Model-Based Testing in the Cloud

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## Conformiq in Nutshell

<table>
<thead>
<tr>
<th>Who We Are</th>
<th>What We Deliver</th>
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<tbody>
<tr>
<td>- Privately held high-technology company</td>
<td>- Software for <strong>Automated Test Design™</strong></td>
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<tr>
<td>- Offices in US, Sweden, Finland and Germany; partner presence in India</td>
<td>- 5X to 20X productivity gain in <strong>test design</strong> with improved test coverage and quality</td>
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<td>- Focus on black-box functional and feature testing</td>
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System Model Driven Test Generation

Specifications → Knowledge acquisition → Mental Model → Test case design → Test Cases

-Pretschner 05

Direct codification

Automatic test case generation
System Model…

- Computer-readable
- Describes the correct operation of the system
- Small and high-level
- Easy to modify
- Has same level of abstraction as the test harness
- An object-oriented computer program
System Model Driven Test Generation

- Specifications
- Knowledge acquisition
- Mental Model
- Test case design
- Test Cases

- System Model
- Direct codification
- Automatic test case generation

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## Test Generation from System Models

<table>
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<th>Benefits</th>
<th>Difficulty</th>
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<td>• Productivity improvement (we have measured consistently five-fold productivity improvement in test case design in industrial projects)</td>
<td>• Algorithmic complexity (depending on assumptions) is</td>
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<tr>
<td>• Direct correspondence between specifications and system models</td>
<td>– NP-hard</td>
</tr>
<tr>
<td></td>
<td>– PSPACE-hard</td>
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<tr>
<td></td>
<td>– Non-elementary</td>
</tr>
<tr>
<td></td>
<td>– Undecidable</td>
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→ Performance is a general bottleneck and hindrance for adoption
Conformiq’s Test Generation Solution

IDE for automatic test design
Eclipse® based desktop application

Server component for test generation mathematics
Multicore-enabled service
The Cloud Version

IDE for automatic test design
Eclipse® based desktop application

Distributed, parallel computation architecture for test generation
Typical Use During Test Development

1. **User wants feedback on effects of recent changes to the model**
   - Edit Model

2. **User proceeds to run the tests against the system under test**
   - Regenerate Tests

3. **User not content with generated tests**
   - Run tests

4. **User possibly proceeds to change the model based on the feedback from execution**
   - Edit Model

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Problem Characteristics

• Test generation with the current approach scales algorithmically well to 20 – 100 CPUs based on the system model’s complexity

• Typical test generation times on single workstation range from 10 minutes to 6 hours

• In a mature deployment, it seems that roughly ¼ of test engineers are primary users of the technology, with another ¼ having a supportive role

• Quick turn-around time in test generation is important for the general efficiency of the team

• Usage is somewhat sporadic, i.e. test generation activity can be high or low depending on the current project’s stage
Benefits of the Cloud Approach

• Enables high peak performance and fast test generation turn-around time, making automated test design teams more productive

• When deployed in a flexible, elastic cloud, reduces capital expenditure as the peak use can be tolerated without reserving the computational power permanently
Scalability via Cloud Computing

- High-Performance Computing
- Automatic Test Case Generation
- Massively Parallel Services

Peak performance per user vs. Number of concurrent users
Standardization Perspective

• We use currently CORBA (an OMG standard) as the middleware, and the standards-driven interoperability between the Java ORB and ACE/TAO (a C++ ORB) is crucial for us
  – WSDL/SOA/XML is the key to many of the present grid/cloud computing technologies, but CORBA is faster and has less overhead than the web services stack, making it suitable not only for configuration but also for runtime data exchange
  – At the same time, traditional HPC-standards for distributed computing such as MPI have proven to be of only little value to us, especially because they seem to handle dynamic configurations poorly (number of CPUs changes during a single run)

• We do not use tree reduction frameworks or huge databases (cf. the Google approach)
Summary

- Automatic test generation from system model is computationally intensive but delivers measurable and significant benefits

- Automatic test generation activity in teams is sporadic and depends on project stage

- For this problem, the cloud approach provides scalability both in terms of peak performance (test generation time) as well as in the number of (concurrent) users

- It is an interesting, new HPC application with direct applications in the everyday operations of software companies
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