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## Optimizing Test Coverage Using Orthogonal arrays

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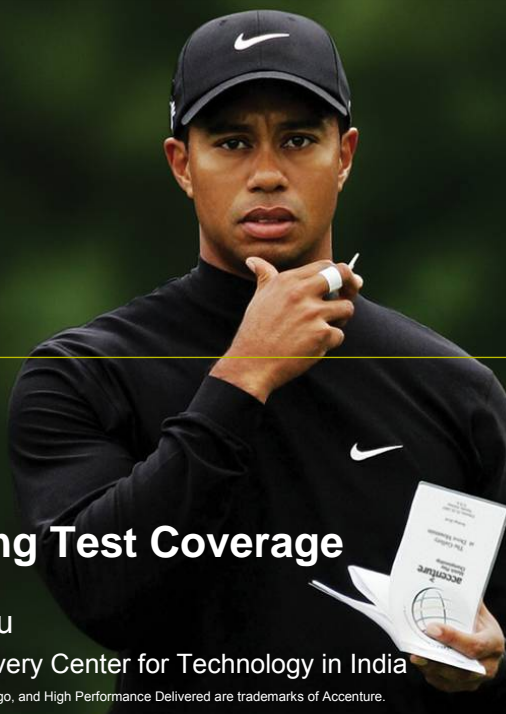
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**Optimizing Test Coverage**

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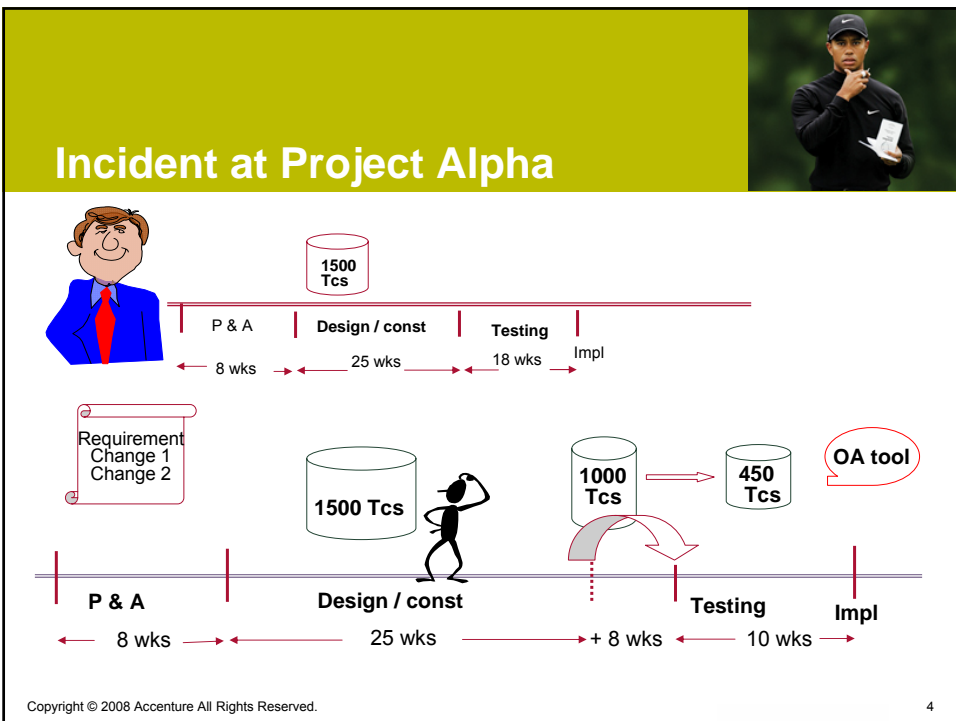
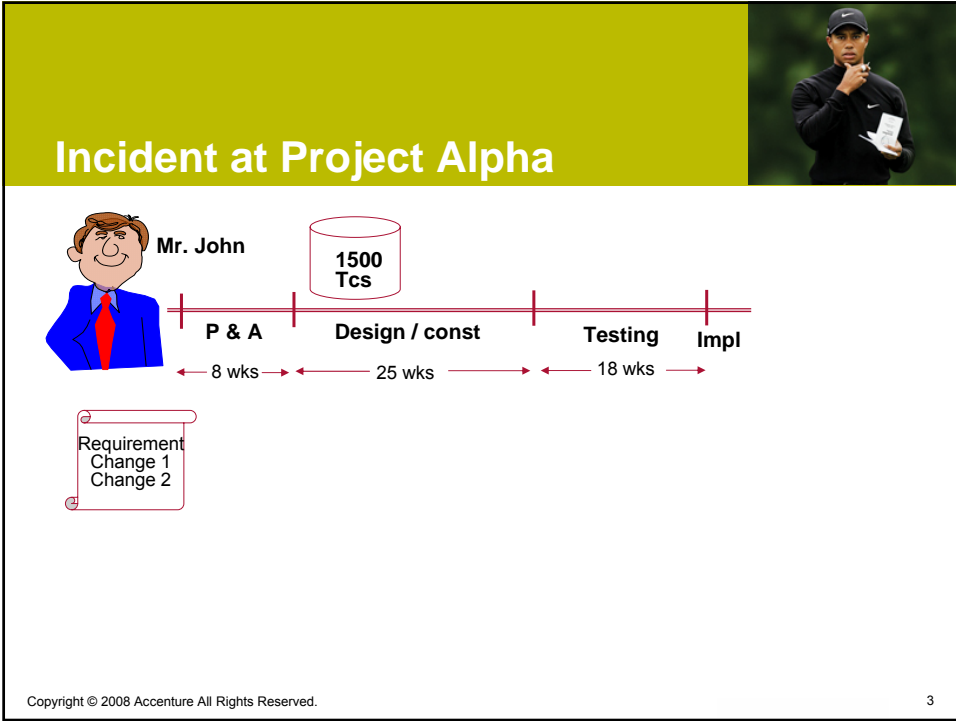


## Agenda

- Introduction
- Problem Statement / Paradigm shift
- Solution Approach – Illustration
- Inputs - results - Analysis - Inference
- Feasibility of Implementation
- References

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## Introduction



- Design of Experiments (DOE)
  - Statistical approach to test case design
  
- Introduction to Orthogonal Array
  - Most popular method adopted in in the world of DOE
  - Invented by Copeland monks (early 19<sup>th</sup> century)
  - Dr. Genechi Taguchi (1986) first proponent of OA... often referred to as Taguchi's methods

Math behind OA...

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## Introduction – Theory of OA



- Test of Orthogonality: summation ( $\sum$ ) of dot product of any 2 columns should equate to zero (0)
  
- Dot product of Columns 1 and 2:
 
$$(+1 \times +1) + (-1 \times -1) + (+1 \times -1) + (-1 \times +1)$$

$$\rightarrow 1 + 1 + (-1) + (-1) = 0$$
  
- Dot product of Columns 3 and 1:
 
$$(+1 \times +1) + (+1 \times -1) + (-1 \times +1) + (-1 \times -1)$$

$$\rightarrow 1 + (-1) + (-1) + 1 = 0$$

Col 1	Col 2	Col 3
+ 1	+ 1	+ 1
- 1	- 1	+ 1
+ 1	- 1	- 1
- 1	+ 1	- 1

Popular problem statements...

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## Popular problem statements

From Project manager: Lot of defects are reported by Customer which is not found by the Quality Control/Validation team.


QA finding defects late in the cycle and makes it difficult to deliver the software in time!!!

Voice of the test team:

- Very Little time allotted to testing for each release
- There are close to 500 test cases in the repository... which one to execute?

**Paradigm Shift**

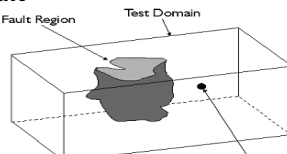
- Efficiency to Effectiveness
- Effort based to Quality based
- Test efficiency to Test effectiveness, density



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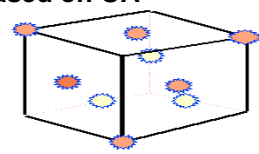
## Solution approach: An illustration

### Region/Isolated fault



- a. Minor section of fault/defect existing in the application
- b. High probability that this section getting missed out (during cons/test phase)

### Test case – based on OA




- a. Makes sure test cases are evenly or thoroughly distributed

Entering into OA...

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## Solution Approach - Data grid (for F-XXXX)



Parameters (grouping of factors)	Value (levels)
No. of requirements (system requirements)	6
Feature complexity	Medium
No. of states – the feature needs to be implemented	11
Interfaces to be tested	5
No. of schemas	2
Types of service (business and residential)	2
No. of transfer indicator	4
No. of field identifiers	2
Types of request (single/bulk arrangement)	2


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## Solution Approach - Results of tool




Parameters	Value
Total no. of test case combinations	121
No. of invalid combinations [Legend: red]	10
No. of valid test combinations	111
No. of test cases (the tester had designed – without OA): Original test suite [Legend : yellow]	53
Delta Test suite (updated based on result of OA) [Legend: Tan]	53 + 15 = 68
Redundant test conditions [Legend: blank]	43

**Analysis/Results**



F-XXXXX OA  
result



F-XXXXX OA  
analysis.xls

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## Solution Approach - Inference



### Improved defect coverage/effectiveness

No. of defects excavated based on Org. test suite	6 defects
Defects excavated based on the updated test suite	6 + 2 = 8 defects
Improved defect coverage or effectiveness	33.4 %

### Overall effort reduction

Improved Test coverage ( 53 → 68 Nos )	28.34 %
Test case design effort - per estimates	218 hrs
Test case design effort (without tool)	200 hrs
Test case design & effort (with tool) : Data grid preparation effort + Test case identification + Redundant tc removal effort + review effort	152 hrs
Overall effort reduction	31.5 %

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## Tools - References



**JENNY:** Jenny is a time tested tool for generating test conditions. freeware available at <http://burtleburtle.net/bob/math/jenny.html>

Author: Bob Jenkins

Features:

- Coded in C language
- Guarantees pair wise testing for all the features paired together

**JWRAP:** Open source wrapper for JENNY

<https://sourceforge.net/projects/jwrap>

JWrap has 2 components

- JWrap Engine: Converts all the Jenny format to Human understandable form
- TWrap template: Populates all the values in the spread sheet

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## Advantages and Features



- Productivity improvement with test cycle time reduction
- Few/less test cases, uncovering most of the defects
- Independent of platform/domain
- High probability of earlier detection
- Time required for pattern generation is consistently less
- Better test efficiency and lower defect leakage ratio
- Easy to understand and approach
- Cost of experimentation is less



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## Reference - Tools



Pro-Test tool (Sigma Zone)	<a href="http://www.sigmazone.com/protest.htm">http://www.sigmazone.com/protest.htm</a>
AETG tool: Telcordia	<a href="http://aetgweb.argreenhouse.com/">http://aetgweb.argreenhouse.com/</a>
T – Config (author: Alan Williams, Asst. Prof at University of Ottawa)	<a href="http://www.site.uottawa.ca/~awilliam/">http://www.site.uottawa.ca/~awilliam/</a>
Test cover:	<a href="http://www.testcover.com/">http://www.testcover.com/</a>
Test vector generator (Free source)	<a href="http://sourceforge.net/projects/tvg/">http://sourceforge.net/projects/tvg/</a>
Approach to testing based on combinatorial design	<a href="http://www.argreenhouse.com/papers/gcp/AETGieeee97.shtml">http://www.argreenhouse.com/papers/gcp/AETGieeee97.shtml</a>
References from Madhav Phadke	<a href="http://www.phadkeassociates.com/index_files/contactus.htm">http://www.phadkeassociates.com/index_files/contactus.htm</a>

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