PerOpteryx

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

Anne Martens
Karlsruhe Institute of Technology (KIT), Germany
Heiko Koziolek, Steffen Becker, Ralf Reussner

WOSP / SIPEW 2010
Software Performance Engineering

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

Transform C1

Change component and deployment

Transform C2

Solve

3 sec
p(fail) 0.01%
$5700

2.5 sec
p(fail) 0.02%
$12000

Optimise multiple criteria at once
Multicriteria Optimisation

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Multicriteria Optimisation

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Multicriteria Optimisation

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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

<table>
<thead>
<tr>
<th>Variation point</th>
<th>Which instance to use for component type C?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of options</td>
<td>C1, C2, or C3</td>
</tr>
</tbody>
</table>
# Types of Degrees of Freedom in CBSE

<table>
<thead>
<tr>
<th><strong>Software</strong></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><strong>Deployment</strong></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>
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>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Component selection for D

Component selection for C

Processor speed of server 1

Allocation of C

Allocation of D

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

- **Candidate Model**
  - Evaluate
  - Response in 2.5 s
  - \( P(\text{failure}) = 0.02\% \)
  - Cost $6000

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**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]

Motivation – Related Work – Approach – Case Study – Future Work – Conclusion
Case Study with PerOpteryx (1/2)

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

- **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**
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