Effort Comparison for Model-based Testing Scenarios

Barış Güldalı, Michael Mlynarski, Yavuz Sancar
6.4.2010, A-MOST & QuoMBaT Workshop @ ICST
Software Quality Lab (s-lab)

- 5 software engineering professors at University of Paderborn
- 8 associated partners, 6 project partners
- 3 senior-researchers, 19 researchers

Our expertise
- Test management, test automation
- Formal methods
- Domain specific languages

Domains
- Automotive systems
- Business information systems
- Smart card systems

http://s-lab.upb.de
Testing research transfer

Are there new testing techniques?

How to improve testing technically and organizationally?

What is model-based testing?

Is model-based testing suitable for us?

What are the costs and gains of model-based testing?
Stepwise adoption of MBT in industry

- Needs analysis
- Scenario analysis
- Technology selection
- Technology adoption
- Pilot project & Evaluation

Effort comparison for MBT scenarios

Manual, Capture/Replay, Keyword-driven, …
efforts & promises
Porantim tool [Dias-Neto et al.]

Enterprise Architect, Eclipse, DSL, JUnit, …
costs & gains
Scenario analysis: Definitions (Testing)

- Requirements
- Specification
- Mental model
- Redundancy
- Test cases
- Code
- Actual behavior
- Expected behavior
- Test results
- Test selection criteria

Effort comparison for MBT scenarios
Scenario analysis: Definitions (MBT)

- Requirements
- Specification
- Test model
- Test cases
- Code
- Test results

Test selection criteria

Origin?
Automation?

Scenarios analysis: literature

Effort comparison for MBT scenarios
Scenarios analysis: point of interests
Efforts in MBT

Testing activities
- Defining test models
- Generating test cases
- Executing test cases
- Evaluating test results

Organizational aspects
- Improving test maturity
- Training test personal
- Adopting tools
- Coordination with developers

Pretschner: "Development of adapters is missing. Requires 50% of efforts!"
How to measure efforts?

**Testing activities**
- Defining test models
- Generating test cases
- Executing test cases
- Evaluating test results

**Organizational aspects**
- Improving test maturity
- Training test personal
- Adopting tools
- Coordination with developers

**Reusability**
- TML: Test maturity level [TPI@Sogeti]
- MML: Modeling maturity level [MDA]

**Automation level**
- Redundancy

**Team dependency**
**GQM-like approach**

**G: How much efforts are needed for adopting a particular MBT scenario?**

**Testing activities**

- **Q1:** How costly is the definition of test models?
- **Q2:** How costly is the generation of test cases?
- **Q3:** How costly is the execution of test cases?
- **Q4:** How costly is the evaluation of test cases?

**Organizational aspects**

- **M1:** Reusability
- **M2:** Automation
- **M3:** Redundancy
- **M4:** TML
- **M5:** MML
- **M6:** Dependency

**V:**
- **M1:** high, middle, low
- **M2:** high, middle, low
- **M3:** high, middle, low
- **M4:** 1..13
- **M5:** 1..5
- **M6:** high, middle, low

**Effort comparison for MBT scenarios**

- **Q8:** How costly is it to coordinate the development and testing activities?
- **Q7:** How costly is it to adopt new automation tools?
- **Q6:** How costly is it to train the testers such that they gain modeling skills?
- **Q5:** How costly is it to lift the test process to a required maturity level?
# Tabular comparison

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Scenario1</td>
<td>$v_{M1}$</td>
<td>$v_{M2}$</td>
<td>$v_{M3}$</td>
<td>$v_{M4}$</td>
<td>$v_{M5}$</td>
<td>$v_{M6}$</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>$v_{M1}$</td>
<td>$v_{M2}$</td>
<td>$v_{M3}$</td>
<td>$v_{M4}$</td>
<td>$v_{M5}$</td>
<td>$v_{M6}$</td>
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Effort comparison for MBT scenarios
Scenarios of MBT

- Pretschner & Philips 2005
  - Common model
  - Automatic model extraction
  - Manual modeling
  - Separate models

- Further scenarios:
  - Model extraction from test cases
  - Model transformations

Test selection criteria → Test cases → Code
Common model

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Metric value</th>
</tr>
</thead>
<tbody>
<tr>
<td>high reuse of models</td>
<td>$V_{M1}$: high</td>
</tr>
<tr>
<td>highly automated in generation, low automation in evaluation</td>
<td>$V_{M2}$: middle</td>
</tr>
<tr>
<td>no redundancy</td>
<td>$V_{M3}$: low</td>
</tr>
<tr>
<td>maturity in test automation</td>
<td>$V_{M4}$: 7</td>
</tr>
<tr>
<td>maturity in modeling</td>
<td>$V_{M5}$: 5</td>
</tr>
<tr>
<td>teams dependent</td>
<td>$V_{M6}$: high</td>
</tr>
</tbody>
</table>

Effort comparison for MBT scenarios

[Utting & Legeard 06]

Separate models

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Metric value</th>
</tr>
</thead>
<tbody>
<tr>
<td>no reuse of models</td>
<td>(VM₁: low)</td>
</tr>
<tr>
<td>no automation in derivation, highly automated in generation, high automation in evaluation</td>
<td>(VM₂: middle)</td>
</tr>
<tr>
<td>high redundancy</td>
<td>(VM₃: high)</td>
</tr>
<tr>
<td>maturity in test automation</td>
<td>(VM₄: 7)</td>
</tr>
<tr>
<td>maturity in modeling</td>
<td>(VM₅: ≥4/5)</td>
</tr>
<tr>
<td>teams independent</td>
<td>(VM₆: low)</td>
</tr>
</tbody>
</table>

Effort comparison for MBT scenarios

### Effort comparison for MBT scenarios

Model extraction from test cases

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Metric value</th>
</tr>
</thead>
<tbody>
<tr>
<td>reuse of old test cases</td>
<td>((V_{M1}: \text{high}))</td>
</tr>
<tr>
<td>high automation in derivation, highly automated in generation, high automation in evaluation</td>
<td>((V_{M2}: \text{high}))</td>
</tr>
<tr>
<td>high redundancy</td>
<td>((V_{M3}: \text{high}))</td>
</tr>
<tr>
<td>maturity in test automation</td>
<td>((V_{M4}: 7))</td>
</tr>
<tr>
<td>maturity in modeling</td>
<td>((V_{M5}: \geq 1))</td>
</tr>
<tr>
<td>teams independent</td>
<td>((V_{M6}: \text{low}))</td>
</tr>
</tbody>
</table>

**Test model**

- z.B. [Jääskeläinen, et al. Synthesizing Test Models from Test Cases. 2008]

**Test cases**

- Old
- New

**Test results**

**Requirements**

**Test selection criteria**

**Code**
### Tabular comparison

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<tr>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Common model</td>
<td>H</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>2</td>
<td>Model from code</td>
<td>H</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>3</td>
<td>Manual modeling</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>4</td>
<td>Separate models</td>
<td>L</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>5</td>
<td>Model from test cases</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>6</td>
<td>Model from model</td>
<td>H</td>
<td>H</td>
<td>M</td>
</tr>
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Tabular comparison

### Testing activities

<table>
<thead>
<tr>
<th></th>
<th>G: How much efforts are needed for adapting a particular MBT scenarios?</th>
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<tbody>
<tr>
<td>Q1</td>
<td>How costly is the definition of test models?</td>
</tr>
<tr>
<td>Q2</td>
<td>How costly is the generation of test cases?</td>
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<td>Q3</td>
<td>How costly is the execution of test cases?</td>
</tr>
<tr>
<td>Q4</td>
<td>How costly is the evaluation of test cases?</td>
</tr>
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</table>

### Organizational aspects

<table>
<thead>
<tr>
<th></th>
<th>Q5: How costly is it to lift the test process to a required maturity level?</th>
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<tbody>
<tr>
<td>Q6</td>
<td>How costly is it to train the testers such that they gain modeling skills?</td>
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<td>How costly is it to coordinate the development and testing activities?</td>
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### Effort comparison for MBT scenarios

<table>
<thead>
<tr>
<th></th>
<th>High effort</th>
<th>Middle effort</th>
<th>Low effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Common model</td>
<td>➣</td>
<td>➤</td>
<td>➤</td>
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<tr>
<td>2) Model from code</td>
<td>➣</td>
<td>➤</td>
<td>➤</td>
</tr>
<tr>
<td>3) Manual modeling</td>
<td>➤</td>
<td>➤</td>
<td>➤</td>
</tr>
<tr>
<td>4) Separate models</td>
<td>➤</td>
<td>➤</td>
<td>➤</td>
</tr>
<tr>
<td>5) Model from test cases</td>
<td>➣</td>
<td>➣</td>
<td>➤</td>
</tr>
<tr>
<td>6) Model from model</td>
<td>➣</td>
<td>➣</td>
<td>➤</td>
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Diagram:

- High effort ➣ ➤ Low effort
Messages of the comparison

• Which efforts are needed for individual MBT scenarios?
• How do efforts differ?

• No statement about
  – Total costs
  – Test quality
  – Test coverage
  – How to combine the scenarios?
  – ...

Effort comparison for MBT scenarios
What is the next step?

Needs analysis

Scenario analysis

Technology selection

Technology adoption

Pilot project & Evaluation

Manual, Capture/Replay, Keyword-driven, …

efforts & promises

Porantim tool [Dias-Neto et al.]

Enterprise Architect, Eclipse, DSL, JUnit, …

costs & gains

Effort comparison for MBT scenarios
Conclusion

- MBT is not for free
- Different scenarios → different efforts
- Efforts are comparable
- No best scenario! Choice is context dependent!
- Redundancy in test artifacts is important!

Effort comparison for MBT scenarios

- Pretschner: “Development of adapters”
- GI working Group: “Maintenance of test models”, “Context important, e.g. migration”
Thank you for your attention.

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The Software Quality Edge
## Comparison wrt TPI key areas

<table>
<thead>
<tr>
<th>TPI Key Areas</th>
<th>Teststrategie</th>
<th>Zeitpunkt der Beteiligung</th>
<th>Testspezifikations-techniken</th>
<th>Testautomatisierung</th>
<th>Testfunktionen und Training</th>
<th>Reichweite der Methodik</th>
<th>Kommunikation</th>
<th>Testware management</th>
<th>Low-Level Tests</th>
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<tr>
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Model extraction from code

- Requirements
- Test model
- Test selection criteria
- Test cases
- Code
- Test results


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Highly automated in derivation and generation, low automation in evaluation | \( V_{M_2} \): middle
No redundancy | \( V_{M_3} \): low
Maturity in test automation | \( V_{M_4} \): 7
Maturity in modeling | \( V_{M_5} \): \( \geq 1 \)
Teams dependent | \( V_{M_6} \): high

Effort comparison for MBT scenarios
Manual modeling

Test model

Requirements

Test selection criteria

Test cases

Code

Test results

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Models from model transformations

Requirements → Test model → Test selection criteria → Test cases → Code

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