Recent Developments in Context-oriented Programming  
(at HPI)

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Some History…

- Software Architecture
- Distributed Processing Environments
- Dynamic Aspect-oriented Programming
- Reflective Designs
- Dynamic Service Adaptation
- Context-oriented Programming

with Pascal Costanza and Oscar Nierstrasz

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Context

context = everything computationally accessible

location

time of day

temperature

connectivity

bandwidth

battery level

preferences

subscriptions

energy consumption

age

mood...
COP Basics Overview

Layer 1
Layer 2
Layer n

Class 1
Class 2
Class m

Behavioral variation
Active layer

introduce
activate
deactivate
remove

context
## AOP, FOP, and COP

<table>
<thead>
<tr>
<th></th>
<th>AOP</th>
<th>FOP</th>
<th>COP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverse dependencies</td>
<td>✗</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>1:n relationships</td>
<td>✗</td>
<td>✓</td>
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<tr>
<td>Layers</td>
<td></td>
<td></td>
<td>✓</td>
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<tr>
<td>Dynamic activation</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Scoping</td>
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<td>✓</td>
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</tbody>
</table>
COP Extensions (Some…)

- ContextS
- ContextS2
- ContextJS
- JCop (ContextJ)
- ContextPy
- PyDCL
- UseCasePy
- PyContext
- ContextR
- ContextG
- ContextAmber
- L1…4

- ContextL
- ContextScheme
- ContextJ*
- ContextErlang
- EventCJ
- Lambic
- Ambience
- COP.JS
- delMDSCO/cj
- Phenomenal Gem
- Subjective-C
- Context Petri Nets
Recent Developments in Context-oriented Programming

Recent COP Developments at HPI

- tooling: Vivide
- use-cases: UseCasePy
- contracts: PyDCL
- development layers: ContextJS / Lively
- image/objects: ContextJS / Babelsberg
- meta-tracing JITs: R/Squeak-VM / PyPy
- behavioral scoping: Context*
- structural scoping: ContextJS / Lively
- event-based composition: JCop
- reactive composition: ContextJS / Babelsberg
- constraint-based composition: ContextJS / Babelsberg
- constraint layers: ContextJS / Babelsberg
- semantics: ContextFJ
- layers only: L1...4
- foundations: VM/runtime

developers
users
Behavioral Variations

- **Behavioral (dynamic) scoping**
  - Dynamic extent of execution
  - Almost all COP extensions

- **Structural (topological) scoping**
  - ContextJS
  - Development layers

- **Open implementation for scoping strategies**
  - Allows for domain-specific scoping
  - Mainly applied to UI framework structures
    - Lively: Morphic
    - Webwerkstatt: Parts
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Development Support

• More applied → more useful
• In PL work tool support often neglected
  – Usually too expensive, especially early…
    → Need for explorative tool building support
    • Vivide
• Crosscutting nature of layers lends itself nicely to crosscutting software engineering concerns
  – Explicit use-cases representation
    • UseCasePy
  – Dynamic contract layers
    • PyDCL
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Reactive Approaches

- event-based composition
- reactive composition
- constraint-based composition
- constraint layers

Frameworks:
- JCop
- ContextJS / Babelsberg

Diagram:
- User Code
- Layer composition
- Crosscutting Concern

Game Elements:
- Link: Where is the beast? I will crush its bones!
- ImageProvider
- KeyboardListener
- GameWindow
- EntityUI
- WorldUI
- RegionUI
- AiCharacter
- Hero
- World

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Foundations

- **Semantics and types**
  - ContextFJ
- **Symmetry**
  - No classes, only layers
  - No base system
    - $L_{1..4}$
- **Sideways composition very expensive**
  - Runtime support for optimizations
  - Meta-tracing JITs
    - R/Squeak-VM
  - Higher performance $\Rightarrow$ more (meta-level) flexibility

$$ PT(m, C, L_0) \text{ undefined } \quad mbody(m, C, L', L) = x.e \text{ in } D, L'' $$

$$ mbody(m, C, (L'; L_0), \bar{L}) = x.e \text{ in } D, L'' $$
Acknowledgements

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