Robust Solutions
for
Efficient & Sufficient Testing

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Agenda

• Testing Challenges
• Wipro’s Solution – Robust Test Methodology
  • DSM/SCE/SCIM for Test Strategy & Planning
    • Essence of these techniques
    • Examples
  • Orthogonal Array for Test Case Design
    • What is OA Based Testing
    • Walkthrough of the Wipro OA tool
    • Sample Case studies with Benefits
• Reliability Modeling for Residual Defect Estimation
  • About Reliability Modeling
  • Assumptions behind the Wipro Reliability Tool
  • Demo of Wipro Reliability Tool
• Summary of Solutions to Address Testing Challenges
• Q & A
Business Challenges

Tight Budget
Demanding Customer
Schedule Pressure

The Key to success is to address these Challenges as well as to ensure quality!!
• How to detect most of defects early in the testing lifecycle?
• How to prioritize on Test Areas?
• How to Map resources to Test Areas?
• How to Allocate proportionate time to test different test Areas?
• Are all the paths covered? (Unit Testing or white box testing)
• Are all interfaces tested? (Integration Testing)
• Is the system functionality validated? (System Testing)
• Are all single mode and double mode faults detected?
• It is next to impossible to do exhaustive testing (100% possible test cases)
• How to ensure that there is no redundancy in test cases?
• When to Stop Testing?
Robust Test Methodology

**DSM/SCE**

- Systematic Test Strategy
- Prioritizing Test Areas
- Early Defect Detection
- Effective Time & Resource Allocation

**OA Technique**

- Maximize Test Coverage
- Minimize Test Cases
- Foundation for Defect Correlation

**Reliability**

- When to stop testing
- Certify S/w Quality Levels
- Facilitate to Plan Maintenance Resources

**Lean Management & Six sigma Techniques**

**Test Strategy & Planning**

- Systematic Test Strategy
- Prioritizing Test Areas
- Early Defect Detection
- Effective Time & Resource Allocation

**Test Design & Execution**

- Maximize Test Coverage
- Minimize Test Cases
- Foundation for Defect Correlation

**Test Results Analysis**

- When to stop testing
- Certify S/w Quality Levels
- Facilitate to Plan Maintenance Resources

DSM – Dependency Structure Matrix  SCE – Software Complexity Estimate  OA – Orthogonal Array
Prioritize the Test Areas by identifying the most complex Test Area to facilitate early defect detection.

Sequence the Order of Testing of Different Test Areas so that there is minimal delay or waiting time between activities which will facilitate in Schedule adherence.

Prioritize the Test Area & Test Cases in case of Regression Testing for optimal use of Testing effort.

**Input/Output Summary for DSM tool**

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<th>Objective/Tool</th>
<th>Inputs</th>
<th>Output</th>
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<td>1. No of Components/Activities</td>
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<td>3. Components/activities that can be done in parallel</td>
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</tr>
</tbody>
</table>

Helps in identifying components for concurrent engineering resulting in optimizing schedule.
### System Complexity Estimator

#### XYZ

<table>
<thead>
<tr>
<th>Name of Project</th>
<th>Contact person</th>
<th>Email</th>
</tr>
</thead>
</table>

**Number of Modules**: 12

**SYSTEM COMPLEXITY**: 37.5

#### SCE Inputs

<table>
<thead>
<tr>
<th># of functions</th>
<th>Module Dependency Matrix</th>
<th>Component1</th>
<th>Component2</th>
<th>Component3</th>
<th>Component4</th>
<th>Component5</th>
<th>Component6</th>
<th>Component7</th>
<th>Component8</th>
<th>Component9</th>
<th>Component10</th>
<th>Component11</th>
<th>Component12</th>
<th>Module contribution to Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Component1</td>
<td>Row ED Col</td>
<td>Row LD Col</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>Row LD Col</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>3.16</td>
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<td>Row HD Col</td>
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<td>Row ED Col</td>
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<td>ND</td>
<td>Row ED Col</td>
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<td>Row ED Col</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>Row ED Col</td>
<td>2.82</td>
</tr>
</tbody>
</table>

Relative System Complexity & Component level Complexity is calculated for prioritization.
### Real Life example from Telecom Domain

<table>
<thead>
<tr>
<th>Software Change Impact Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Change Requests/Requirements/Enhancements</strong></td>
</tr>
<tr>
<td><strong>Modules/Components</strong></td>
</tr>
</tbody>
</table>

#### Inputs to SCIM
- Change Requests/ Requirements/ Enhancements

#### Outputs of SCIM

#### A Quantitative Framework for Test Area Prioritization & Effort Allocation.
OA Based Testing is a methodology which facilitates in ensuring a higher coverage of Testing the Possible causes of failure with a lower number of Test Cases

The first Step in OA based Test design is to parameterize the Test Area into Factors & levels

Once factors & levels identified are fed into Wipro’s OA tool, Test Runs are automatically generated which reduces the test case writing time.

OA ensures that all levels of each factors are tested at least once & all possible pair wise combinations of factors are tested at least once.

Wipro’s OA application experience indicate benefits of significant reduction in total testing effort or significant improvement in test coverage of possible failure modes.
Walk Through
Of
Wipro OA Tool
Enter the number of factors identified in the Test Area
Name the factors & specify the number of Levels for each factor.

<table>
<thead>
<tr>
<th>Level of Factor</th>
<th>Factor Name</th>
<th>No Of Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of Factor 1</td>
<td>A</td>
<td>7</td>
</tr>
<tr>
<td>Level of Factor 2</td>
<td>B</td>
<td>6</td>
</tr>
<tr>
<td>Level of Factor 3</td>
<td>C</td>
<td>5</td>
</tr>
</tbody>
</table>
Name the level for each of the factors & generate OA

<table>
<thead>
<tr>
<th>Factor Name</th>
<th>No Of Levels</th>
<th>Level Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>0 1 2 3 4 5 6</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>0 1 2 3 4</td>
</tr>
</tbody>
</table>
If there is any dependency between levels of Factors, click ok otherwise click Cancel.
Specify the Infeasible combination in the Matrix.
Test Sets are generated & the proportion of coverage of all the possible combinations are given as output. Expected output for the tests have to be manually specified.
Once Factors & Levels are identified, test sets are generated by the tool.

All levels of each factor are tested at least once. (All single mode failures are covered)

All possible pair wise combinations are tested at least once (All Double mode failures are covered at least once)
OA Applied in Telecom - Project 1

Project Objective:
- To optimize test cases
- To improve test coverage, defect detection

Methodology Used: DSSS + Orthogonal Array

Results:
- Full factorial test cases: 58632
- OA based test cases: 535
- After adding a few more test cases: 563

Business Benefits:
- Test case reduction by 35%
- New bugs found using OA: 6
- All defects found in previous releases detected

OA Applied in Telecom - Project 2

Project Objective:
- To optimize test cases
- To improve test coverage, defect detection

Methodology Used: DSSS + Orthogonal Array

Results:
- Full factorial test cases: 58632
- OA based test cases: 535
- After adding a few more test cases: 563

Business Benefits:
- Test case reduction by 35%
- New bugs found using OA: 6
- All defects found in previous releases detected

OA Applied in Retail Domain

Project Objective:
- Optimize the number of test cases
- Reduce testing effort
- 100% functionality coverage

Methodology Used: DSSS + Orthogonal Array

Results:
- 848 test cases reduced to 167

Business Benefits:
- Able to complete 2 complete cycles of testing in planned time
- Test case reduction by 80%
- 100% functionality covered
- Validated with requirements traceability matrix

OA Applied in Finance Domain

Project Objective:
- Optimize the number of test cases
- Reduce testing effort

Methodology Used: DSSS + Orthogonal Array

Results:
- Full factorial: 548 test cases
- rdExpert (industry standard tool): 290tc
- Wipro OA tool: 236tc

Business Benefits:
- Reduced testing effort by 56%

Concluding remarks of the practitioner:
- Wipro OA tool generated lower test cases when the factors and levels are high
- Despite the lower number of test cases, the coverage is more when compared with rdExpert (industry standard tool)
S/W Reliability Modeling

Static Modeling

Y = f(x1, x2, x3, x4) + e

Dynamic Modeling

Total Dev Phase

Testing Phase

Rayleigh Model

Exponential & other models

NHPP & Other Models

Based on Current Project Data

Dependent

Project Attributes

Dependent

Independent

Eg:- Defect rate

Complexity, skill level, etc

Based on Past Project Data

Based on Past Project Data
Assumptions Behind The Wipro Reliability Tool

- Effort in Testing is homogeneous throughout the testing phase.
- Since this assumption is not always applicable, normalization of defect data wrt test cases is required.
- An acceptable amount of coverage is achieved by the test cases under use (Use of OA based test case design or other robust methods is assumed)
- The time sequence of the defect data should be maintained
- At least 75% of the testing (test case execution) should be complete for predictive validity AND
- A plot of the defect rate should indicate a declining defect trend

Tool is not to be used for defect estimation without Test Execution.
Wipro Reliability
Tool Walkthrough/Demo
Navigating through the tool

<table>
<thead>
<tr>
<th>Day/Week</th>
<th>Cum TC</th>
<th>Cum Defects</th>
<th>Day</th>
<th>TC</th>
<th>Cum Failures</th>
<th>Model</th>
<th>Delayed S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate Remaining Defects</td>
<td>MSE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Predict Defects for Specified Test Cases</td>
<td>Alpha</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate Defects for Untested Features</td>
<td>Beta</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total Estimated Defects</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total Defects Detected</td>
<td>Accuracy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total TCs Executed</td>
<td>Tested</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Residual Defects</td>
<td>Untested</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Additional TCs Required</td>
<td></td>
</tr>
</tbody>
</table>

Input Columns: Cum TC – Cumulative test cases
Cum Defects – Cumulative no of defects detected
Day/Week – WK no which indicates the times series order in which the testing is carried out
Option 1 – Estimate Remaining defects

On click of this button, a dialog box pops up which asks for the required confidence level. Once that is specified, the tool gives the output as shown in the next slide.

<table>
<thead>
<tr>
<th>Day</th>
<th>TC</th>
<th>Cum Failures</th>
<th>TC</th>
<th>Defects</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>49</td>
<td>6</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>73</td>
<td>6</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>134</td>
<td>7</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>250</td>
<td>8</td>
<td>6</td>
<td></td>
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<tr>
<td>6</td>
<td>500</td>
<td>12</td>
<td>7</td>
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<td></td>
</tr>
<tr>
<td>7</td>
<td>900</td>
<td>22</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1012</td>
<td>45</td>
<td>9</td>
<td></td>
<td></td>
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<tr>
<td>9</td>
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</tr>
<tr>
<td>10</td>
<td>1119</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Options available:

1. Estimate Remaining Defects
2. Predict Defects for Specified Test Cases
3. Estimate Defects for Tested and Untested Features

Output Display:

- Model: MSE, Alpha, Beta
- Confidence Interval
- Accuracy: Tested, Untested
- Total Estimated Defects, Total Defects Detected, Total TCs Executed, Residual Defects, Additional TCs Required
- Defects vs. %
When you click on Estimate Remaining Defects, the tool asks for a confidence level for the estimate. Specify a confidence level of 95% in most of the cases & click on the continue tab.
Outputs of the tool are in the form of Three tables.
1st table gives the details of the Statistical model which has been chosen for estimation.
2nd table gives the details of the remaining defects & no of test cases to be executed to find out the remaining defects.
3rd table gives the estimated breakup of testcases to be executed & remaining defects that will be found out.
The tool also provides a graphical output of the Estimated total defects Vs. total Test Cases Distribution.
Summary of Solutions to Address Testing Challenges
## OA Tool

### Orthogonal Array

### Test Phase: Test Optimization

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
</table>
| - Systematic and statistical method of pairwise combinations of selected factors or variables across their levels.  
- Creates an optimized test suite with lesser test cases.  
- Detects all single mode and double mode defects.  
- Increases confidence level in the system by executing a concise set of tests and uncovering most of the bugs. | - Helps in productivity improvement with cycle time reduction.  
- Helps in improving the test coverage.  
- Helps in minimizing the size of test suite by eliminating the redundant test cases from the test suite.  
- Test effort reduction in terms of test case writing and execution. |

### Case Study

**Client Name:** A large North American telecom equipment manufacturer

**Project Scope:**
- Testing of a large IP-PBX system.
- Live Communication Version features to be incorporated.
- Initial test suite contains more than 800 test cases.

**Challenges:** Optimizing the test suite without compromising on the test coverage.

**Benefits:** Considerable amount of saving in terms of test effort and time.
- The number of test cases was reduced from 800 to 170.
- There was a reduction in approx. 75% of the testing effort.
- No compromise on test coverage.
CoDeC Tool

CoDeC is an integrated tool consists of DSM, SCE and SCIM features

<table>
<thead>
<tr>
<th>DSM Tool (Dependency Structure Matrix)</th>
<th>SCE Tool (System Complexity Estimator)</th>
<th>SCIM Tool (System Change Impact Matrix)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Sequencing</strong></td>
<td><strong>Effort Estimation</strong></td>
<td><strong>Maintenance Phase</strong></td>
</tr>
<tr>
<td>Dependency Structure Matrix analyses the dependencies among the modules and Helps project managers in</td>
<td>System Complexity Estimator analyses the complexity and the dependency of modules in a system and helps project managers in estimating testing effort distribution across the modules.</td>
<td>System Change Impact Matrix analyses the system complexity, and the impact of each Change Request (CR) on all the modules in a system and helps project managers in</td>
</tr>
<tr>
<td>- Determining the sequence of test execution of the modules.</td>
<td>Which module requires maximum testing effort?</td>
<td>- Estimating the relative test effort distribution across modules during maintenance phase.</td>
</tr>
<tr>
<td>- Deciding which modules should be kept under a single team.</td>
<td></td>
<td>- Estimating the relative test effort distribution across different CRs.</td>
</tr>
<tr>
<td>- Deciding which modules can be executed in parallel without any dependency clash.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CASE STUDY**

Which module requires maximum attention from a change perspective?

- Before using DSM around 871 regression test cases were executed. However during the beta testing conducted in Feb 2007, only 208 optimized (DSM) regression test cases were executed by avoiding duplication.

**Which modules should be tested first?**

- The test cycle time got reduced from 20 person days to 12 person days.

**Client:** A large North American server and storage manufacturer.
**Project:** Asset Management Systems (Maintenance Project)

**Project Scope**
- to reduce the test execution cycle time of the release.

**Challenges**
- to find the correct sequence of execution of modules.

**Benefits**
- Helped in determining the sequence of execution without any dependency clash

**Benefits**
- to avoid unnecessary repetition of test cases.
- to ensure that there is no defect slippage because of the reduced set of regression test cases.
DFA Tool

Defect Flow Analysis

DFA Tool has 2 features: Metric Analysis and Reliability Analysis

**Metric Analysis**

**Test Reporting**

This tool helps project managers in
- systematically analyzing various metrics applicable in a testing project faster and thus with less effort.
- standardizing reports generated across projects by providing graphical and tabular representation of
  - Defect Trend
  - Test case productivity, Pass rate, test efficiency
  - Defect priority analysis etc.

**Reliability Analysis**

This tool analyses the trends of Defect Detection in a test cycle and helps the test manager in
- Estimating residual defects in the system.
- Deciding when to stop Testing of a system.

![Reliability Graph]

**Case Study**

**Client:** A large North American Telecom Equipment manufacturer.

**Project Scope**
- verification of leading north American equipment vendor's element management system for his broadband access products.

**Challenges**
- whether to release product or continue testing.

**Benefits**
- Predicted number of defects in the past were validated by the response from the field.
- Helped in taking a decision on whether to continue testing or release the feature.
- Based on the reliability output, recommendation was given to stop the general availability of one of the release.
Thank You