PerOpteryx

Automatically Improve Software Architecture Models for Performance, Reliability, and Costs using Evolutionary Algorithms

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An animated version of this slide set (as PowerPoint ppsx) can be found at http://sdqweb.ipd.uka.de/wiki/PerOpteryx
Software Performance Engineering

Motivation – Related Work – Approach – Case Study – Future Work – Conclusion
Not only Performance!

Motivation – Related Work – Approach – Case Study – Future Work – Conclusion
Multicriteria Optimisation

Motivation – Related Work – Approach – Case Study – Future Work – Conclusion
Multicriteria Optimisation

Motivation – Related Work – Approach – Case Study – Future Work – Conclusion

Time

5s

$40K

Costs

Generated & Evaluated
Multicriteria Optimisation

**Motivation** – Related Work – Approach – Case Study – Future Work – Conclusion
Related Work: Quality Optimisation

- Rule-based approaches: Single quality only

- Multicriteria evaluation: No improvement
  - Bondarev2007, Grunske2007

- Optimisation: Limited degrees of freedom

**Missing:** Flexible multicriteria optimisation at the design level
PerOpteryx Approach

Flexible degrees of freedom

Multiple qualities

Multi-criteria optimization

Motivation – Related Work – Approach – Case Study – Future Work – Conclusion
Degrees of Freedom

Design decision that can still be made

Variation point

<table>
<thead>
<tr>
<th>Range of options</th>
<th>Which instance to use for component type C?</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C2, or C3</td>
<td></td>
</tr>
</tbody>
</table>

Degree of freedom
# Types of Degrees of Freedom in CBSE

<table>
<thead>
<tr>
<th>Software</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Component selection</td>
<td></td>
</tr>
<tr>
<td>Middleware selection</td>
<td></td>
</tr>
<tr>
<td>Component replication</td>
<td></td>
</tr>
<tr>
<td>Software configuration</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deployment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Allocation</td>
<td></td>
</tr>
<tr>
<td>Processing Rate</td>
<td></td>
</tr>
<tr>
<td>Number of Servers</td>
<td></td>
</tr>
</tbody>
</table>

Motivation – Related Work – **Approach** – Case Study – Future Work – Conclusion
## Instances of Degrees of Freedom

<table>
<thead>
<tr>
<th>Degree</th>
<th>Matching Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allocation</td>
<td>Each component</td>
</tr>
<tr>
<td>Processor speed</td>
<td>Each server</td>
</tr>
<tr>
<td>Component selection</td>
<td>Search alternatives</td>
</tr>
</tbody>
</table>

**Component selection for D**

**Allocation of D**

**Component selection for C**

**Allocation of C**

**Processor speed of server 1**

**Motivation – Related Work – Approach – Case Study – Future Work – Conclusion**

12.02.2010, Anne Martens, Software Design and Quality Group, IPD
## Search Problem

<table>
<thead>
<tr>
<th>Degree</th>
<th>Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component selection C</td>
<td>C2</td>
</tr>
<tr>
<td>Allocation C</td>
<td>Server1</td>
</tr>
<tr>
<td>Speed server 1</td>
<td>2 GHz</td>
</tr>
</tbody>
</table>

Response in 2.5 s
P(failure) 0.02%
Cost $6000

Motivation – Related Work – **Approach** – Case Study – Future Work – Conclusion
Search Implementation

Motivation – Related Work – Approach – Case Study – Future Work – Conclusion
Quality evaluation

Palladio Component Model
[Becker2007]

PCM2LQN
[Koziolek2008]

PCM2DTMC
[Brosch2009]

PCM2Cost
[Martens2010]

∑

Cost

Performance

Reliability
Case Study with PerOpteryx (1/2)
Case Study with PerOpteryx (1/2)

- Component allocation
- Processing rates
- Component selection

- 1235 candidates
- 58 Pareto optimal
- 8h running time

Motivation – Related Work – Approach – Case Study – Future Work – Conclusion
Case Study with PerOpteryx (2/2)

Motivation

Related Work

Approach

Case Study

Future Work

Conclusion

Average Response Time (Seconds)

RT: 1.34 s
POFOD: 5.2E-4
Cost: 69.83
Only four, but faster servers
Different Webserver

RT: 2.2 s
POFOD: 6E-4
Cost: 98

All candidates
Pareto-optimal candidates
Initial Candidate

Costs (K$)
Future Work

Short term

• Performance heuristics
• Requirement support
• More degrees of freedom

Long term

• Handle uncertainty of predictions
• QoS process integration
Conclusions

Automated Architecture Improvement

Flexible degrees of freedom

Multiple qualities

Multi-criteria Optimization

http://sdqweb.ipd.kit.edu/wiki/PerOpteryx