Improving Models for Model-based Testing using Exploratory Testing

1st International Workshop on Advanced Topics on Software Engineering (ATSEN)
7 November 2014, İstanbul Kültür University, Istanbul, Turkey

Hasan Sözer
together with Ceren Şahin Gebizli
Overview

• Model-based testing (MBT)
  • Automated test case generation based on models that represent the desired behavior of the system under test (SUT)

• Refinement of models
  • by exploiting the **domain knowledge** of experienced test engineers
  • can lead to **30%** increase in the number of detected errors
Case Study: TV Software

- Types of tests performed
  - Functional tests and performance tests (4 weeks)
  - Experience based tests (2 weeks)
  - Torture tests with automation (2 weeks)

- Challenges:
  - Large code base
    - 5M LOC in total
    - ~1.5M LOC modified within 2013
  - Short time-to-market
  - Limited resources
Applied Model Based Testing Approach

- Event Sequence Graphs (ESG)
  - A formalism to express the SUT model
  - Inputs and states are represented together by assigning them to events

- Modeling Tools
  - TSD (works with ESG models)
  - MaTeLo
Limitations of MBT

• Modeling is manual and error-prone
  • based on Functional Requirements Specification (FRS) documents
Applied Exploratory Testing Approach

• Test engineers / technicians perform manual tests

• Iterative Process
  • Learn about the product;
  • Plan the testing work to be done;
  • Design and execute the tests;
  • Report the results.

• Proved effective in detecting critical faults
• The domain knowledge and experience are not documented and shared
The Overall Approach
Industrial Case Study-1

• Digital Video Broadcasting - Terrestrial Channel Installation (DVB-TCI) module

• ESG Model of the DVB-TCI
Mapping Model Elements to Execution Traces

- Execution Traces: sequence of function calls
- Model Elements: high level events
- Mapping in the form of regular expressions

```cpp
// <Event Sequence>
 r
 as
 an,s
 st
 ps
 po
 f,l*
 m,p*

//

: <Model Element>
 : Install And Retune;
 : Auto Search;
 : Analog;
 : Start Search;
 : Press Standby;
 : Press 1;
 : Freq=121.00MHz;
 : Media Video Playing;
```
Refinement of the DVB-TCI ESG Model

e4: Start search --> prgrp, prgrp : Missing destination event, an event that "prgrp, prgrp" function call sequence is mapped, should be added

e4: Start search --> e1: InstallAndRetuneMenu : Missing edge, add edge between "e4: Start search" and "e1: InstallAndRetuneMenu"
Results from Case Study-1

<table>
<thead>
<tr>
<th></th>
<th># of Nodes</th>
<th># of Edges</th>
<th># of Test Cases</th>
<th># of Faults</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before Refinement</strong></td>
<td>1225</td>
<td>1501</td>
<td>217</td>
<td>3</td>
</tr>
<tr>
<td><strong>Exploratory Testing</strong></td>
<td>5 faults found including the 3 faults that were also found with MBT (before refinement)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>After Refinement</strong></td>
<td>2012</td>
<td>2868</td>
<td>349</td>
<td>8</td>
</tr>
</tbody>
</table>

Additional (and highly critical) 3 faults revealed
- Caused the TV to reset itself
- Duplicate channels after a channel search is performed
- Caused the TV to crash
Industrial Case Study-2

• Media Browser (MB) Module

• ESG Model of the MB Module
Example Warning Messages for the MB ESG Model

1. Tune to analog channel --> e: Enter Media Browser
2. Missing source event!
3. A new mapping must be added for
4. "Tune to analog channel"
5. function call sequence

6.

7. e58: While video playing --> Press subtitle for embedded subtitle
8. Missing destination event!
9. A new mapping must be added for
10. "Press subtitle for embedded subtitle"
11. function call sequence
Example Refinement of the MB ESG Model
## Results from Case Study-2

<table>
<thead>
<tr>
<th></th>
<th># of Nodes</th>
<th># of Edges</th>
<th># of Test Cases</th>
<th># of Faults</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before Refinement</strong></td>
<td>294</td>
<td>424</td>
<td>132</td>
<td>36</td>
</tr>
<tr>
<td><strong>Exploratory Testing</strong></td>
<td>44 faults found including the 36 faults that were also found with MBT (before refinement)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>After Refinement</strong></td>
<td>341</td>
<td>478</td>
<td>139</td>
<td>48</td>
</tr>
</tbody>
</table>

Additional (and highly critical) 4 faults revealed
- Disappear audio/video output
- Corrupted remote controllers key buffers
- Undetectable user commands
- Caused the TV to reset itself
Conclusions

- Consumer electronics domain
  - Limited resources, large code bases
- Automation is essential; MBT is employed in the industry
- Yet, critical faults are often revealed with Exploratory Testing
  - Domain knowledge and experience are valuable
- Approach: MBT coupled with Exploratory Testing activities
  - SUT models are refined based on recorded execution traces
- Real and critical faults found
  - Not detected with MBT
  - Also missed during exploratory testing