THE VERIFICATION COCKPIT - A ONE-STOP SHOP FOR YOUR VERIFICATION DATA

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“Information is the oil of the 21st century, and analytics is the combustion engine.”

– Peter Sondergaard, senior vice president, Gartner Research.
Introduction

Modern day verification is a highly automated process that involves

- Tens or hundreds verification engineers
- Tens of different tools
- Compute farms with thousands servers

The verification process is becoming increasingly interconnected, intelligent, and instrumented

Control and management of the verification process are among the biggest challenges faced by verification teams

While more data is available, less of the data is being effectively captured, managed, analyzed, and made available to the people who need it
### Dynamic Verification Main Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Execution platform</strong></td>
<td>• Simulation, acceleration, emulation, and silicon</td>
</tr>
<tr>
<td><strong>Stimulus generation</strong></td>
<td>• Legal, useful input data and sequential patterns</td>
</tr>
<tr>
<td></td>
<td>• Constrained random generation, directed tests</td>
</tr>
<tr>
<td><strong>Response checking</strong></td>
<td>• Does DUV behavior fully conform to specification?</td>
</tr>
<tr>
<td></td>
<td>• Reference model, assertions, behavioral rules, manual checking</td>
</tr>
<tr>
<td><strong>Coverage measurement and analysis</strong></td>
<td>• Has the DUV been fully exercised?</td>
</tr>
<tr>
<td></td>
<td>• Quantify behavioral spaces of DUV features</td>
</tr>
</tbody>
</table>
Dynamic Verification Flow

- Test Plan
- Directives
- Stimuli Generator
- Coverage Reports
- Coverage Analysis Tool
- Checking, Assertions
- Test
- Simulator
- Design Under Test
- Fail
- Pass
- Version Control
- Bug Tracking
- Failure Tracking
- Test Submission
As a verification engineer, I would like to know if the test template I created for the new feature is doing its work.

As a verification lead, I would like to see a quick, concise and informative view of my unit status.

As a verification lead, I would like to know which tests should I use in my nightly regression to maximize efficiency.

As a project manager, I would like to know if I will meet the reliability requirements on tape-out date.

As verification lead, I would like to know what areas / functions are at risk (low coverage, high defect rate, high defect backlog).

As verification lead, I would like to know if the bug finding rate increases or decreases.

As verification lead, I would like to be alerted when events that were previously hit are no longer hit by designated test templates.

As a verification lead, I would like to know when an unusual volume of bugs (high or low) is found today.
Vision

A consolidated platform for planning, tracking, analysis, and optimization of a large scale verification project.
A consolidated platform for planning, tracking, analysis, and optimization of a large scale verification project

- Runs daily, some hourly
- Run-times vary from few min to hours
- ETL run is “non blocking” for using the data

- Millions of tests run
- Thousands test-templates
- 100Ks coverage events tracked

- ~2T, ~5G per day
- ~200 tables, biggest with 0.5M lines
Challenges

- Many independent tools - data sources
- Tools are optimized for operational work
- Vast amount of data
Our Platform

ETL - Extract, Transform, Load Java, JDBC

IBM Verification Cockpit Advanced Analytics Engines

IBM Cognos Analytics

IBM Verification Cockpit VC REST API

IBM DB2 BLU Acceleration

IBM Verification Cockpit Configuration Hub
Main User Objectives

- Comprehensive Test Bench
- Project is Converging to Support the Tape Out Schedule
- Effective Use of Computer Resources
Analytics Examples

User Perspective
Dashboard
How many tests did I run?

Daily Test Count

<table>
<thead>
<tr>
<th>Day</th>
<th>Test Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

What’s my fail rate?

Daily Fail Rate

% Log Scale

0.1%

0.0%
Comparison of Tests and Cycle Distribution Across Environments

Test Count Summary (by Env)

Cycles Summary (by Env)

Cycles per Test Summary (by Env)
Defect (Bugs) Tracking

How big is my backlog – open and answered issues?

<table>
<thead>
<tr>
<th>Unit</th>
<th>Open</th>
<th>Answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of Defects
What is the trend?

Defects Backlog

Week

Open
Open + Answered
Answered
Open
Backlog Trend on Various Environments

Backlog Unit 1

Backlog Unit 2

Defect Count

Time

Model A
Model B
Model C
Model D
Model E
Model F
Model G
Model H

Model A
Model B
Model C
Model D
Model E
Model F
Model G
Model H
What is the average processing time for issues?
What is the average processing time for issues?
How effective are each of the models at finding defects?
Coverage

What is the coverage status in my units?

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>covered</td>
<td><strong>1000</strong></td>
<td><strong>750</strong></td>
<td><strong>500</strong></td>
<td><strong>250</strong></td>
<td><strong>100</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lightly</td>
<td></td>
<td></td>
<td></td>
<td><strong>250</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-hit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Coverage:
- A: 100%
- B: 80%
- C: 60%
- D: 40%
- E: 20%
- F: 0%
- G: 80%
- H: 60%
- I: 40%
- J: 20%
- K: 0%
- L: 80%
What is my coverage trend?

<table>
<thead>
<tr>
<th>Week</th>
<th>Covered</th>
<th>Lightly</th>
<th>0-Hit</th>
<th>Events Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>80%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>3</td>
<td>60%</td>
<td>40%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>4</td>
<td>40%</td>
<td>60%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Total Covered: 4,000
Events Total: 24
Show me the coverage status by model, with drill down to events

<table>
<thead>
<tr>
<th>#</th>
<th>Entity</th>
<th>S</th>
<th>Total</th>
<th>Covered</th>
<th>Lightly Covered</th>
<th>Zero Hit</th>
<th>Aged Out</th>
<th>Never Hit</th>
<th>Newly Hit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>xu_app_zmac</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>xu_tlb2_c_zmac</td>
<td>40</td>
<td>17</td>
<td>42.5</td>
<td>2</td>
<td>5</td>
<td>21</td>
<td>52.5</td>
<td>2</td>
</tr>
<tr>
<td>17</td>
<td>xu_tlb2_lru_zmac</td>
<td>73</td>
<td>33</td>
<td>45.2</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>54.8</td>
<td>23</td>
</tr>
<tr>
<td>21</td>
<td>xu_ztop</td>
<td>3,244</td>
<td>2,050</td>
<td>63.2</td>
<td>23</td>
<td>0.7</td>
<td>1,171</td>
<td>36.1</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>xu_tlb2_lkup_zmac</td>
<td>8</td>
<td>6</td>
<td>75</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>xu_tlb2_estation_zmac</td>
<td>335</td>
<td>283</td>
<td>84.5</td>
<td>22</td>
<td>6.6</td>
<td>30</td>
<td>9.0</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>xu_async_quiesce_ztop</td>
<td>2,014</td>
<td>1,802</td>
<td>89.5</td>
<td>199</td>
<td>9.9</td>
<td>13</td>
<td>0.6</td>
<td>12</td>
</tr>
<tr>
<td>20</td>
<td>xu_xlate_ztop</td>
<td>431</td>
<td>390</td>
<td>90.5</td>
<td>4</td>
<td>0.9</td>
<td>37</td>
<td>8.6</td>
<td>36</td>
</tr>
<tr>
<td>11</td>
<td>xu_tlb2_a_zmac</td>
<td>109</td>
<td>101</td>
<td>92.7</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>7.3</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>xu_misc_ztop</td>
<td>644</td>
<td>632</td>
<td>98.1</td>
<td>2</td>
<td>0.3</td>
<td>10</td>
<td>1.6</td>
<td>10</td>
</tr>
</tbody>
</table>
Regression Test Quality Analysis

**Goal**

- Run optimized regression in quality (bugs) and resources

**Descriptive**

- Rank the regression tests according to their ability to fulfill verification goals
  - Target areas in the design that changed recently
  - Find bugs
  - Improve coverage
Regression Test Quality Analysis

Analysis method – simple statistics on measures related to the tests

- Multi sources – Job submission, defect tracking, coverage database, version control
- Cross sources – Probability of hitting rare events, defects per million tests

Prescriptive

- Use the analysis results (manually or automatically) to direct the job submission system
Template Aware Coverage (TAC) Data

Test Templates $T = (t_i)$

Coverage Space $E = (e_j)$

Probabilistic

$P_{hit} = \begin{pmatrix} \ldots & \ldots & \ldots \\ \ldots & p_{i,j} & \ldots \\ \ldots & \ldots & \ldots \end{pmatrix}_{\text{templates}}$

$P_{i,j}$ is the probability that a test instance generated from template $i$ will hit event $j$

For test template $t_i$

$\frac{\# \text{ of tests hit } e_j}{\# \text{ of tests}}$
TAC Use Cases

- List all **Events** that are hit by a given **Template**
- Best **Templates** to hit an **Event**
- List all **Events** that are uniquely hit by a given **Template**
Hitting Hard-to-Hit Events

Hard To Hit Events Count

Started to run TAC
Test Case Length

Long vs Short

?
VC Summary

Main objective

• Data science as the backbone of the verification

Key ingredients

Instrumentation

• Identify new data, improve existing data, maintain history

Interconnect

• Data available at central point; model key data relations

Intelligence

• Based on various analytics techniques; by data analysts
Conclusions

The verification process produces tons of data

- Many verification tools with many data items per tool

Extracting useful information from the data can significantly benefit the verification process

- Provides a deep understanding of the data and the underlying world it represents
- Allows speculation over the future and making decisions based on revealed insights

Data analytics is a powerful weapon in extracting such information

- And even simple data analytics methods can go a long way

To build such an information retrieval system, one needs

- Centralized hub to connect data sources (and store the data)
- Verification tools that are open and can be connected to the hub
- Ideas and methods for extracting the information out of the data
Questions