Efficient-- Accomplishes the goal quickly
  - Satisfaction–- User enjoys the experience
- Test Categories and objectives
  - Interactivity (Pull down menus, buttons)
  - Layout
  - Readability
  - Aesthetics
  - Display characteristics
  - Time sensitivity
  - Personalization

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Usability testing can be formal, informal or heuristic based on the needs and the availability.

There are many frameworks formulated for usability testing like NIST has formulated a CIF (Common Industry Format) for reporting the findings of the test.

Interactivity – Are interaction mechanisms(pull down menus ,pointers) easy to understand

Layout – Are navigation mechanisms, content and functions placed in a manner that allows the user to find them quickly?

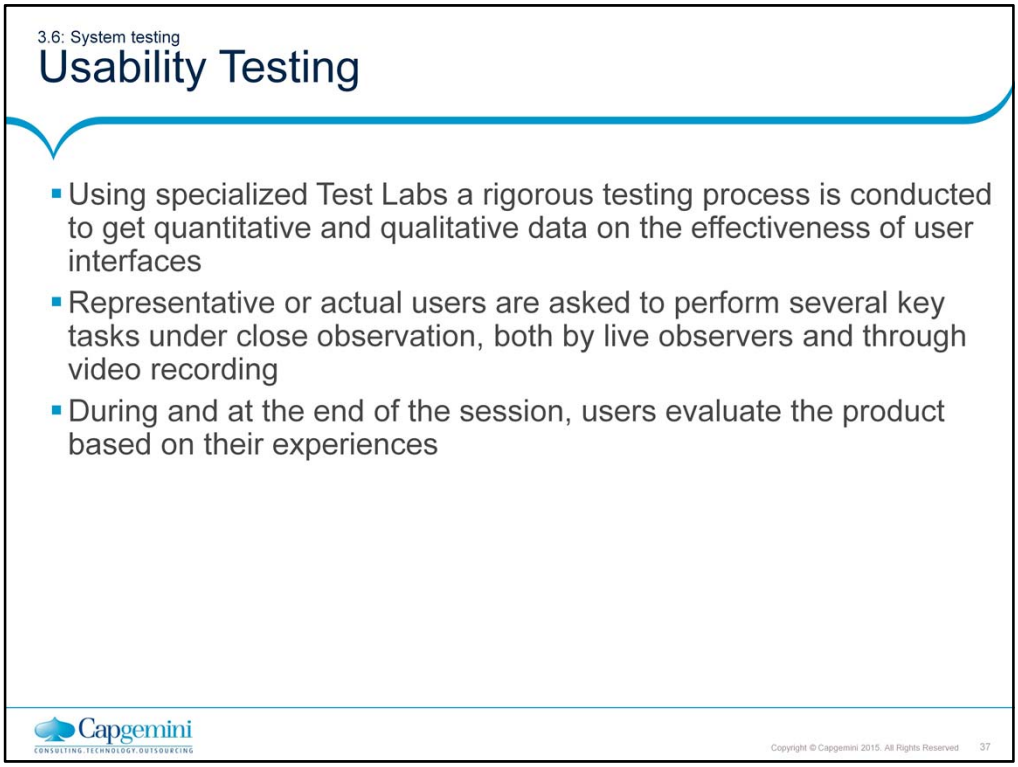
Readability – Is text well written and understandable ? Are graphic representation easy to understand?

Aesthetics – Do layout, color, typeface and related characteristics lead to ease of use? Do users feel comfortable with the look and feel.

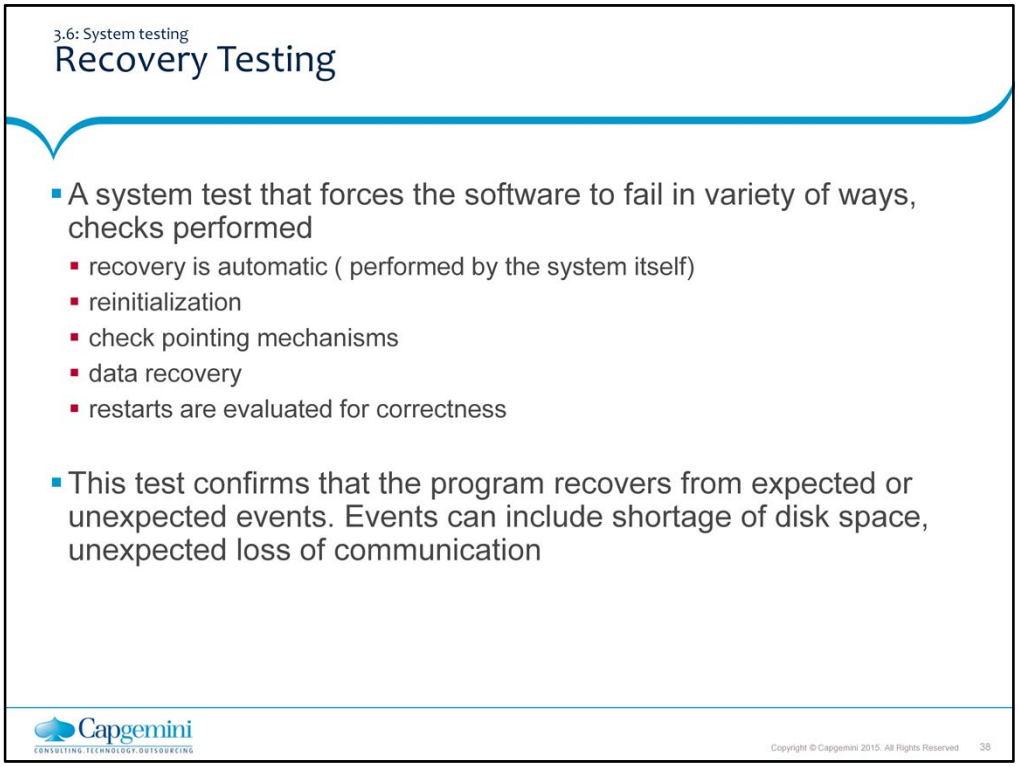
Display Characteristics – optimal use of screen size and resolution.

Time sensitivity – Can important features, functions and content be used or acquired in a timely manner

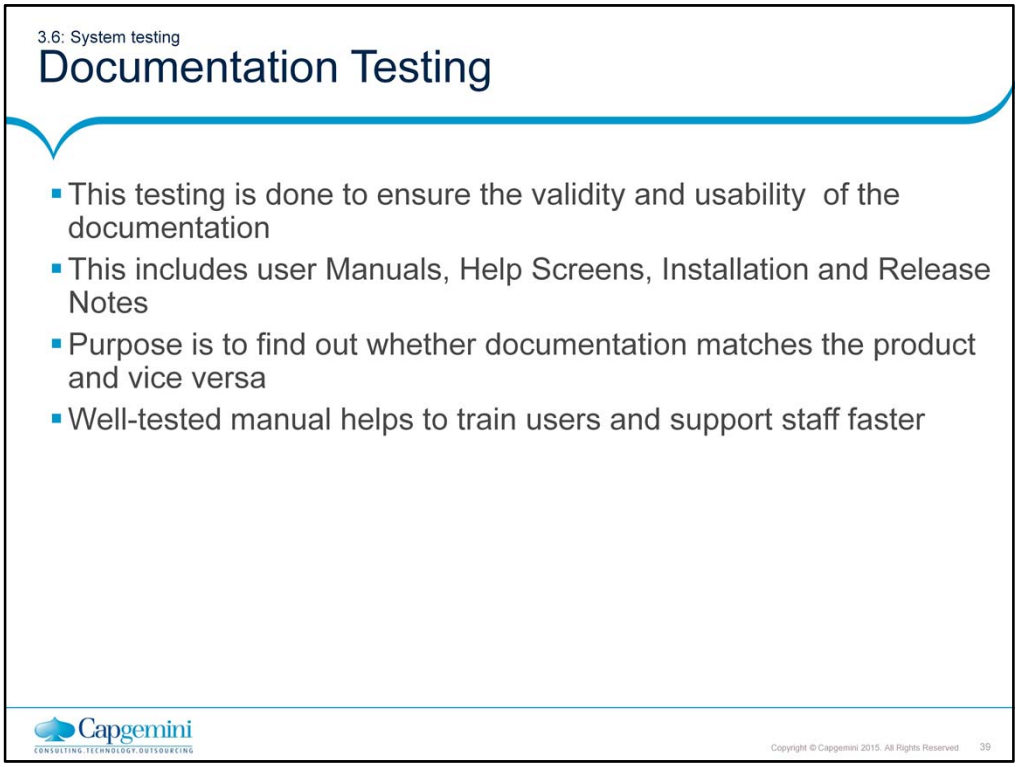
Personalization – Does the web application tailor itself to the specific needs of different user categories or individual users?



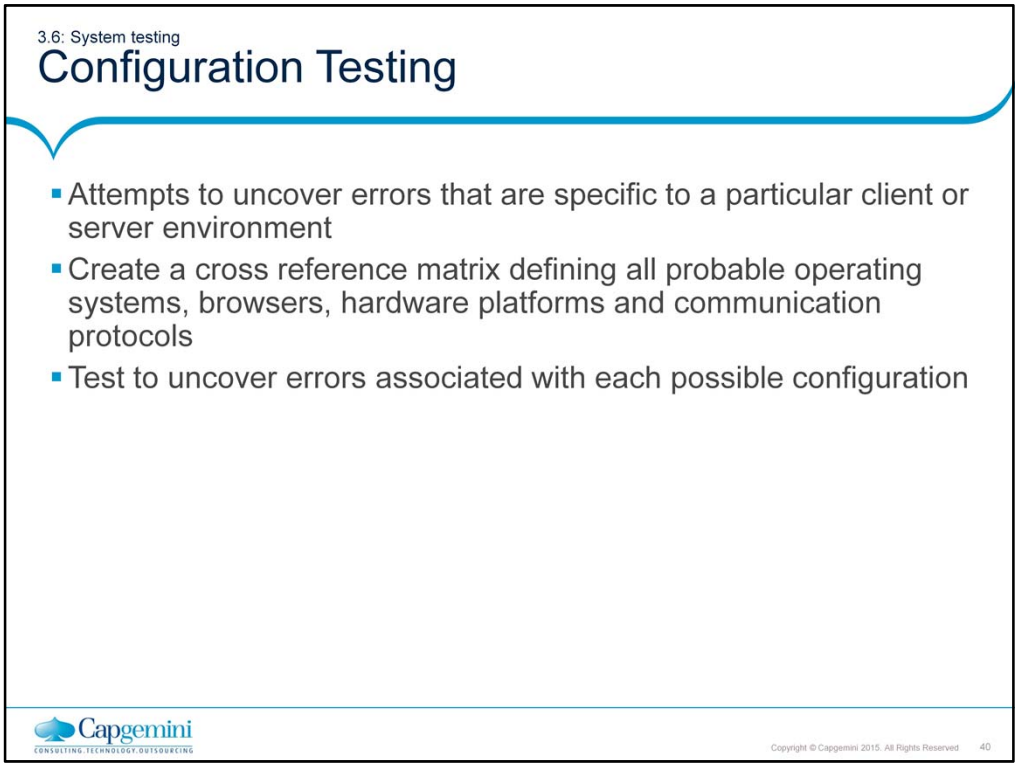
Trainer notes



It Confirms that the program recovers from expected or unexpected events without loss of data or functionality. Events can include shortage of disk space, unexpected loss of communication, or power out conditions.



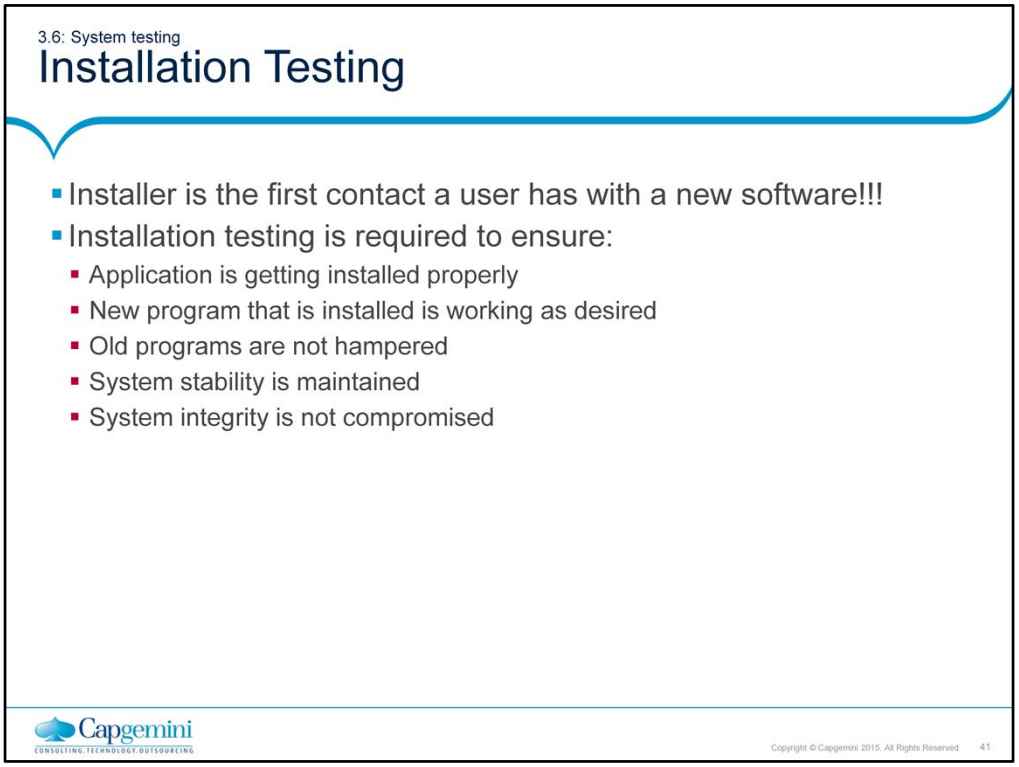
Generally, Technical Writers work to tight schedules, which often does not include documentation testing because there is no time. Besides, no one wants to take the risk of causing a rewrite or correcting product design and not shipping on schedule.
Bad documentation has a ripple effect on the number of users it impacts such as Product Development, Training, and Customer Support.



Configuration Test

Analyze system behaviour:

- in various hardware and software configurations specified in the requirements
- sometimes systems are built in various configurations for different users
- for instance, a minimal system may serve a single user, other configurations for additional users.


3.6: System testing
Installation Testing
Installer is the first contact a user has with a new software!!!
Installation testing is required to ensure:
Application is getting installed properly
New program that is installed is working as desired
Old programs are not hampered
System stability is maintained
System integrity is not compromised
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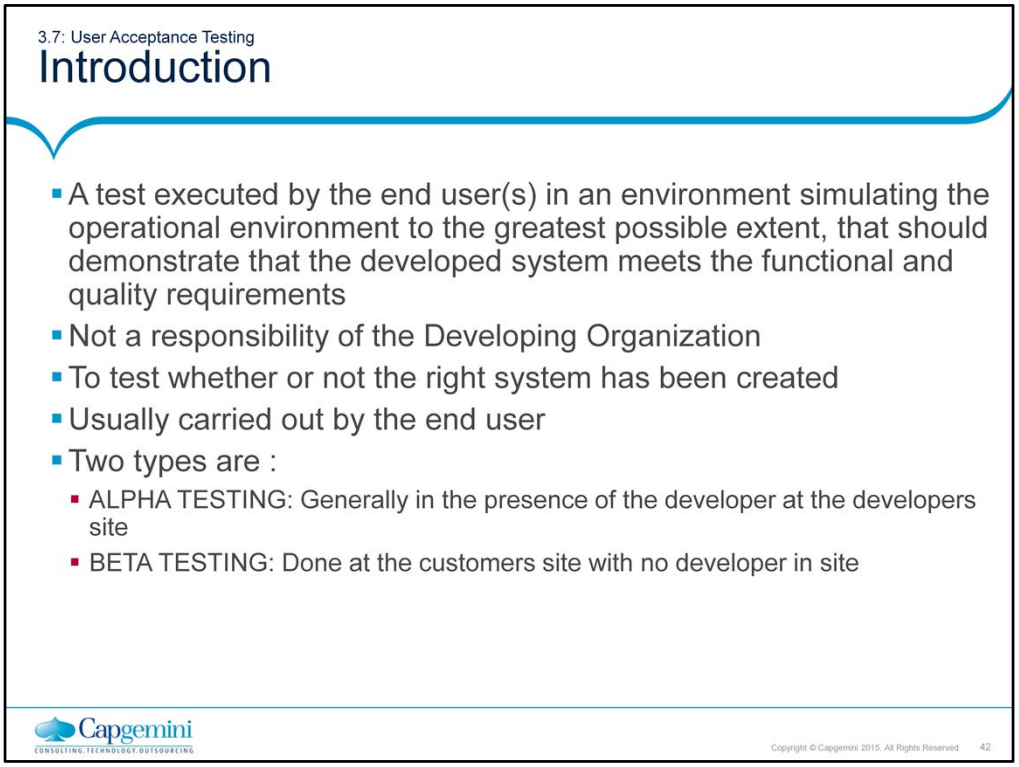
3.7: User Acceptance Testing
Introduction
A test executed by the end user(s) in an environment simulating the operational environment to the greatest possible extent, that should demonstrate that the developed system meets the functional and quality requirements
Not a responsibility of the Developing Organization
To test whether or not the right system has been created
Usually carried out by the end user
Two types are :
ALPHA TESTING: Generally in the presence of the developer at the developers site
BETA TESTING: Done at the customers site with no developer in site
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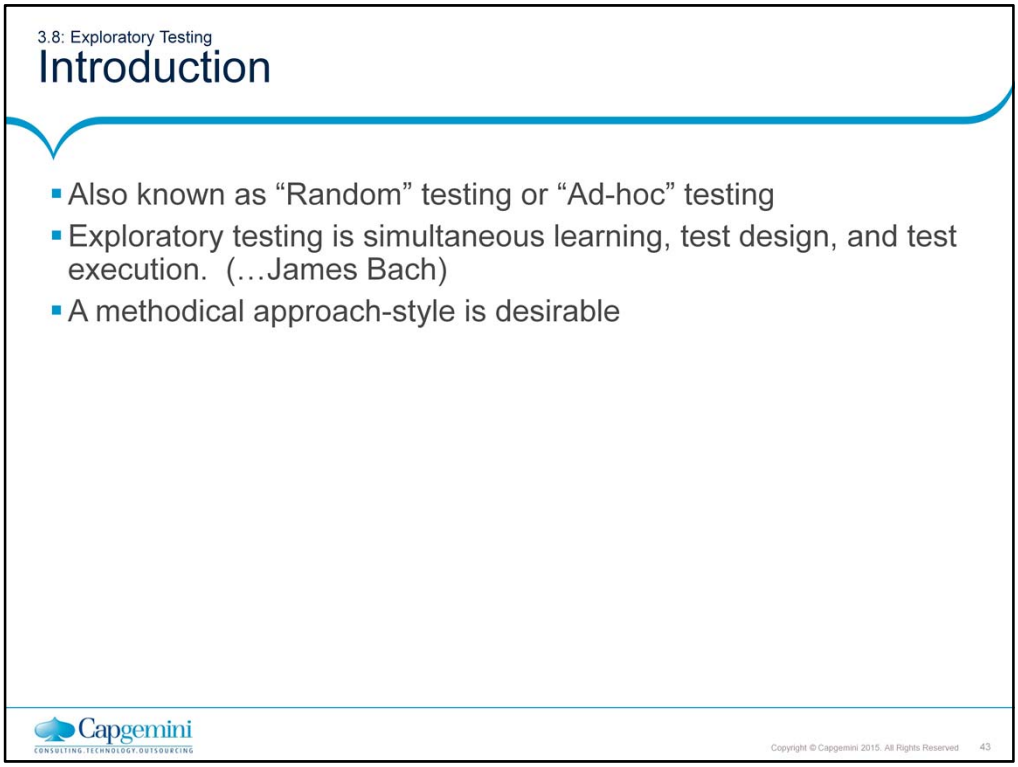
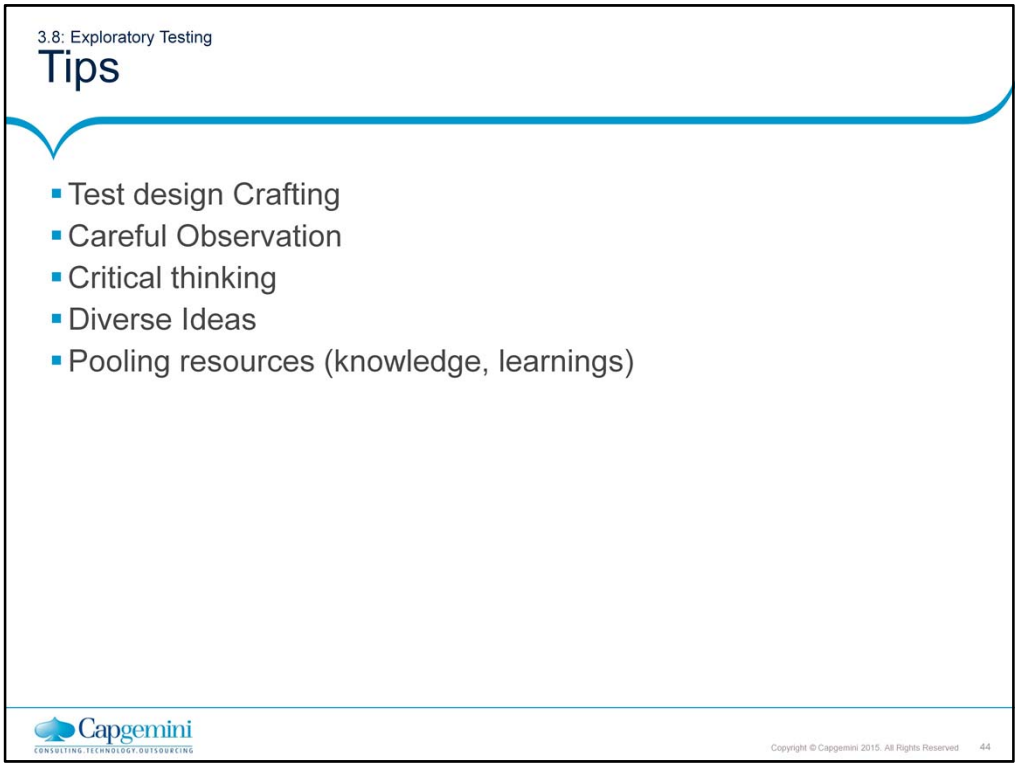
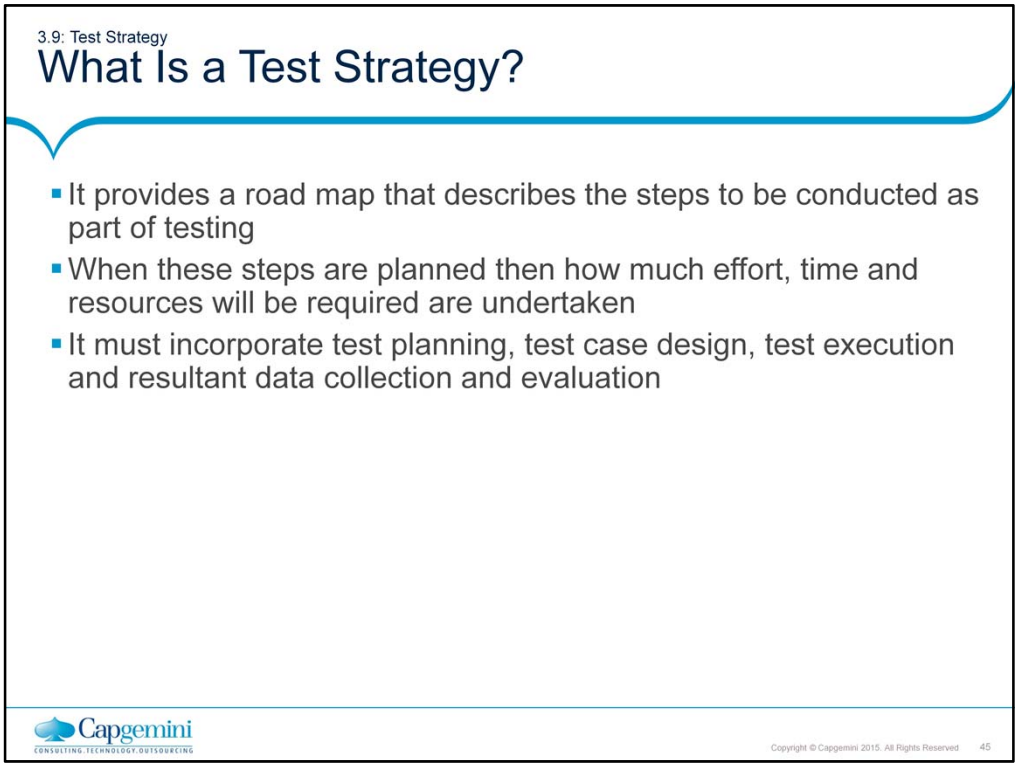


Among the hardest things to explain is something that everyone already knows. We all know how to listen, how to read, how to think, and how to tell anecdotes about the events in our lives. As adults, we do these things everyday. Yet the *level* of any of these skills, possessed by the average person, may not be adequate for certain special situations. Psychotherapists must be *expert* listeners and lawyers *expert* readers; research scientists must scour their thinking for errors and journalists report stories that transcend parlor anecdote.
So it is with exploratory testing (ET): simultaneous learning, test design and test execution.



1. **Test Design:** An exploratory Test Engineer is first and foremost a test designer. Anyone can design a test accidentally, the excellent exploratory tester is able to craft tests that systematically explore the product. That requires skills such as the ability to analyze a product, evaluate risk, use tools, and think critically, among others.
2. **Careful Observation:** Excellent exploratory testers are more careful observers than novices, or for that matter, experienced scripted testers. The scripted tester need only observe what the script tells him to observe. The exploratory tester must watch for *anything* unusual or mysterious. Exploratory testers must also be careful to distinguish observation from inference, even under pressure, lest they allow preconceived assumptions to blind them to important tests or product behavior.
3. **Critical Thinking:** Excellent exploratory testers are able to review and explain their logic, looking for errors in their own thinking. This is especially important when reporting the status of a session of exploratory tests, or investigating a defect.
4. **Diverse Ideas:** Excellent exploratory testers produce more and better ideas than novices. They may make use of heuristics to accomplish this. Heuristics are mental devices such as guidelines, generic checklists, mnemonics, or rules of thumb.
5. **Rich Resources:** Excellent exploratory testers build a deep inventory of tools, information sources, test data, and friends to draw upon. While testing, they remain alert for opportunities to apply those resources to the testing at hand.



Test Strategy – Generic characteristics:

- To perform effective testing a software should conduct effective formal technical reviews. By doing this, many errors will be eliminated before testing commences.
- Testing begins at the component level and works “outward” toward the integration of the entire computer-based system.
- Different testing techniques are appropriate at different points in time.

A strategy for software testing must accommodate low-level tests that are necessary to verify that a small source code segment has been correctly implemented as well as high-level tests that validate major system functions against customer requirements.

A strategy must provide guidance for the practitioner and a set of milestones for the manager. Because the steps of the test strategy occur at a time when deadline pressure begins to rise , progress must be measurable and problems must surface as early as possible.

Summary

- In this lesson, you have learnt:
  - Verification refers to a set of activities which ensures that software correctly implements a specific function.
  - Validation refers to a different set of activities which ensures that the software that has been built is traceable to customer requirements.
  - Different testing phases are
    - Unit testing
    - Integration testing
    - System testing
    - Acceptance testing
  - Exploratory testing is simultaneous learning, test design and test execution.

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Review Question

- Question 1: _____ is a Quality improvement process
- Question 2: Volume tests executes a system in a manner that demands resources in abnormal quantity, frequency, or volume
  - True/False
- Question 3: Acceptance testing is not a responsibility of the Developing Organization
  - True/False

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Review Question: Match the Following

1. Beta testing	A. Volume testing
2. Response time	B. Exploratory testing
3. Aesthetics	C. Acceptance testing
	D. Documentation testing
	E. Performance testing
	F. Usability testing

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Testing Concepts for V&V Automation Testing

Lesson 4: Test Case Execution/Testing Metrics

Lesson Objectives

- Test Case execution
- The objective is to understand various metrics that evaluate the effectiveness of the testing process
- To learn best practices for test case maintenance

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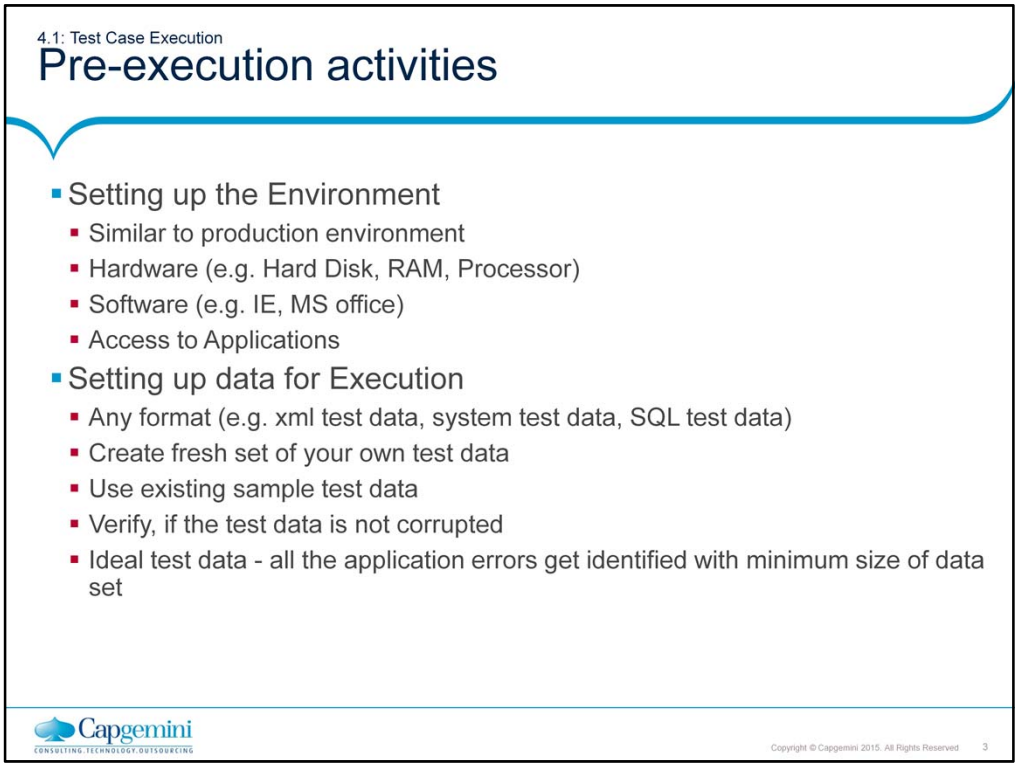
4.1: Test Case Execution
Pre-execution activities
Setting up the Environment
Similar to production environment
Hardware (e.g. Hard Disk, RAM, Processor)
Software (e.g. IE, MS office)
Access to Applications
Setting up data for Execution
Any format (e.g. xml test data, system test data, SQL test data)
Create fresh set of your own test data
Use existing sample test data
Verify, if the test data is not corrupted
Ideal test data - all the application errors get identified with minimum size of data set
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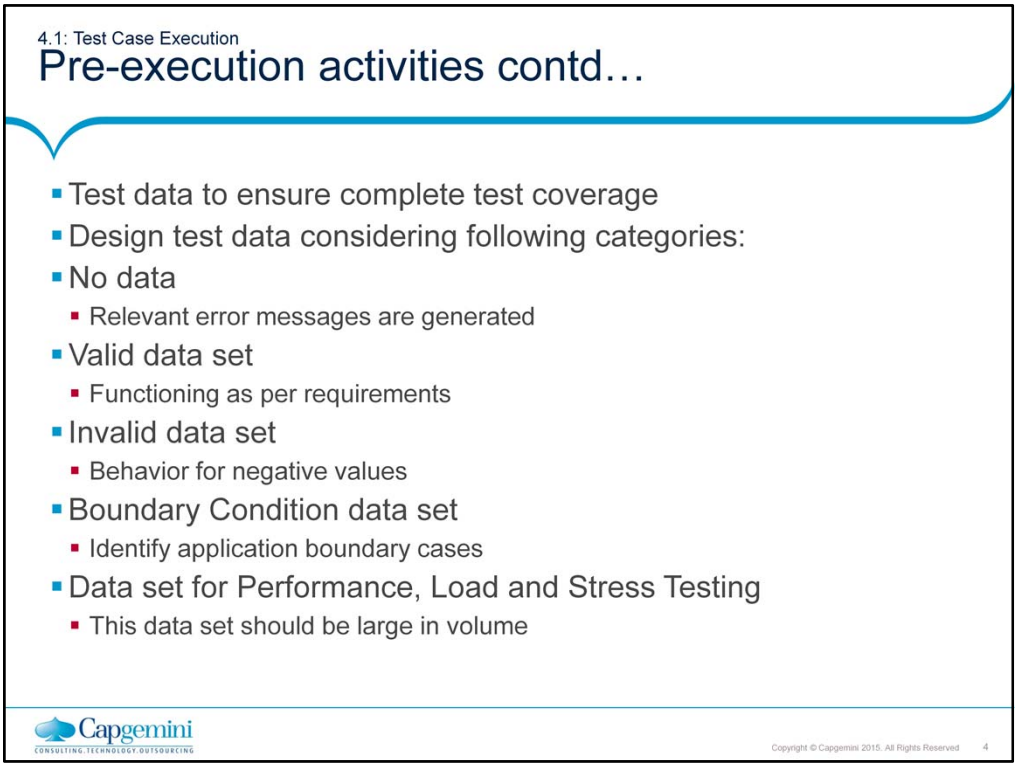
4.1: Test Case Execution
Pre-execution activities contd…
Test data to ensure complete test coverage
Design test data considering following categories:
No data
Relevant error messages are generated
Valid data set
Functioning as per requirements
Invalid data set
Behavior for negative values
Boundary Condition data set
Identify application boundary cases
Data set for Performance, Load and Stress Testing
This data set should be large in volume
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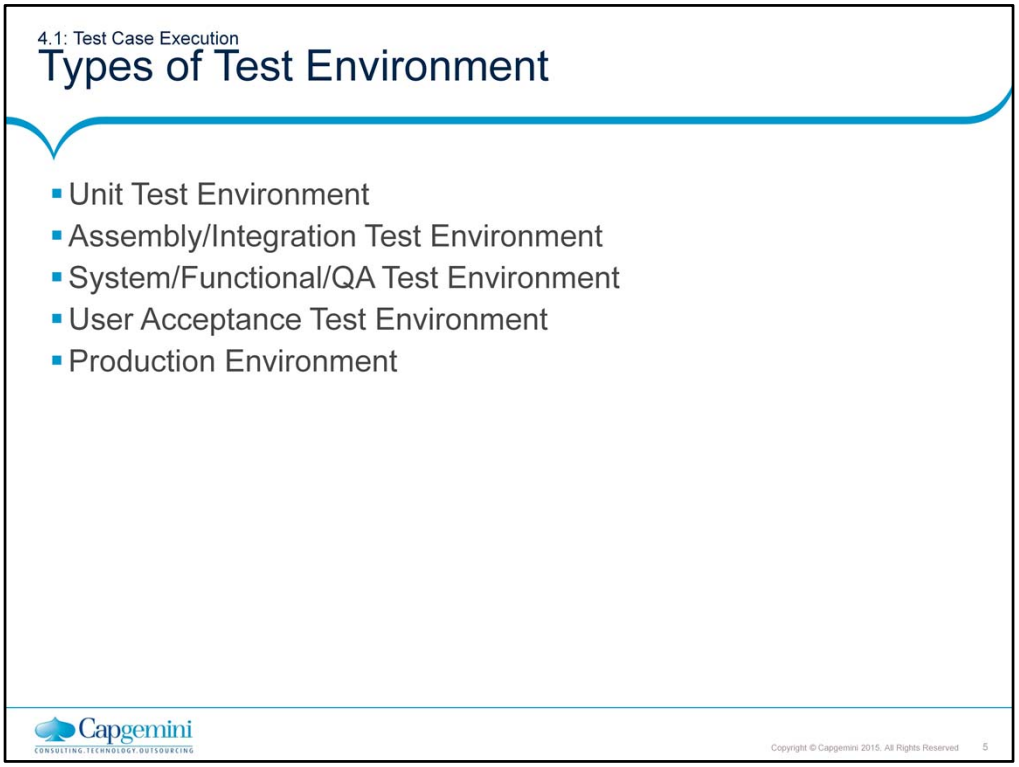
4.1: Test Case Execution
Types of Test Environment
Unit Test Environment
Assembly/Integration Test Environment
System/Functional/QA Test Environment
User Acceptance Test Environment
Production Environment
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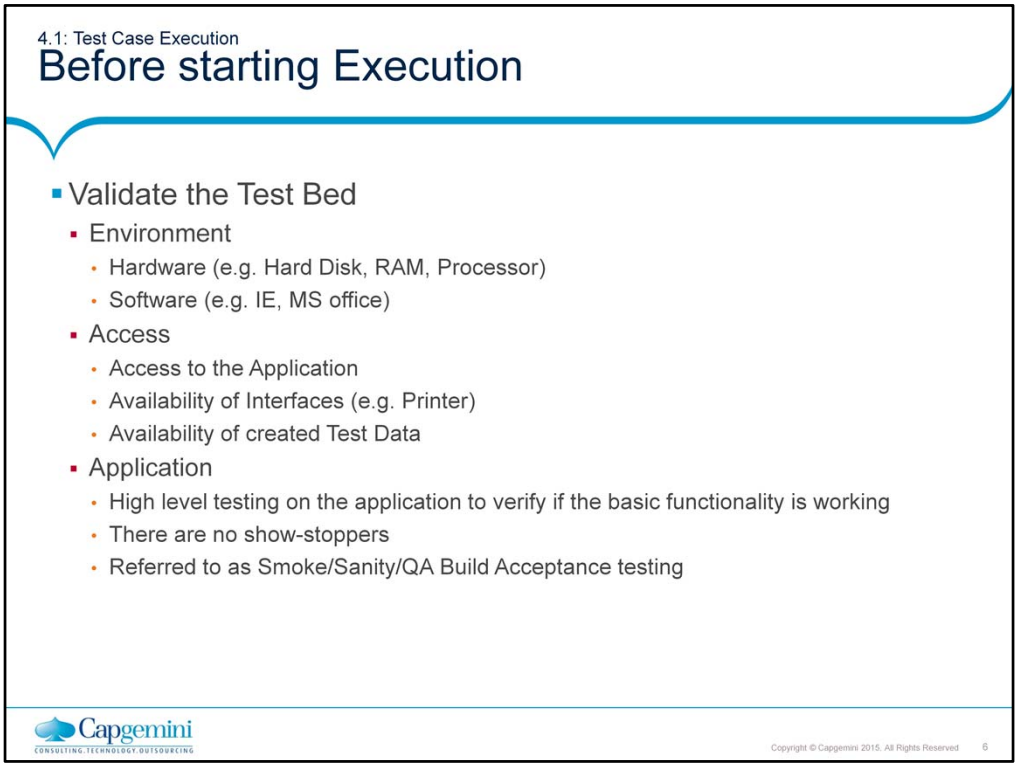
4.1: Test Case Execution
Before starting Execution
Validate the Test Bed
Environment
Hardware (e.g. Hard Disk, RAM, Processor)
Software (e.g. IE, MS office)
Access
Access to the Application
Availability of Interfaces (e.g. Printer)
Availability of created Test Data
Application
High level testing on the application to verify if the basic functionality is working
There are no show-stoppers
Referred to as Smoke/Sanity/QA Build Acceptance testing
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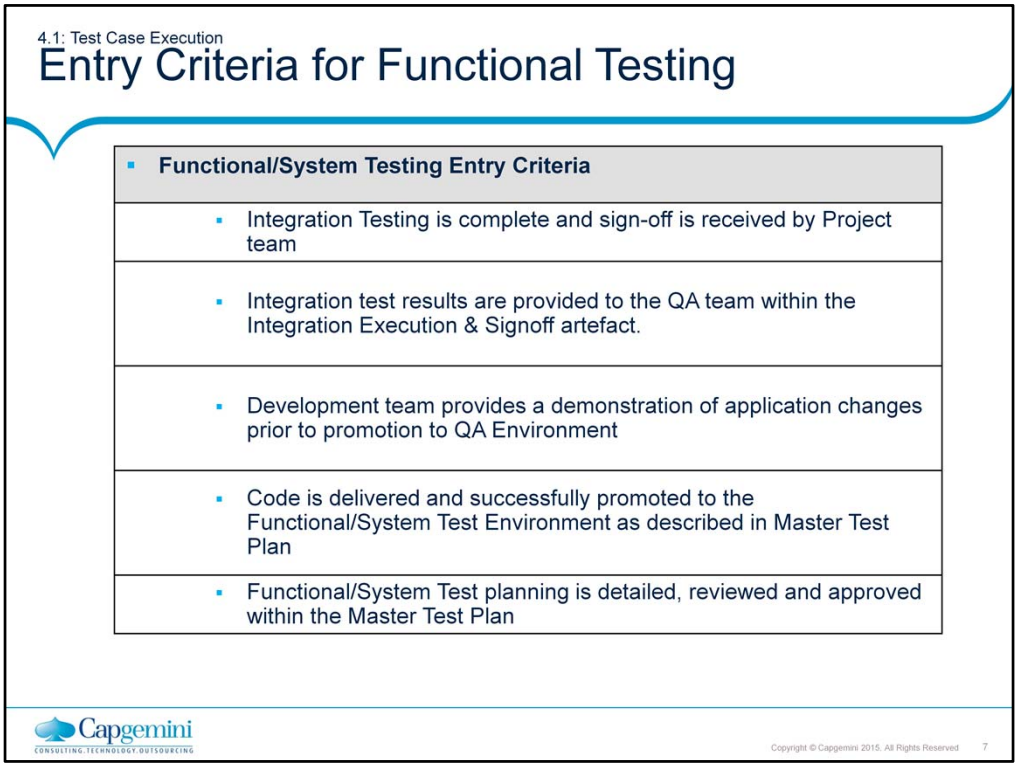
4.1: Test Case Execution
Entry Criteria for Functional Testing
Functional/System Testing Entry Criteria
Integration Testing is complete and sign-off is received by Project team
Integration test results are provided to the QA team within the Integration Execution & Signoff artefact.
Development team provides a demonstration of application changes prior to promotion to QA Environment
Code is delivered and successfully promoted to the Functional/System Test Environment as described in Master Test Plan
Functional/System Test planning is detailed, reviewed and approved within the Master Test Plan
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4.1: Test Case Execution

Entry Criteria for Functional Testing Contd…

Functional/System Testing Entry Criteria
➢ Smoke /Shake down test has been completed to ensure test environment is stable for testing.
➢ Functional/System Test planning is detailed, reviewed and approved within the Master Test Plan
➢ Test cases created are traceable back to SRS, and any approved change requests, using HPQC
➢ Functional/System Test Cases are created, reviewed and approved within the RBC Enterprise approved tool (HP QC)
➢ Test data is ready for Functional/System Testing

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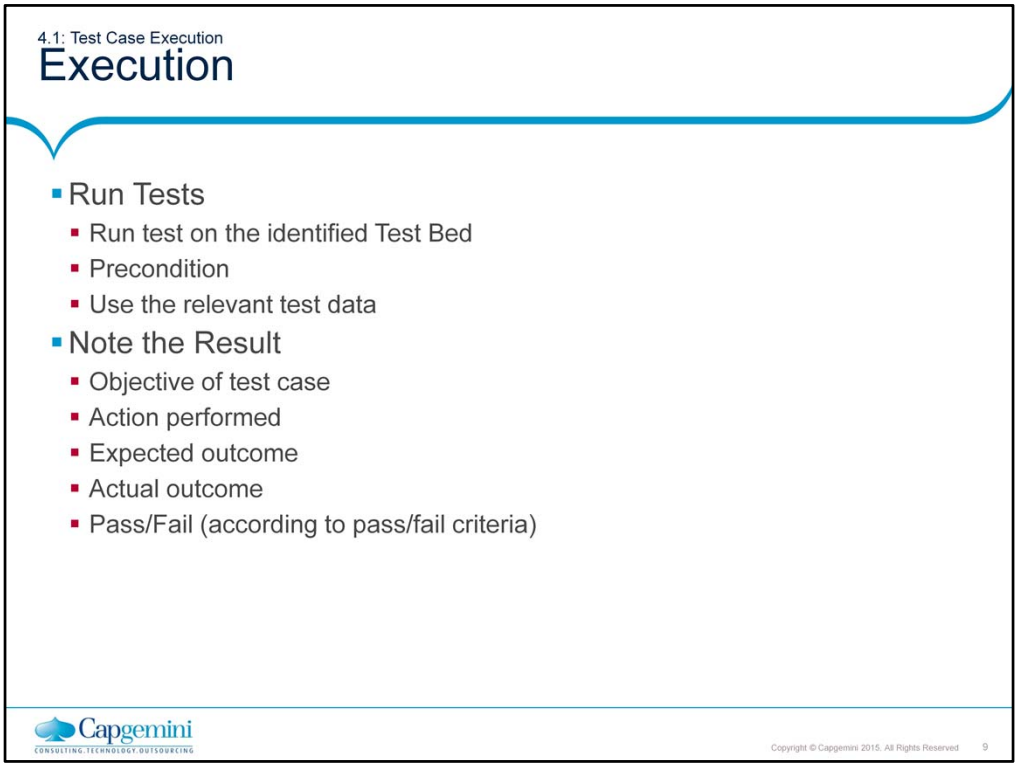
4.1: Test Case Execution
Execution
Run Tests
Run test on the identified Test Bed
Precondition
Use the relevant test data
Note the Result
Objective of test case
Action performed
Expected outcome
Actual outcome
Pass/Fail (according to pass/fail criteria)
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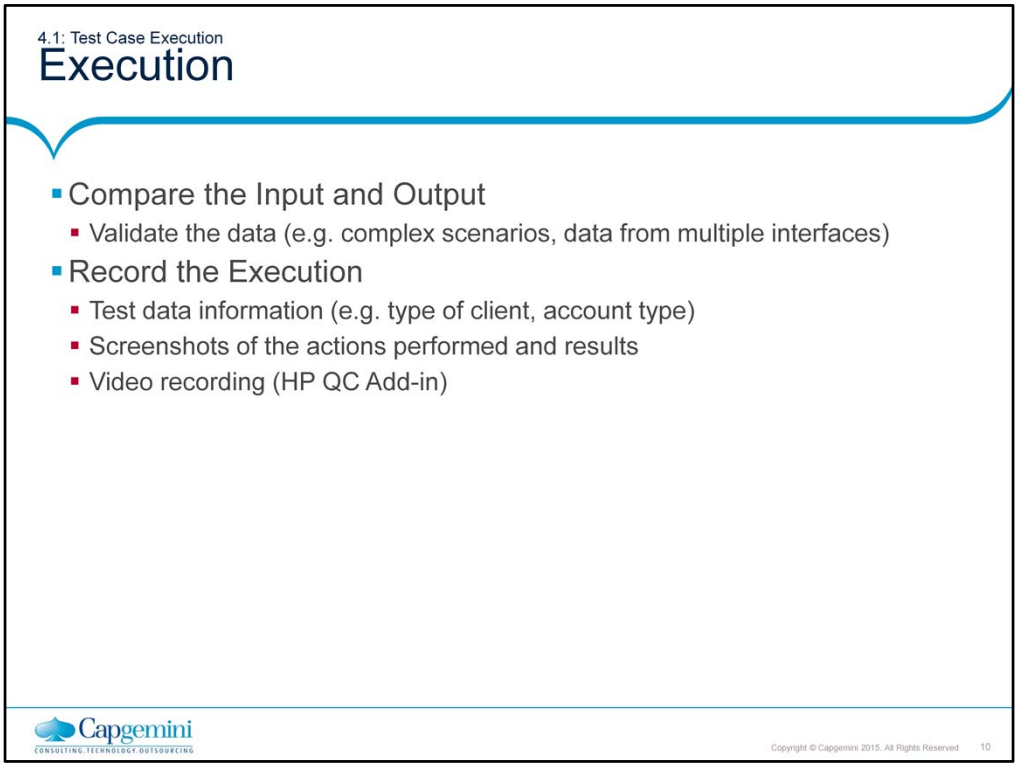
4.1: Test Case Execution
Execution
Compare the Input and Output
Validate the data (e.g. complex scenarios, data from multiple interfaces)
Record the Execution
Test data information (e.g. type of client, account type)
Screenshots of the actions performed and results
Video recording (HP QC Add-in)
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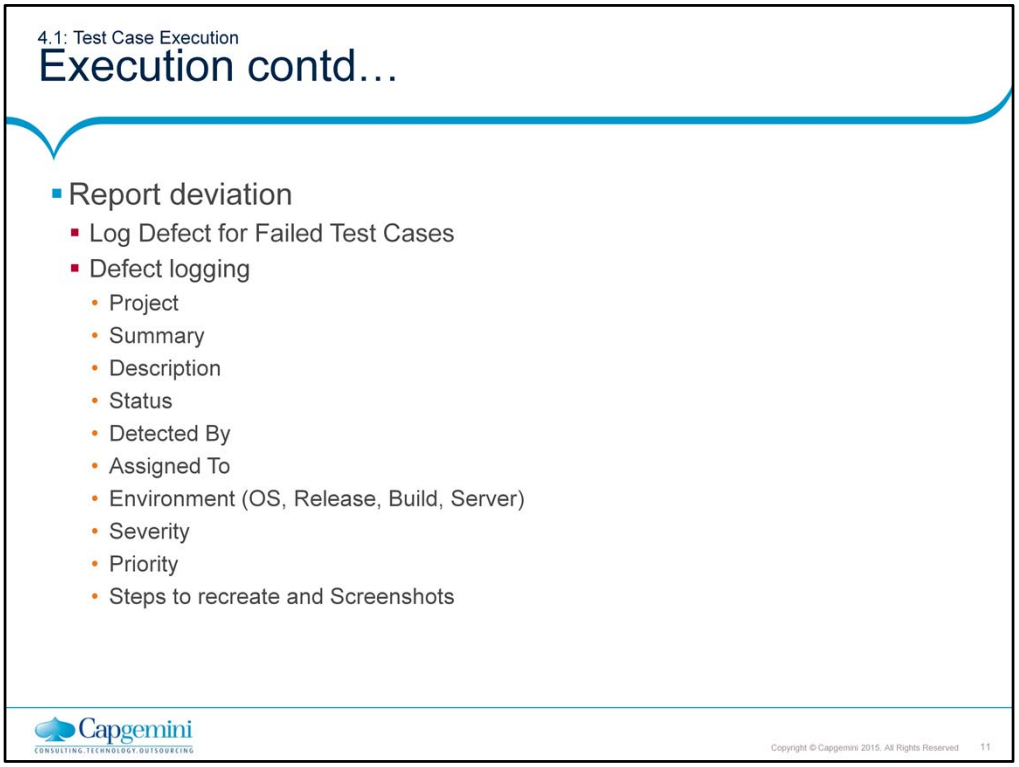
4.1: Test Case Execution
Execution contd…
Report deviation
Log Defect for Failed Test Cases
Defect logging
Project
Summary
Description
Status
Detected By
Assigned To
Environment (OS, Release, Build, Server)
Severity
Priority
Steps to recreate and Screenshots
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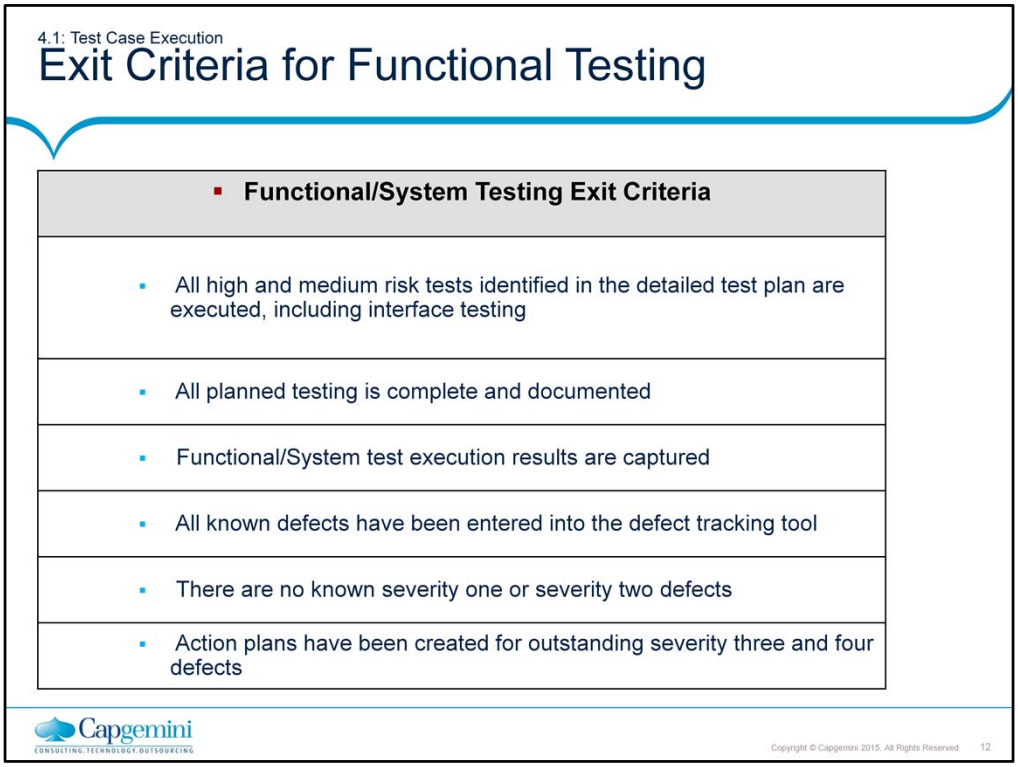
4.1: Test Case Execution
Exit Criteria for Functional Testing
Functional/System Testing Exit Criteria
All high and medium risk tests identified in the detailed test plan are executed, including interface testing
All planned testing is complete and documented
Functional/System test execution results are captured
All known defects have been entered into the defect tracking tool
There are no known severity one or severity two defects
Action plans have been created for outstanding severity three and four defects
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4.1: Test Case Execution

Exit Criteria for Functional Testing Contd…

Functional/System Testing Exit Criteria
➢ Appropriate signoffs are obtained
➢ Location of test cases, automated test scripts, defects and Functional/System Execution & Signoff artefact are detailed within the SCM plan.
➢ Any known deviations from the BRD and SRS are documented and approved

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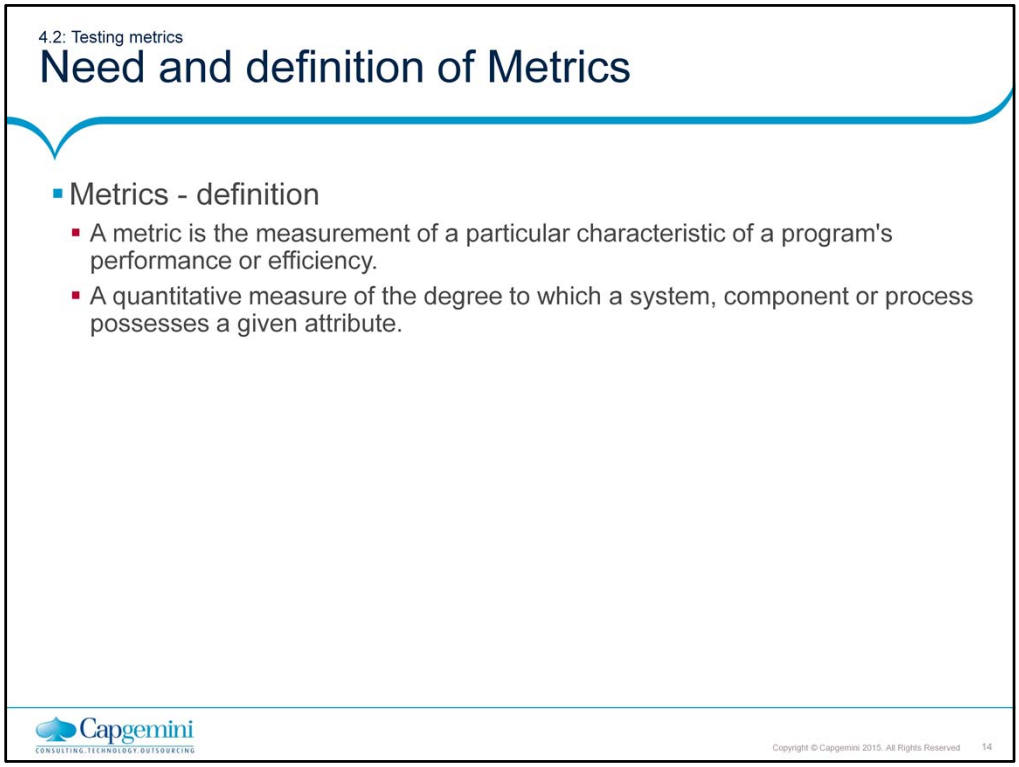


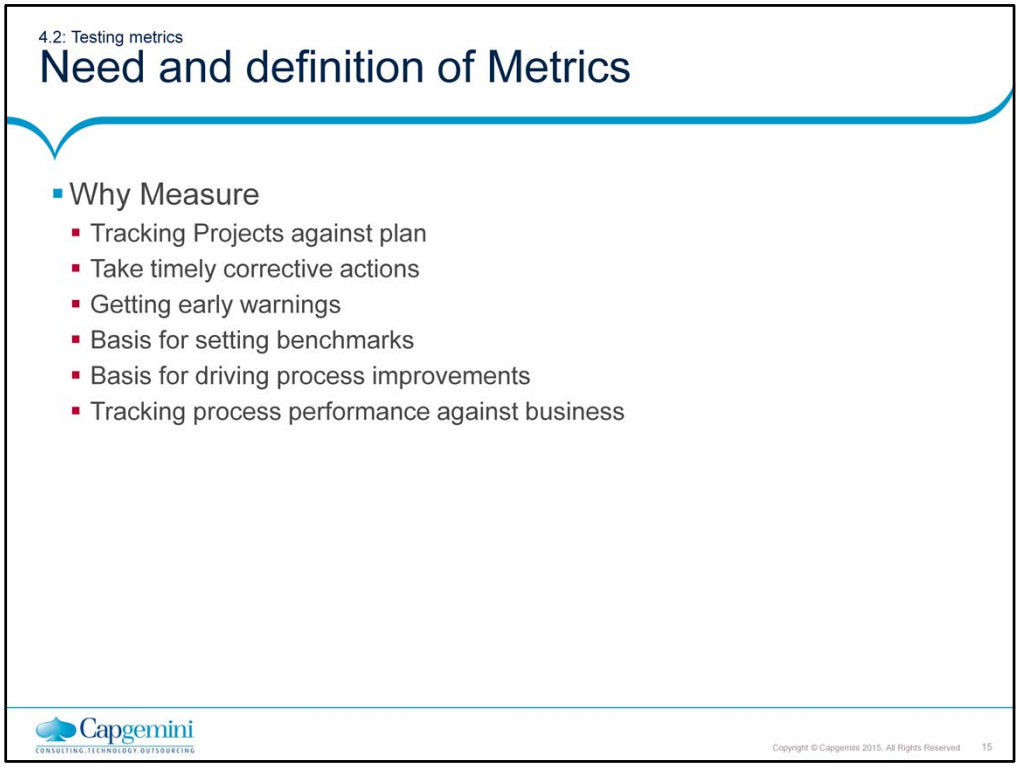
Process measurement and analysis, and utilization of quantitative methods for quality management are the two key process activities at Level 4 Maturity of CMM.

While the need for metrics has been recognized, implementation of structured measurement programs is lagging, especially in the software testing area.

Efficient test process measurement is essential for managing and evaluating the effectiveness of a test process.

Test metrics are an important indicator of the effectiveness of a software testing process.
There are various metrics that evaluate the effectiveness of the testing process and also the other metrics that are affected due to the testing process.

In general, we measure following things
1. Functionality
2. Schedule
3. Cost



- Test Metrics data collection helps predict the long term direction and scope for an organization
- Provides a basis for estimation and facilitates planning for closure of the performance gap
- Provides a means for control/status reporting
- Identify critical processes that will be monitored statistically
- Identifies risk areas that require more testing
- Provides meters to flag actions for faster and more informed decision making
- Helps in identifying potential problems and areas of improvement
- Provide an objective measure of the effectiveness and efficiency of testing

4.2: Testing metrics

Metrics for Testing

- Defect Density
  - Total Defect density = (Total number of defects including both impact and non-impact, found in all the phases + Post delivery defects)/Size
- Average Defect Age
  - Average Defect age = (Sum of ((Defect detection phase number – defect injection phase number) * No of defects detected in the defect detection phase))/(Total Number of defects till date)
- Defect Removal Efficiency
  - DRE = 100 * No. of pre-delivery defects / Total No. of Defects

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Defect Density is the no. of defects found in a unit.

Defects are measured as found in
1. Reviews
2. Testing
3. Acceptance
4. Warranty

The defect that are hampering the functionality are 'impact' defects. Defect those are not affecting functionality like look n feel errors, displacement errors are non-impact errors.

The defect impacting the functionality are direct. Impact defect whereas the commenting standard. Defect found in code review is non-impact.

E.g. If Total number of direct impact defects found in all the phases = 20, Post delivery defects = 10, Size = 100, Direct Impact Defect density = 20+15/100 = 0.30

We should try n minimize it. We should minimize impact & non-impact errors.

Average Defect Age

The Average defect age tells us for how long the defect was in the system after it was injected.

For E.g. If Defect detection phase number= 4, defect injection phase number = 2, No of defects detected in the defect detection phase = 10, Total Number of defects till date = 40

Defect Age = 4-2*20/40 = 1 ---------- This is the defect age. Should be kept minimum.

Difference should be kept minimum.

Average Defect age is the sum of defects detected at all the stages.

Defect Removal Efficiency

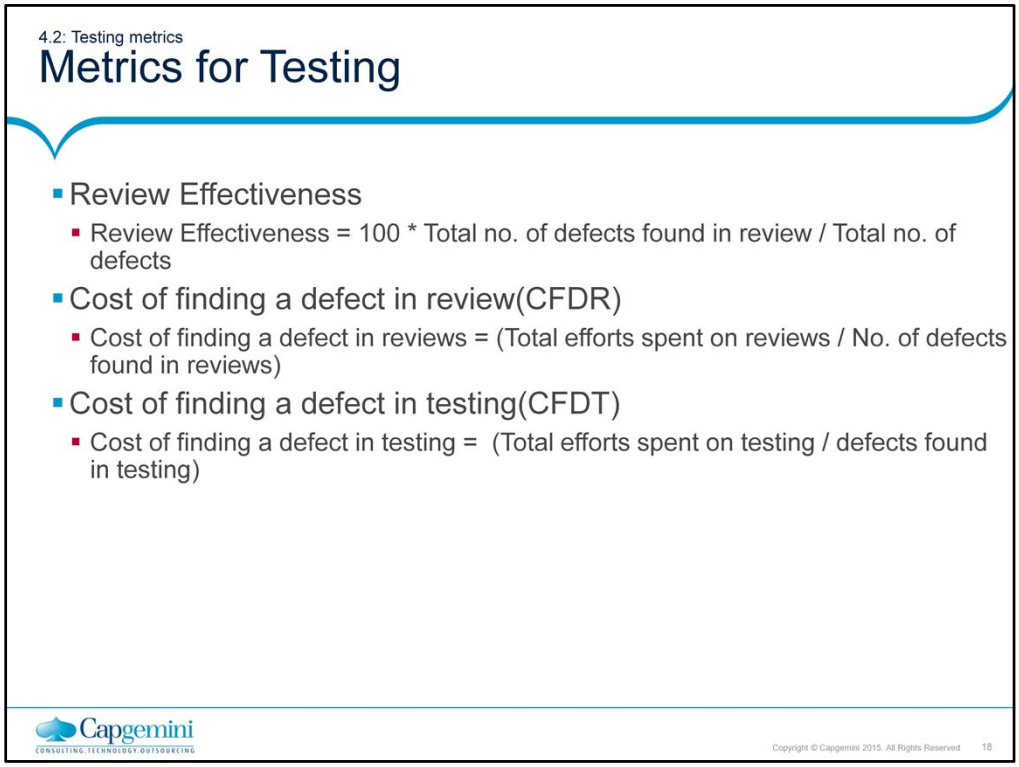
For E.g. If No. of pre-delivery defects = 5, Total No. of Defects = 20,

DRE = 100 *5/20 = 100*0.25=25

This has to be 100%. No of pre-delivery defects should be greater than total no. of defects. So the errors should get find before delivery.

Low Defect Removal Efficiency means – More defects left undetected before delivery,

Reviews and Testing failed to detect them.



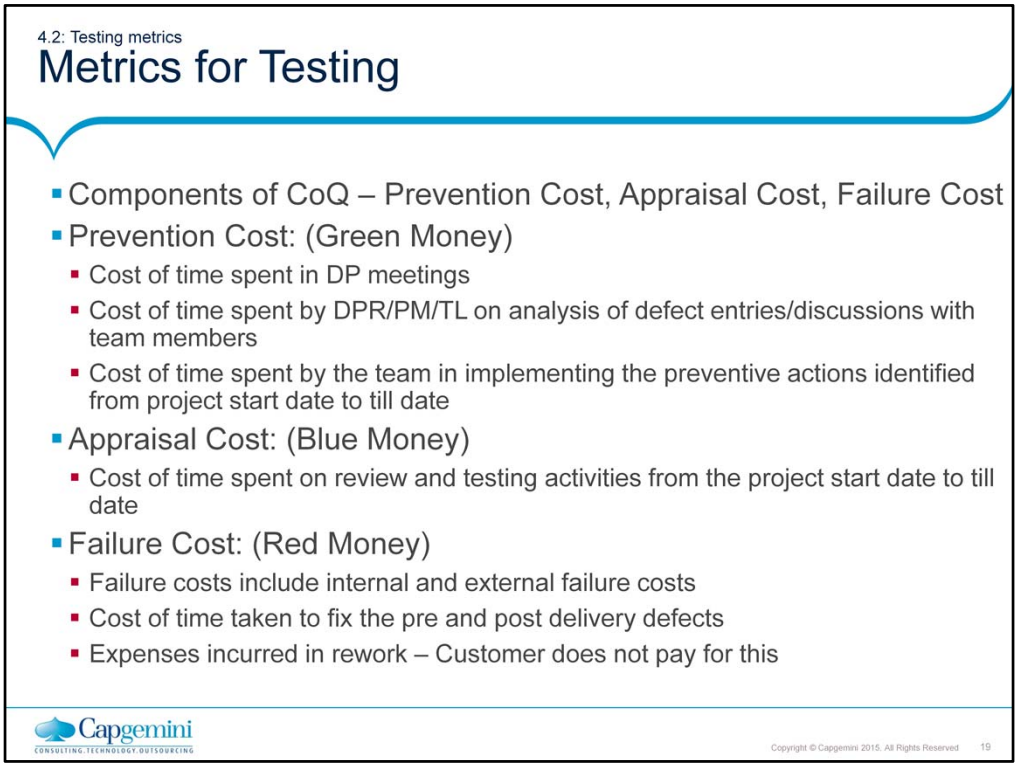
Review Effectiveness :
The review effectiveness tells us how effective is review process. If all the defects are found during the review then the effectiveness % will be 100.
E.g. If Total no. of defects found in review = 20, Total no. of defects=40
RE = 100*20/40= 50. So defects should get find at review stage only to achieve 100 % effectiveness.
Low Review Effectiveness means : More defects detected in testing. Reviews failed to detect early

Cost of finding defect in review
This metric tells us the effort spent in finding a defect in reviews. Cost of reviews include all the efforts spent in review briefing, defect recording etc. This includes reviewer, recorder and creators time if creator is attending the review his/her time also should be recorded.
For E.g. If Total efforts spent on reviews = 40 hrs, No. of defects found in reviews = 20, CFDR= 40/20=2 Hrs

Cost of finding defect in testing

This metric computes the Cost of finding a defect in testing . Total time spent on testing includes time to create and review, run the test cases and recording the defects. This should not include the time spent in fixing the defects.

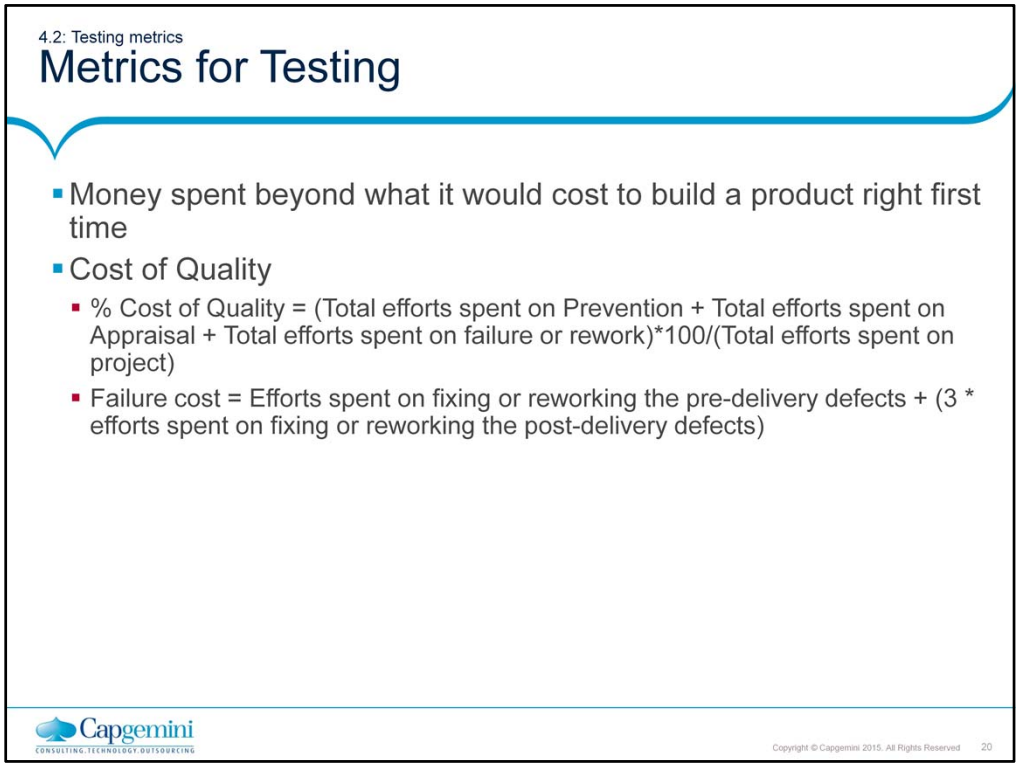
CFDT = Total efforts spent on testing / defects found in testing = 60/30=2 hrs



Prevention - Money required preventing errors and to do the job right the first time is considered prevention cost. This category includes money spent on establishing methods and procedures, training workers and planning for quality. Prevention money is all spent before the product is actually built.

Appraisal – Appraisal costs cover money spent to review completed products against requirements. Appraisal includes the cost of inspections, testing and reviews. This money is spent after the product or subcomponents are built but before it is shipped to the user.

Failure – Failure costs are all costs associated with defective products. Some failure costs involve repairing products to make them meet requirements. Others are costs generated by failures, such as the cost of operating faulty products, damage incurred by using them and the costs incurred because the product is not available. The user or customer of the organization may also experience failure costs.



Cost of Quality - Cost of Quality consists of Prevention cost, Appraisal cost & Failure (or Rework) cost. Here, cost is the efforts measured in terms of person days.

Prevention cost consists of efforts spent on preventing defects such as:

1. Time spent in various Defect Prevention meetings
2. Time spent by Defect Prevention Reviewer/Project Leader on analysis of defect entries/discussions with team members/SQA
3. Time spent by the team in implementing the preventive actions identified from project start date to till date.

For E.g. If Total efforts spent on Prevention = 20, Total efforts spent on Appraisal =30, Total efforts spent on failure or rework = 40, Total efforts spent on project = 140

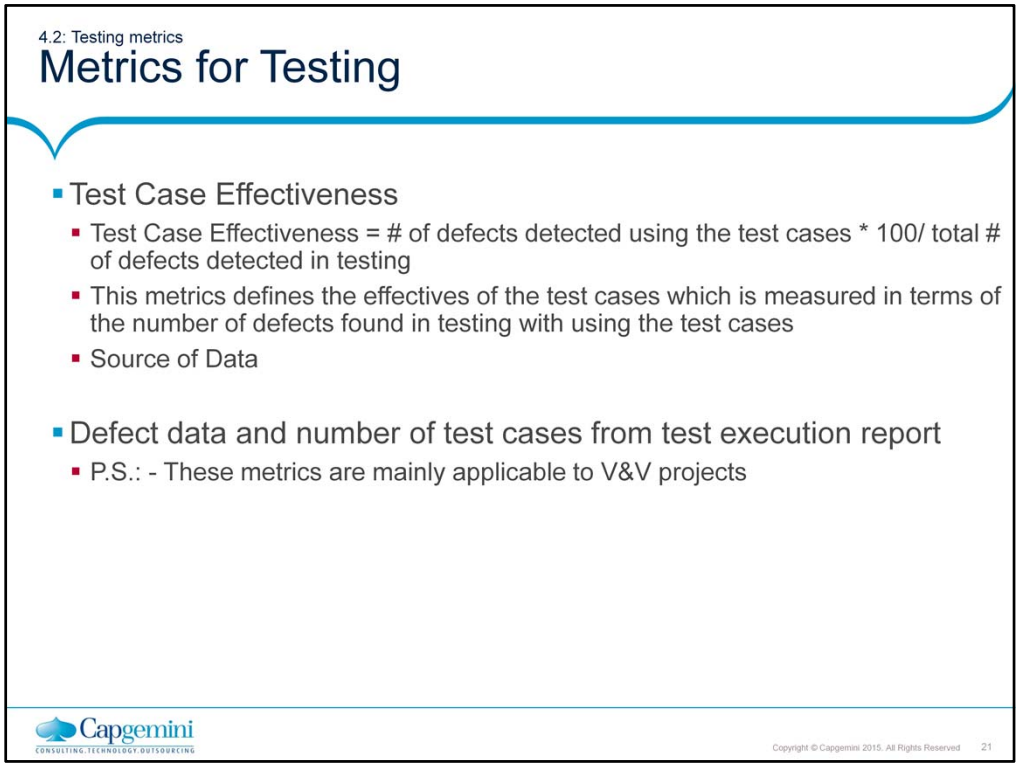
Cost of quality = (20+30+40)*100/140= 64. This has to decrease. Total efforts of all the activities should match with efforts spent on time.

Failure cost = Efforts spent on fixing or reworking the pre-delivery defects + (3 * efforts spent on fixing or reworking the post-delivery defects)

(As the impact of post delivery defects will be high, weightage of “3” has been attached to it)

For E.g. Efforts spent on fixing or reworking the pre-delivery defects = 40, efforts spent on fixing or reworking the post-delivery defects = 20 **Failure cost** = 40+(3*20) = 40+60 = 100.

We need to keep it minimum. So, efforts for post-delivery defects should be 0 to minimize failure cost.

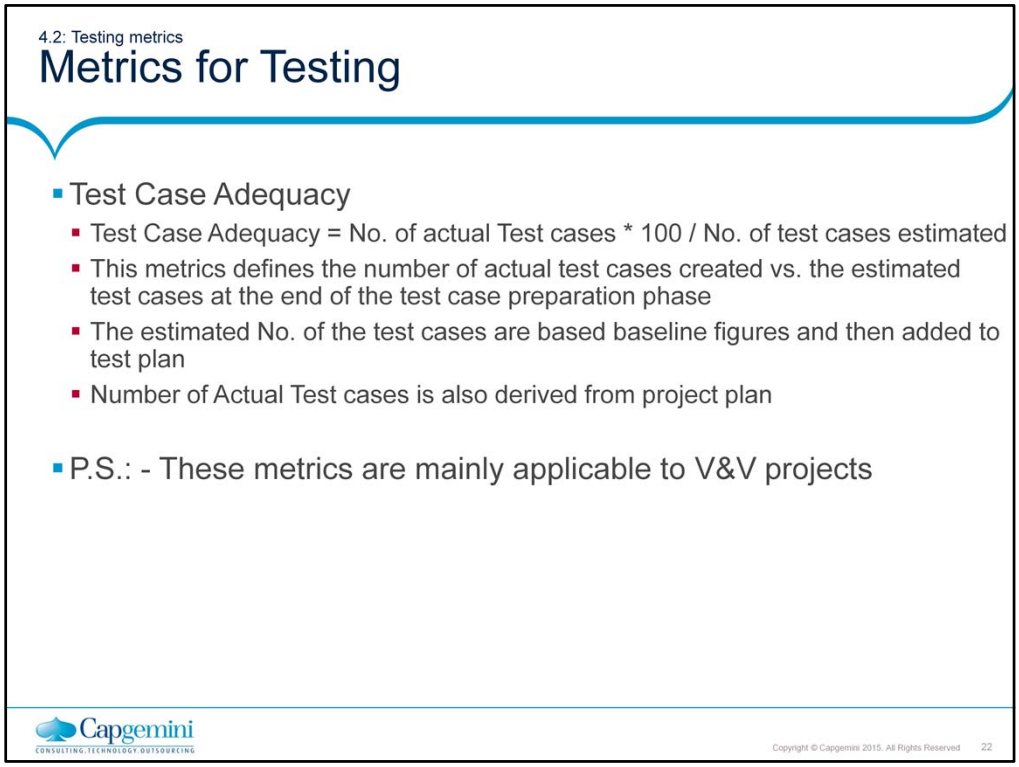


Test Case Effectiveness (TCE) : This metrics defines the effectives of the test
cases which is measured in terms of the number of defects found in testing without using the test cases.

Test Case Effectiveness = # of defects detected using the test cases * 100/ total #
Of defects detected in testing

E.g. If # of defects detected using the test cases = 30, total # of defects detected in testing = 50

Test Case Effectiveness = 30*100/50 = 60
Effectiveness needs to be high. # of defects detected using the test cases should match total # of defects detected in testing to have effectiveness.

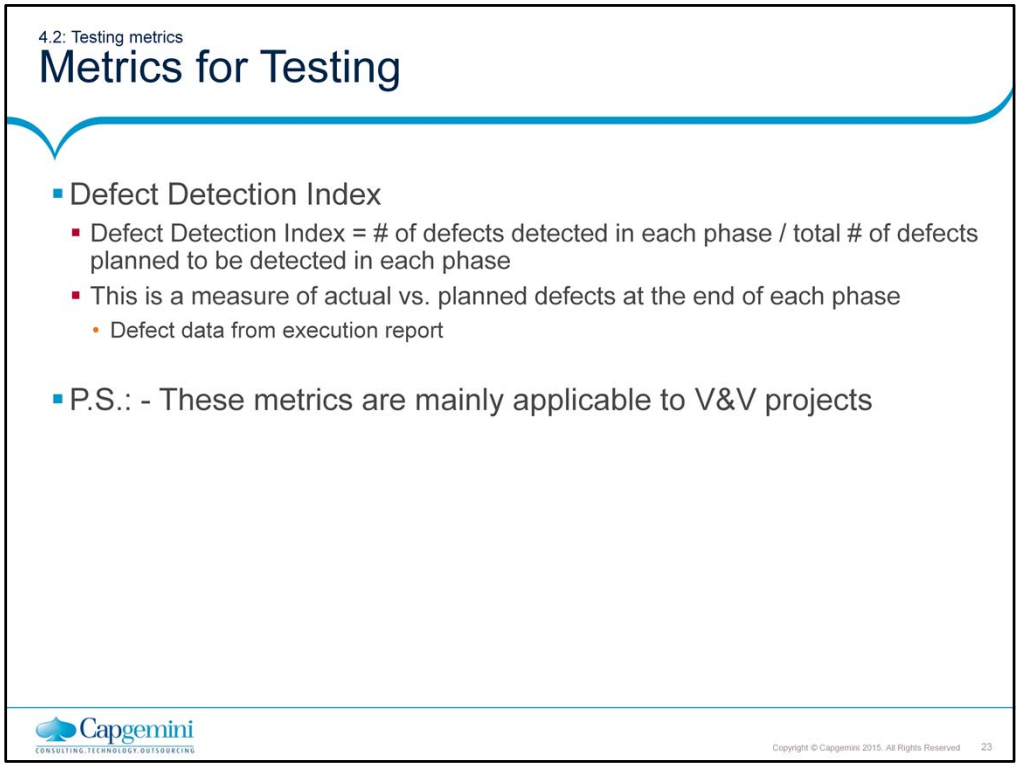


Test Case Adequacy
This metrics defines the number of actual test cases created vs. the estimated test cases at the end of the test case preparation phase. The estimation of the planned test cases are based upon the baseline figures.

For E.g.

If No. of actual Test cases = 30, No. of test cases estimated = 40
Test Case Adequacy = 30*100/40 = 75

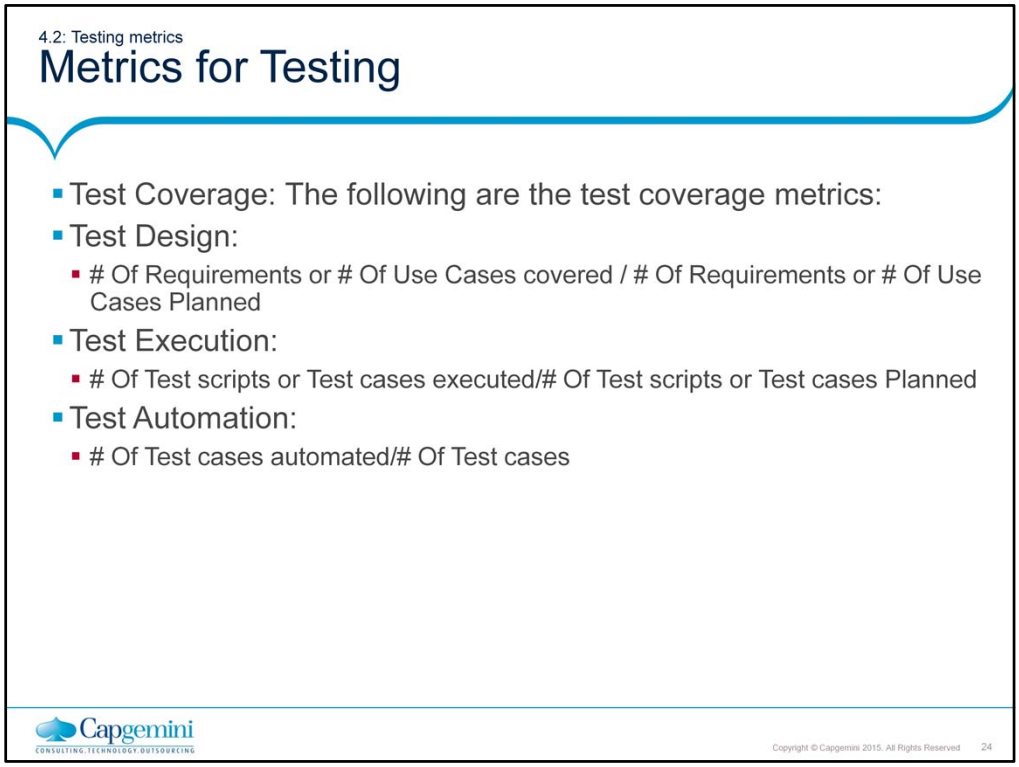
This has to be 100%. For which, No. of actual Test cases should match No. of test cases estimated. There should not be vast difference between them to achieve higher adequacy.



Defect Detection Index (DDI) - This is a measure of actual vs. planned defects at
the end of each phase.

For E.g. If # of defects detected in each phase = 20, total # of defects planned to be detected in each phase = 100

Defect Detection Index = 20/100= 0.50


4.2: Testing metrics
Metrics for Testing
Test Coverage: The following are the test coverage metrics:
Test Design:
Of Requirements or # Of Use Cases covered / # Of Requirements or # Of Use Cases Planned
Test Execution:
Of Test scripts or Test cases executed/# Of Test scripts or Test cases Planned
Test Automation:
Of Test cases automated/# Of Test cases
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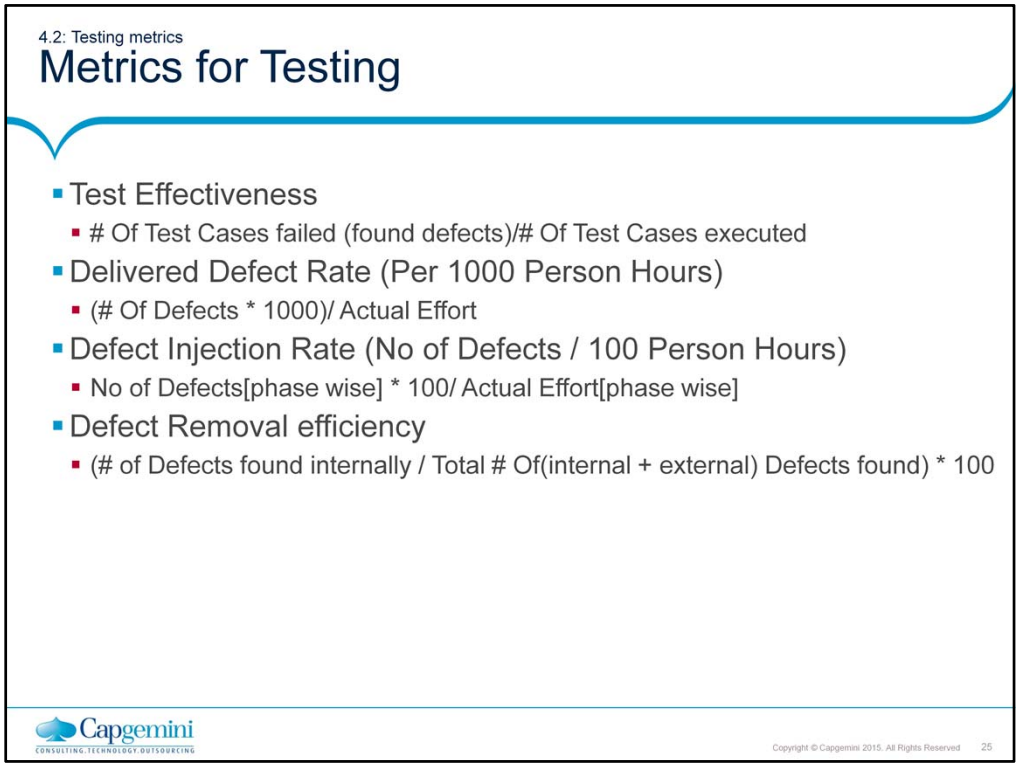


Test Effectiveness
Of Test Cases failed (found defects)/# Of Test Cases executed
This metric indicates the effectiveness of the Test Cases in finding the defects in the product

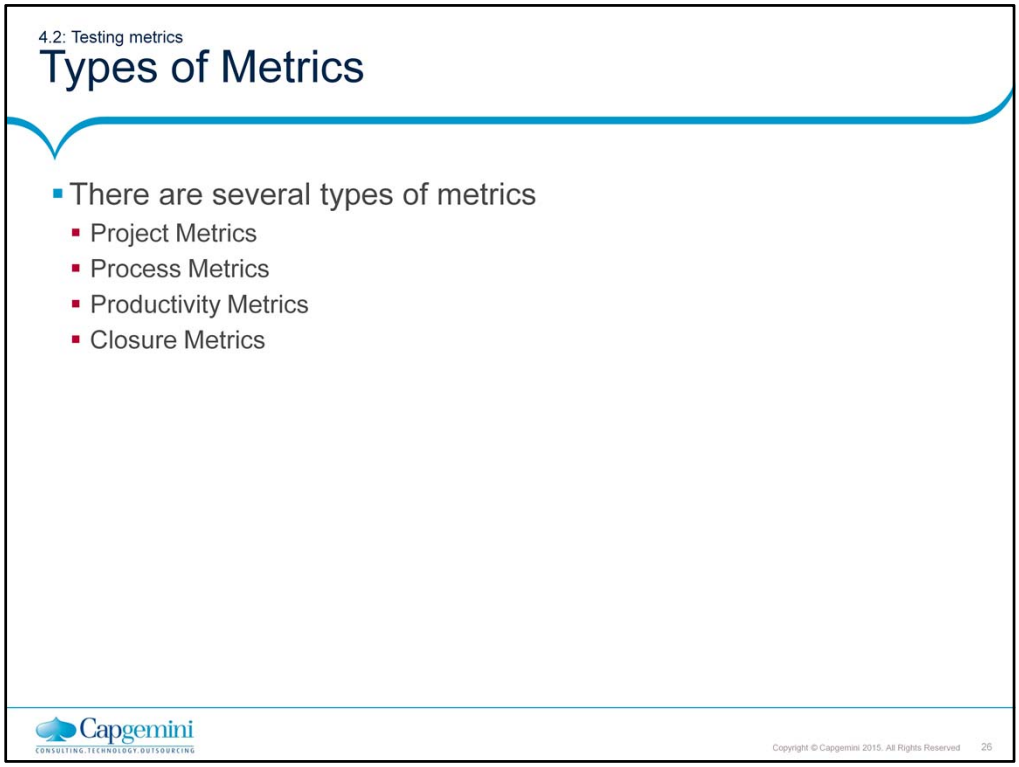
Delivered Defect Rate (Per 1000 Person Hours)
(# Of Defects * 1000)/ Actual Effort
The purpose of this parameter is to measure the defect slippage to our customer vis-à-vis total effort. This parameter will be used to predict the residual defects in the delivered product with our current capability.

Defect Injection Rate (No of Defects / 100 Person Hours)
No of Defects [phase wise] * 100/ Actual Effort [phase wise]
This is used to detect the defects injected during STLC Phases.

Defect Removal efficiency
(# of Defects found internally / Total # Of(internal + external) Defects found) * 100

It indicates the number of defects leaked after several levels of review and these defects are slipped to the customer.

This is same as review effectiveness. Need to discuss before removing.


4.2: Testing metrics
Types of Metrics
There are several types of metrics
Project Metrics
Process Metrics
Productivity Metrics
Closure Metrics
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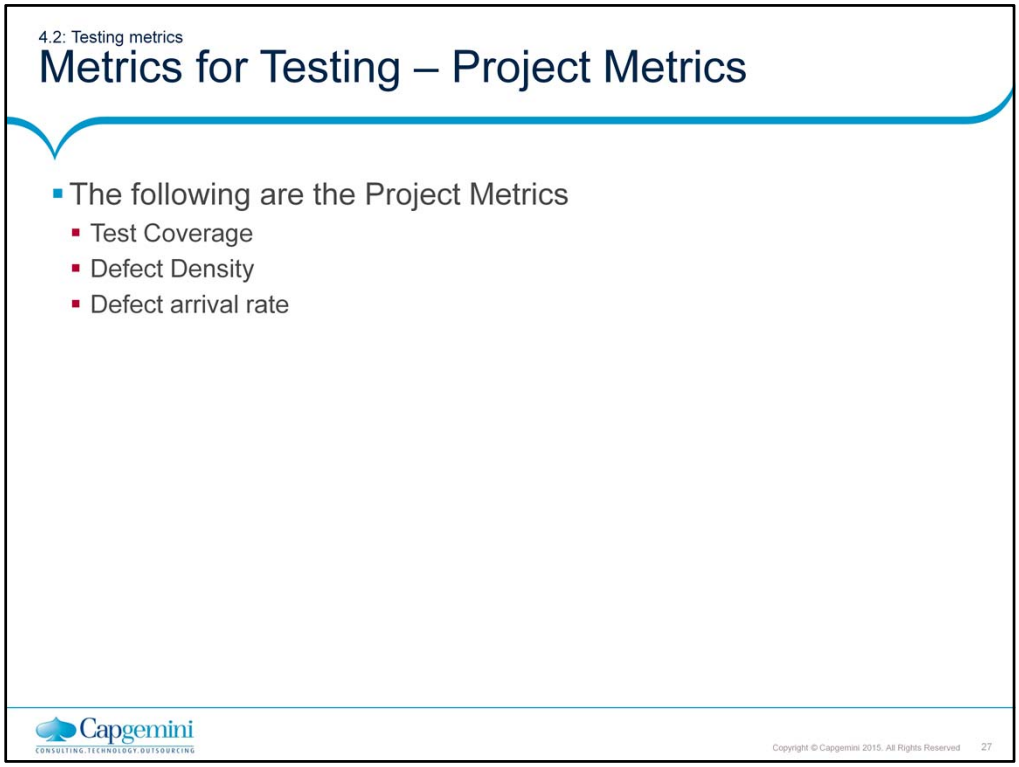
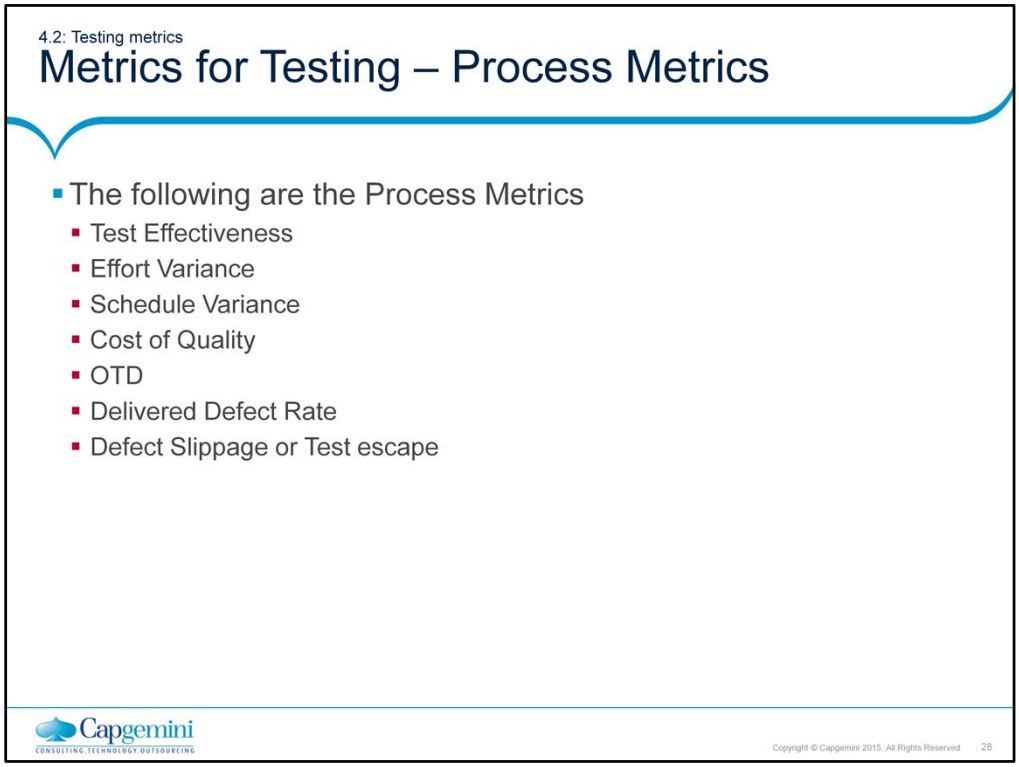


Defect arrival rate:

Of Defects * 100 / # of Test Cases planned for Execution

This metric indicates the quality of the application/product under test.

Lower the value of this parameter is better.



Effort Variance

(Overall and Variance at each milestone)
((Actual effort - Planned effort) / Planned effort) * 100
The purpose of this parameter is to check the accuracy of the Effort estimation process to improve the estimation process.

Schedule variance

(Actual end date - Planned end date) / (Planned end date - Plan start date + 1) * 100
It depicts the ± buffer that can be used for optimum use of resource deployment And monitor the dates committed to the client and helps in better planning of future tasks.

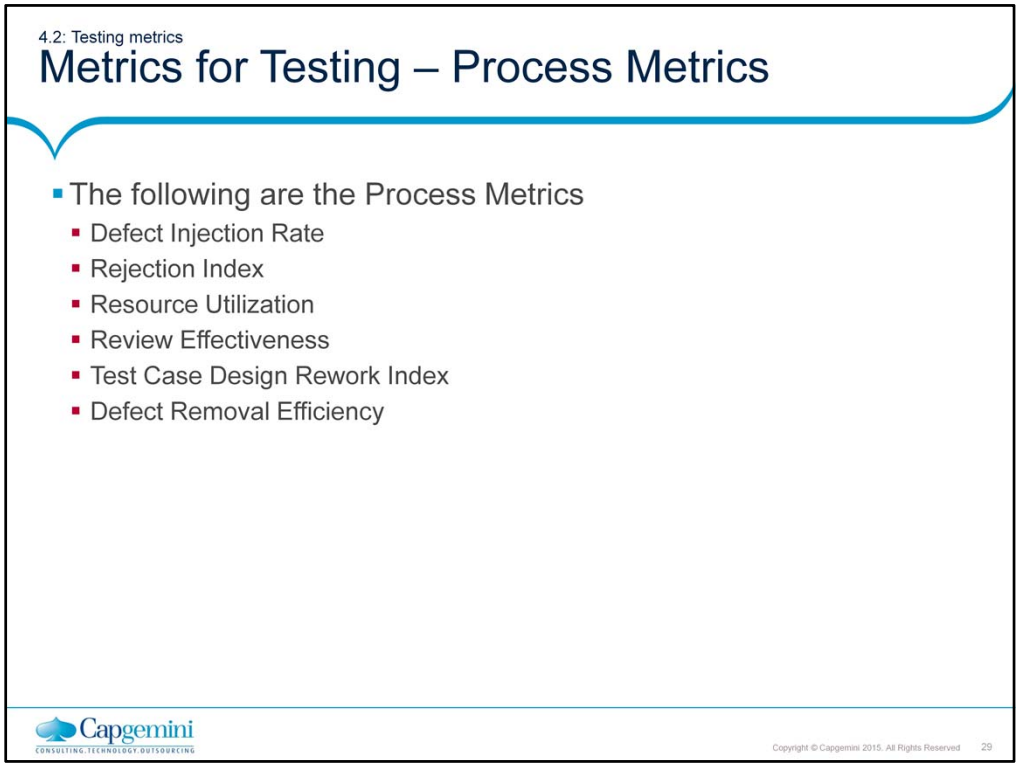
OTD

# of deliveries on schedule / total # of deliverables made

This parameter is to measure the timely delivery of the Deliverables.

Defect slippage or Test escape

(Total # Of External Defects / Total # Of Defects detected (Internal+External)) * 100
This measure helps us to know how effectively we are detecting the defects Various stages of internal testing



Rejection index

Of Defects rejected/# Of Defects raised

The purpose of this parameter is to measure the Quality of the defects raised

Resource Utilization

Actual effort utilized in the month for project activities /Total available Effort in the month

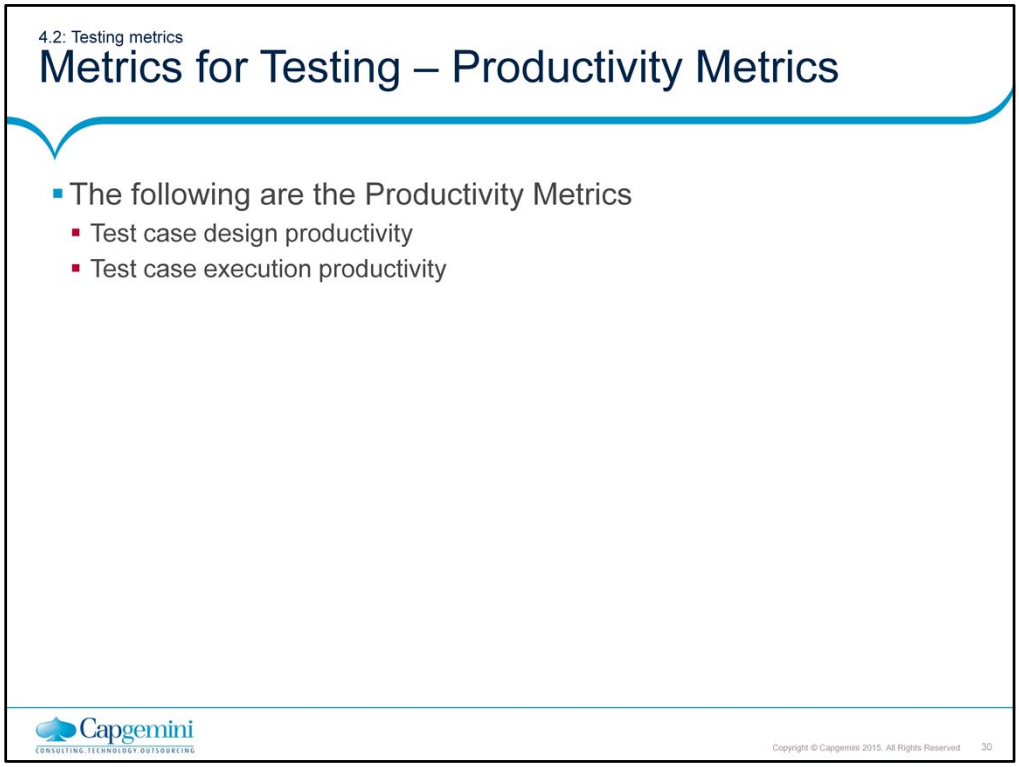
Review Effectiveness

(No of Internal Review Defects / [No of Internal Defects+No of External Defects])*100

The purpose of this parameter is to measure how effective are our reviews in capturing all the phase injected defects.

Test Case Design Rework Index

(Test Cases with Review Comments for rework/Total Test Cases)*100



Test case design productivity

Of Test cases (scripts) designed/ Total Test case design effort in hours
This metric indicates the productivity of the team in designing the test cases.

Test case execution productivity

Of Test cases executed/ Total Test case executed effort in hours
Effort shall include the set up time, execution time. This metric indicates the productivity of the team in executing the test cases.

4.2: Testing metrics

Metrics for Testing – Closure Metrics

- The following are the Closure Metrics Effort distribution
  - Test Design Review Effort
  - Test Design Rework effort
  - KM Effort

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Effort Distribution

(Effort spent on a STLC Phase / Total STLC effort) * 100
This would indicate the effort distribution across STLC phases. Given the type of an
engagement and application, we can re-use this in estimation & planning for future
projects

Test Design Review effort

(Effort spent on Test Case design reviews / Total effort for spent on Test Case design) *
100

This can be used with other process metrics like "Review Effectiveness", "Defect removal
Efficiency", "Defect Injection Ratio" to plan for an adequate review effort for future
projects.

Test Design Rework effort

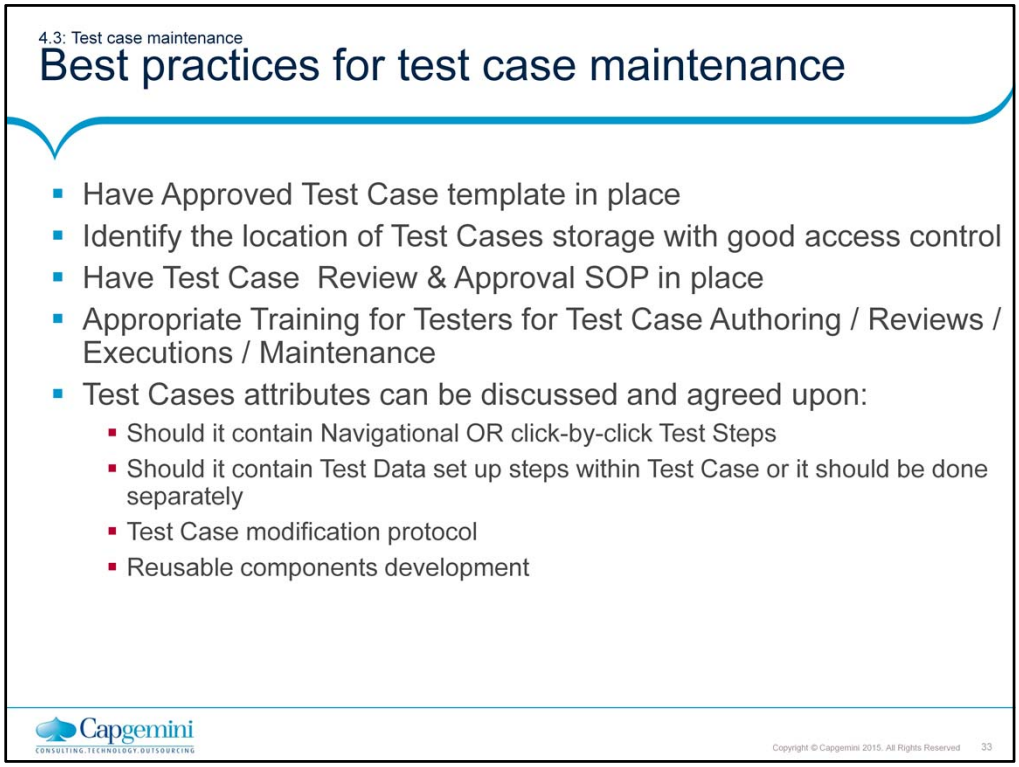
(Effort spent on Test Case design review rework / Total effort for spent on Test Case
design) * 100

This can be used with other process metrics like "Effort Variance", "Schedule Variance"
to plan for an adequate rework effort for future projects.

KM Effort

(Total Effort spent on preparation of the KM artifacts / Total actual effort for the project)
* 100

This indicates the effort spent on KM.This along with other process and product metrics
can be used to plan for KM activities for future projects.



It's really important to think about how you structure and divide your test cases to make them as reusable as possible.

For example, you need to write test cases to test to flow say

Login->View cosmetic product->Select cosmatic product->Checkout.

You should write a short test case for each function, rather than writing a huge test case that tests the entire flow. In this way way, you can reuse the same test cases even if the flow changes, merely re-tying them.

4.3: Test case maintenance

Best practices for test case maintenance

- Audit Trail for every update in Test Case
- Good management of Impact assessments with every update in requirement(s) w.r.t Test Cases coverage
- Better management of Trace Matrix with “every” update
- Maintenance of record of Executed Test Cases and Defects for reference of updates
- It is advisable to store test cases in version control tool so that any subsequent changes can be tracked easily
- Use test case creation and maintenance tools. One such tool is Quality Center from HP

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Summary

- In this lesson, you have learnt:
  - Various testing metrics like
    - Defect Density
    - Average Defect Age
    - Defect Removal Efficiency
    - Review Effectiveness
    - Cost of finding a defect in review
    - Cost of finding a defect in testing
    - Cost of Quality
    - Test Case Effectiveness
    - Test Case Adequacy
    - Defect Detection Index

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Review - Questions

- Question 1: The defect impacting the functionality are _____.(Indirect/Direct/Standard)
- Question 2: CFDR metric tells us the effort spent in finding a defect in testing
  - Option: True / False
- Question 3: Metrics are used to evaluate the effectiveness of the testing process
  - Option: True / False

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Review - Questions

- Question 4: Which of the following are Test Environments
  - Unit Test Environment
  - QA Test Environment
  - Simple Test Environment
  - Product Environment

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Review – Match the Following

1. Minimum	A. Average Defect Age
2. Maximum	B. Defect Removal Efficiency
	C. Cost of finding a defect in testing
	D. Review Effectiveness
	E. Cost of Quality
	F. Test Case Adequacy

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Testing Concepts for V&V Automation Testing

Lab Book

Document Revision History

Date	Revision No.	Author	Summary of Changes
12/8/09	1	Priya Rane	Revamp
06/09/2011	2	Hema G	Revamp
19/06/2013	3	Selvalakshmi P	Revamp
15/04/2015	4	Dayanand Patil	Revamp
23/12/2015	5	Shilpa Bhosle	Customized for V&V – Automation Testing LoT

Table of Contents

Lab 1. Software Testing Basics

Goals	• Understand the process of creating test cases. • Learn to apply basic techniques for writing test cases. • Learn to prepare finite test cases
Time	90 Minutes

1.1 Validate Date field

Validate Date Field using Black Box Testing Techniques. Format of Date field is dd/mm/yyyy

1.2 Validate Command Line utility

Validate Command Line utility - 'MAX'.
The utility displays the maximum of the 2 specified Integers. Please note down any assumptions that you make.
E.g. MAX 2 3

Steps to run Max command line utility

1. create a folder demo on E drive
2. Copy max.exe file in to demo folder
3. Click on start > run. Type **cmd**
4. Type "**E:**"
5. Type " **cd demo**"

Use following command to run max utility

E:\demo> max 25 34
E:\demo> max 25 b
E:\demo> max a 34
E:\demo> max 25.45 34.67

1.3 Validate Phone Number field.

Format of the number is
Country Code (10 to 999) City Code (10 to 99999) Phone Number (1000000 to 99999999)

1.4 Validate Password Field

Write the test case for password field. Password should be the combination of Alphabets, numeric values and special characters. It should contain one upper case letter, at least one digit and at least one special character. The length of the password should be of minimum 8 characters.

Lab 2. Creating Test Cases

Goals	• Read "Product Enquiry Form Instructions" before starting the assignment. • Develop creative test cases for the New Bike Enquiry Form
Time	120 minutes

Note: In this lab use test case design techniques for designing creative test cases based on the requirements given below.

Participant are required to write at least 5 positive test cases, 10 Negative test cases, 5 Basic tests cases. This is minimum expectation.

2.1 Case Study

A customer can enquire about a new vehicle models by filling the "Product Enquiry Form" by visiting dealer's website. This is useful for those customers who wish to upgrade their existing vehicle to a new one or wants to purchase a new vehicle. This website also facilitates a customer to book for a test ride through product enquiry form.

2.2 Rules: Product Enquiry Form

1. The fields marked as * are mandatory fields on the form
2. Customer Name(firstname & lastname) should accept only characters
3. The mobile number should accept only numbers and it should contain only 10 digits
4. The telephone number field should accept only numbers and it should contain only 10 digits
5. The Email field should accept only valid email address e.g. **Dayanand.patil@domain.com**
6. The Vehicle Model should accept only following values
   a. Pleasure
   b. Karizma
   c. Impulse
   d. Splendor
   e. Splendor+

7. Select the state from the state drop down box. This will automatically populate the district based on the selected state in a new drop down box. Refer the below given table for the valid values of states and district combination.

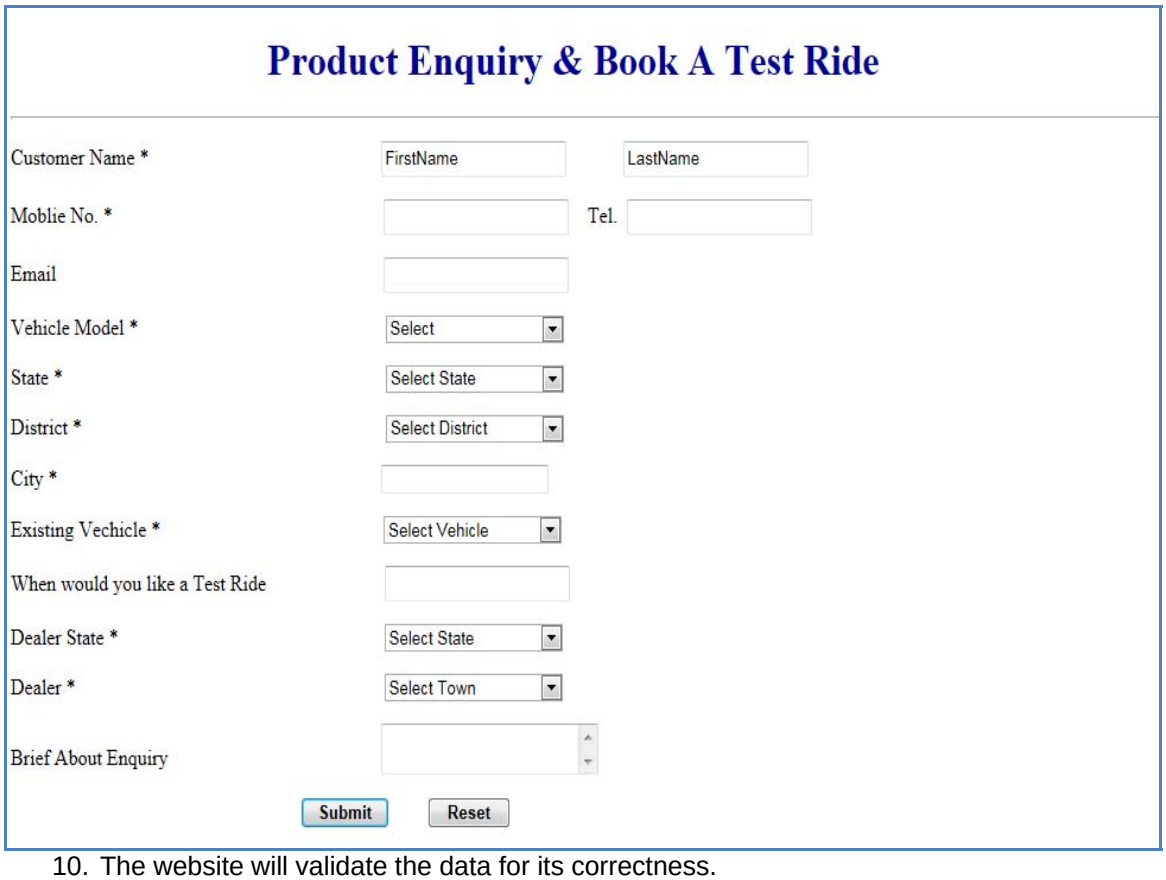
State	District
	Sangli

Maharashtra	Kolhapur
	Pune
Tamilnadu	Chennai
	Coimbatore
	Kancheepuram
Gujarat	Anand
	Dohad
	Rajkot

8. Select dealer's state from the Dealer State drop down box. This will automatically populate the Dealer drop down box. Refer the below given table for the valid values of Dealer's States and Dealers combination.

Dealer State	Dealer
Maharashtra	M/s Ghatge Patil auto and firm,Sangli
	M/s Unique Automobiles(I),Kolhapur
	M/s Lakshya Motors, Pune
Tamilnadu	M/s Mohan Automobiles, Chennai
	M/s Suguna Automobiles, Coimbatore
	M/s Anand Automobiles,Kancheepuram
Gujarat	M/s Prakash Motors,Anand
	M/s Shree Laxminarayan Motors,Doh0d
	M/s Aan Automobiles,Rajkot

9. The Brief about enquire field should accept maximum 100 characters max.



10. The website will validate the data for its correctness.
11. The customer need to fill the required details and should click on the Submit button to submit the enquiry with the website.

Lab 3. Creating Test Cases

Goals	• Read 'BOOKING INSTRUCTIONS' before starting the assignment. • Understand the application and develop creative test cases.
Time	120 minutes

3.1: Software Testing Case Study. 'ONLINE CONFERENCE ROOM BOOKING' on

Intranet

Note : Please do not try using the system available on intranet. This is just a case study.

Booking Instructions

1. Invoke intranet by typing the URL https://intranet.confBook.com
2. Login using id and password
3. Intranet home page is displayed
4. Select Employee Corner and Click on Conference Room Booking option
5. 'My Bookings' option on the Conference Menu Page displays the View / Cancel Booking Page.
6. 'New Booking' option on the Conference Menu Page displays the Conference Booking Page.

Making a new booking:

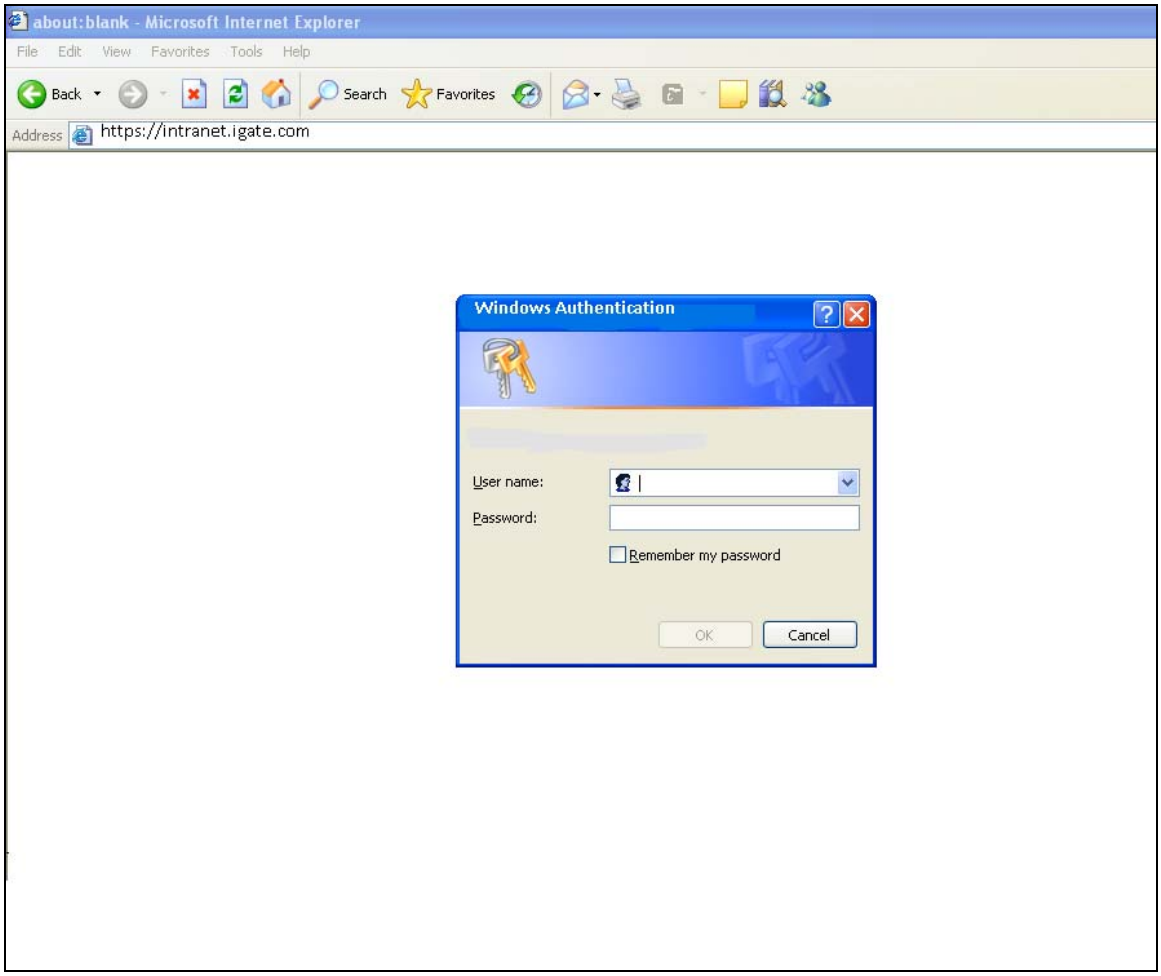
1. If you belong to a Non-GE Business Unit, you can book conference rooms only in Non-GE areas. However if you belong to a GE Business unit, you can book conference rooms at any location.
2. The employee Email id field is automatically filled with the email id of the person logged in.
3. Select the location from the location drop down box. This will automatically populate the sub-locations under the selected location in a new drop down box.
4. Select the sub-location from the sub-location drop down box. This will automatically populate the date drop down boxes.
5. Select the month from the month drop down box. Booking of conference rooms can be done only one month in advance. The date drop down boxes will be appropriately populated for this.
6. Select the date from the date drop down box.
7. Select the year from the year drop down box.
8. Upon selecting a valid location, sub location and date the complete Conference Room booking form is displayed
9. The rooms and devices available at the selected sub-location will be displayed in tabular format.

10. Enter your extension number and email id if it is not displayed correctly.
11. Select the room from the room drop down box.
12. Select the time span for which you want to book the conference room.
13. Select the communication and visual device if required.
14. Clicking 'Submit' button would validate whether the room and devices requested are available in the time span specified.
15. If either the room or devices requested are not available in the time span selected, an appropriate error message will be displayed else the booking will be registered. An Email will be sent to you as a confirmation for the same.

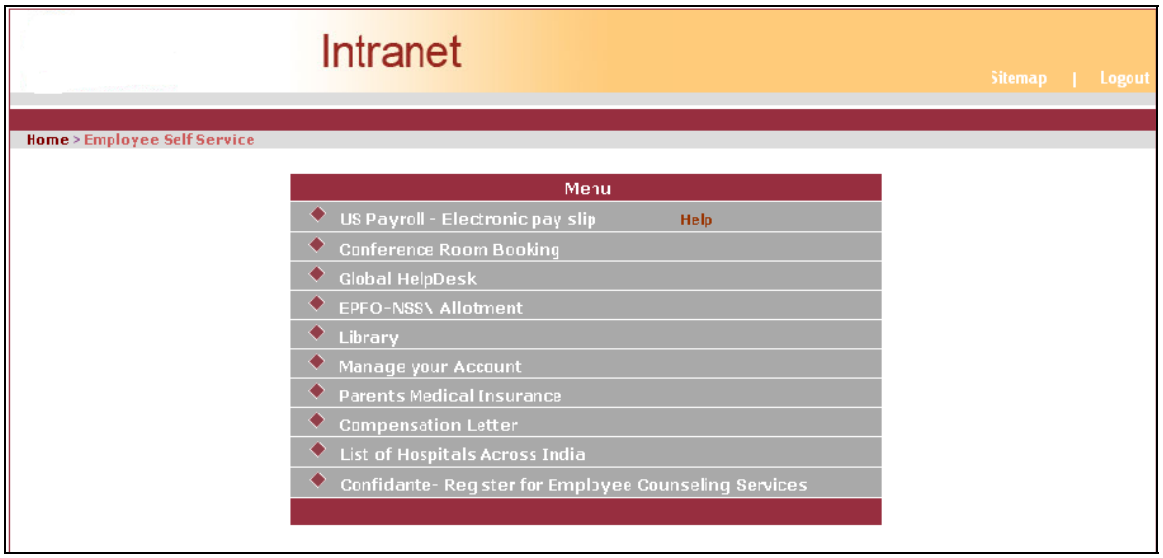
Viewing / Cancellation of Bookings:

1. All the booking made by you will be displayed. Bookings of current and future dates will only be displayed.
2. Select the bookings you wish to delete
3. Click the 'Delete' button to delete the selected bookings.

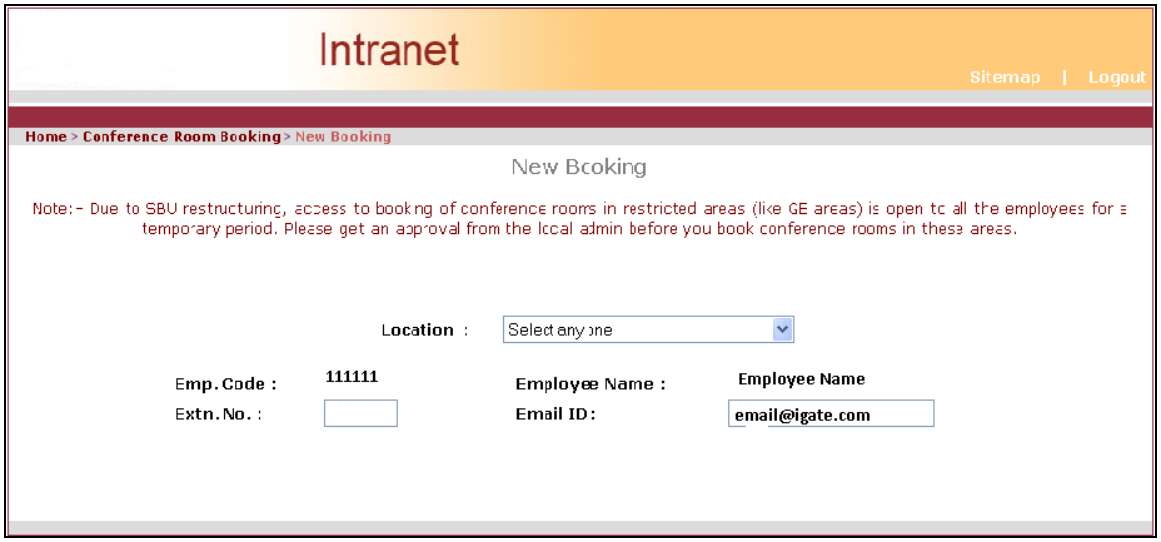
Invoke https://intranet.confBook.com



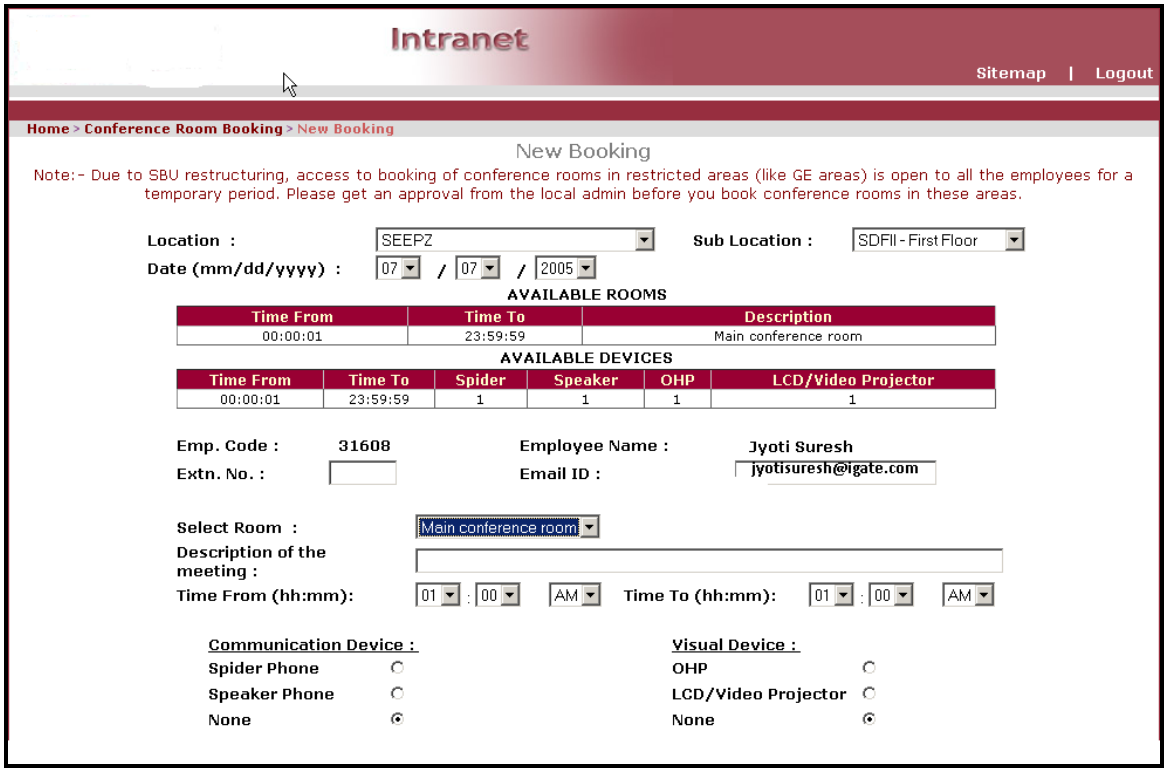
Intranet home →Employee Corner →Conference Room Booking



Conference Room Booking → New Booking

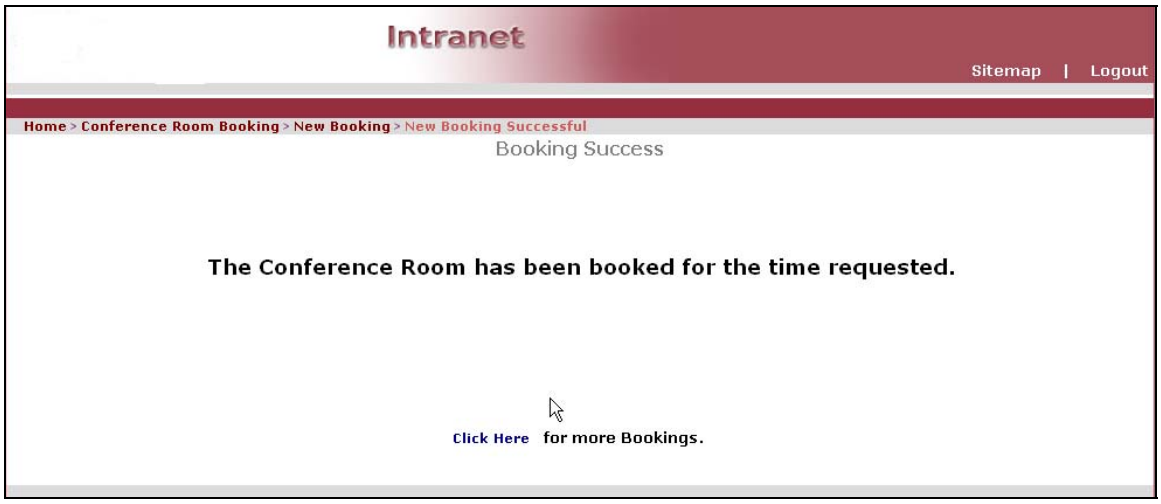


HOME→Conference Room Booking → New Booking



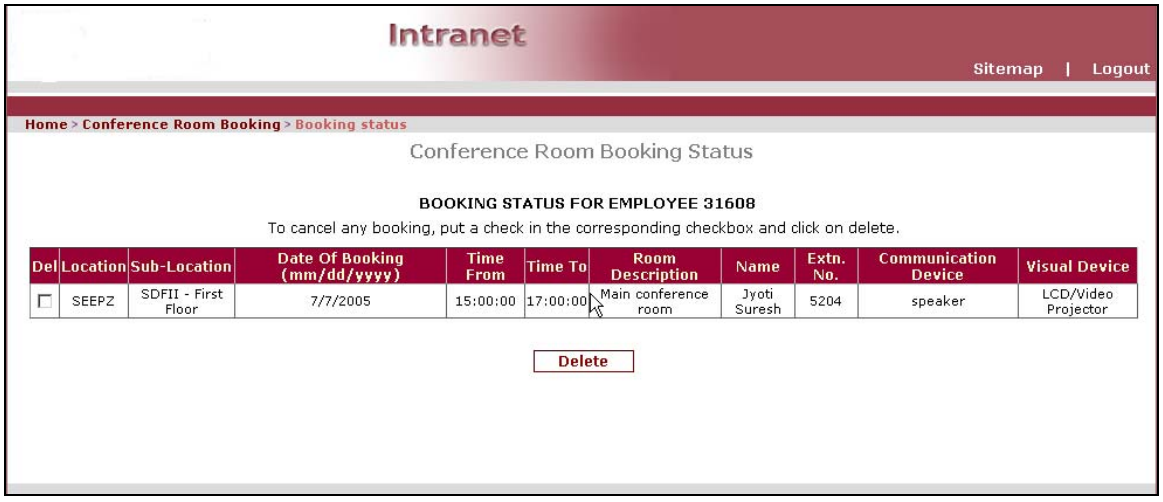
If booking is successful, the following screen is displayed

HOME →Conference Room Booking → New Booking



The booking status is also shown under My Bookings as shown below:-

HOME →Conference Room Booking → Booking Status



Stretched Assignments

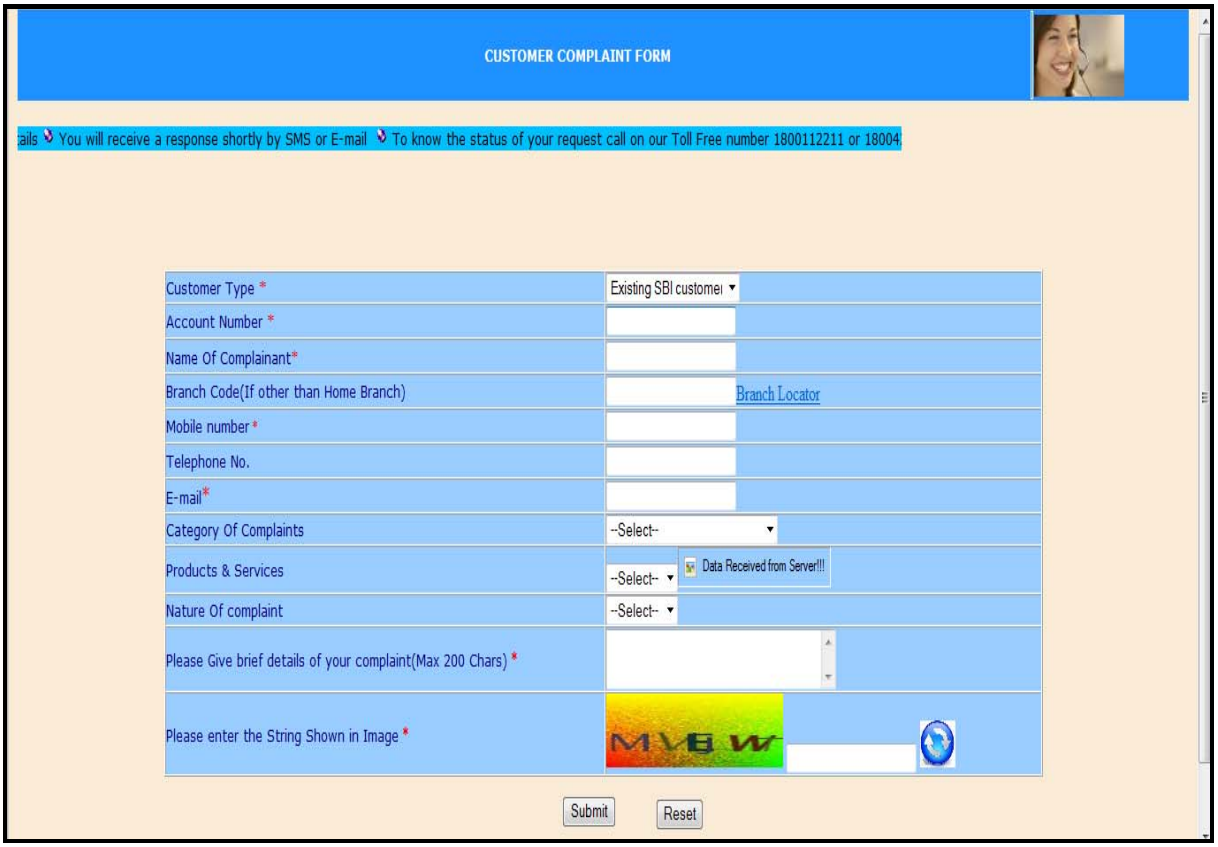
4.1 Customer Complaint Form

This is a customer complaint form for the bank customers, those who want to raise the bank related complaints.

4.2 Instructions

Write the test case for this Customer Complaint form, based on the requirements given below.

While the customer clicking on the submit button, if all are correct, the details should be registered in the database and generated complaint number should be displayed on the screen



4.3 Rules

- **Customer Type** : Existing SBI customer
- **Account Number** : Should be 11 digits
- **Branch Code** : should be 4 digits

- **Nature of Complaint** will be displayed based on the selection of Products & Services and Products & services will be displayed based on the selection of Category of Complaints. Refer the below table.

Category of Complaints	Products & Services	Nature of Complaint
General Banking	Branch Related	• No Response to queries • Single Windows not doing all transactions
	Pass Book Related	• Error in passbook entries • Passbook not issued/Delayed
Deposits	Opening of Accounts	• Nominee Updation Not done • Delay in opening Accounts
	Transfer of accounts	• Delay in transfer of fixed Deposits • Others
Internet Banking	Pre Login Complaints	• Username/Password provided by branch not functional • Transaction rights not given
	Online Bill Payment	• Unable to view Bills • Unable to view payment History

- Details of complaint: Should be of 200 characters max.

