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Modeling Complex User Behavior with the Palladio Component Model
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Motivation

Situation

• Workload specification and execution/simulation essential to evaluate performance properties of application systems (e.g., Krishnamurthy et al. 2006, Menascé et al. 1999, Arlitt et al. 2001)

Complication

• Modeling of complex and representative user behavior (Behavior Model) can be difficult or even unfeasible solely with the PCM usage model
• Workarounds are available, but:
  – Violates the separation of concerns
  – Increases the complexity of the performance models

Resolution

• Extension of PCM usage model meta-model
Limitations
Modeling Complex User Behavior

1) Modeling of backward edges
   - e.g. view_items to add_to_cart

2) Modeling of nested loops is difficult
   - e.g. view_items_quantity, add_to_cart, shoppingcart, clear_cart

3) Linking elements of one branchTransition to elements of another branchTransitions
   - e.g. remove to purchase_cart or defer_order

SPECjEnterprise2010 purchase transaction as probabilistic Behavior Model
Limitations

Reusability

1) Modeling of business processes (BPs) is difficult

2) BPs are a set of one or more linked activities where each activity itself is composed of one or more linked steps

3) The PCM Usage Model do not allow to model multiple connected usage scenarios
Limitations
Probabilistic Conditions

1) In case a combination of probabilistic and guarded conditions is needed, e.g.
   – remove an item from the shoppingcart with a probability of 34 % when itemCount > 0

2) The probability of the edges must be recalculated during simulation
   – When itemCount = 0 then the probability of clear cart is 100% (not 66%)
Limitations

Workarounds
Extension of PCM Usage Model meta model

1 / 4
Extension of PCM Usage Model meta model

2 / 4
Extension of PCM Usage Model meta model

3 / 4
Extension of PCM Usage Model meta-model
Extension of PCM Usage Model meta-model

Example

```
merge node
decision node
```

```
1.0
```

```
0.67
0.11
0.12
0.10
0.66
0.34
0.61
0.18
0.21
0.12
0.10
```

```
1.0
```

```
0.67
0.11
0.12
0.10
0.66
0.34
0.61
0.18
0.21
0.12
0.10
```
Extraction of Extended PCM Usage Models

**WESSBAS2PCM**

- Integrate extraction of PCM usage models into the WESSBAS approach (van Hoorn et al. 2014, Vögele et al. 2015)

- Transform WESSBAS-DSL instances into the extended PCM usage model

- A transformation of WESSBAS-DSL instances to “original“ PCM usage model already but workarounds are needed.
Evaluation
Methodology

- Execute SPECjEnterprise2010 run and collect standard Apache HTTP web logs
- Transform web logs to session log format
- Extraction of WESSBAS-DSL instances (includes clustering and guards and actions)
- Transformation of WESSBAS-DSL instances to the extended PCM usage model
## Evaluation

### Results

<table>
<thead>
<tr>
<th>Request</th>
<th>Orig. MRC</th>
<th>without guards and action SRC</th>
<th>PE%</th>
<th>with guards and actions SRC</th>
<th>PE%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 add to cart</td>
<td>21.376</td>
<td>20.766</td>
<td>2.94%</td>
<td>21.490</td>
<td>0.53%</td>
</tr>
<tr>
<td>2 cancel order</td>
<td>342</td>
<td>350</td>
<td>2.29%</td>
<td>285</td>
<td>20.00%</td>
</tr>
<tr>
<td>3 clear cart</td>
<td>2.043</td>
<td>2.005</td>
<td>1.90%</td>
<td>2.194</td>
<td>6.88%</td>
</tr>
<tr>
<td>4 defer order</td>
<td>2.273</td>
<td>2.237</td>
<td>1.61%</td>
<td>2.249</td>
<td>1.07%</td>
</tr>
<tr>
<td>5 home</td>
<td>19.409</td>
<td>19.039</td>
<td>1.94%</td>
<td>19.009</td>
<td>2.10%</td>
</tr>
<tr>
<td>6 inventory</td>
<td>19.960</td>
<td>19.452</td>
<td>2.61%</td>
<td>19.609</td>
<td>1.79%</td>
</tr>
<tr>
<td>7 login</td>
<td>19.913</td>
<td>19.514</td>
<td>2.04%</td>
<td>19.527</td>
<td>1.98%</td>
</tr>
<tr>
<td>8 logout</td>
<td>19.194</td>
<td>18.838</td>
<td>1.89%</td>
<td>18.812</td>
<td>2.03%</td>
</tr>
<tr>
<td>9 purchase cart</td>
<td>2.811</td>
<td>2.716</td>
<td>3.50%</td>
<td>2.728</td>
<td>3.04%</td>
</tr>
<tr>
<td>10 remove</td>
<td>947</td>
<td>901</td>
<td>5.11%</td>
<td>736</td>
<td>28.67%</td>
</tr>
<tr>
<td>11 sell inventory</td>
<td>43.375</td>
<td>42.741</td>
<td>1.48%</td>
<td>42.089</td>
<td>3.06%</td>
</tr>
<tr>
<td>12 shopping cart</td>
<td>2.991</td>
<td>2.906</td>
<td>2.92%</td>
<td>2.932</td>
<td>2.01%</td>
</tr>
<tr>
<td>13 view items quantity</td>
<td>21.300</td>
<td>20.706</td>
<td>2.87%</td>
<td>21.408</td>
<td>0.50%</td>
</tr>
<tr>
<td>14 view items</td>
<td>67.886</td>
<td>66.518</td>
<td>2.06%</td>
<td>65.112</td>
<td>4.26%</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>243.820</strong></td>
<td><strong>238.689</strong></td>
<td><strong>2.15%</strong></td>
<td><strong>238.180</strong></td>
<td><strong>2.37%</strong></td>
</tr>
</tbody>
</table>

**MRC**: Measured Request Count  
**SRC**: Simulated Request Count  
**PE**: Prediction Accuracy
Future Work

Conceptual Aspects
• Modeling of asynchronous communications
• Modeling of multiple start and end notes
• Integration of extended PCM usage model with *Integrated Business IT Impact Simulation* (IntBIIS) (Heinrich et al. 2015)

Technical Aspects
• Migrate from 3.4.1 \(\rightarrow\) to PCM 4.0
• Graphical editors for extended usage model
Discussion

• Is the proposed concept interesting for SEFF as well?

• Are there further use cases for usage models?
  → Depending on extended observations
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