Organic Computing Middleware for Ubiquitous Environments OCμ

Julia Schmitt, Michael Roth, Rolf Kiefhaber, Florian Kluge, Theo Ungerer

Systems and Networking
University of Augsburg
Germany

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Outline

1. Motivation

2. OCμ Phase 1 & 2 - Architecture and Self-x Services

3. OCμ Phase 3 - Organic Manager and Automated Planner
   - Monitor
   - Analyze
   - Plan
   - Execute

4. Conclusions
Motivation

- Increasing complexity of distributed systems
  - Ubiquitous embedded systems
  - Cloud Computing

- Self-managing middleware required
  - OC techniques

- Our approach: Middleware with Organic Manager
  - Self-x features
  - 2-level approach
OCµ Phase 1 & 2

- Organic Computing Middleware for Ubiquitous Environments OCµ

- Service-oriented architecture and tool implemented in Java

- Ubiquitous Computing Middleware enhanced by an Organic Manager

- Self-x algorithms developed as separate services
  - Self-optimization (human hormone system)
  - Self-configuration (cooperating social groups)
  - Self-protection (immune system)
  - Self-healing (Automated Planner for recovery)
OCµ Phase 1 & 2

- Conflicts between single Self-x services
  - Services influence each other

- No synergy between Self-x techniques used
  - Need similar data
  - Use same actions

- Automated planning
  - Very promising
  - Speed needs to be improved
OCµ Phase 3

- New architecture
  - Targeting Self-management of services in an open distributed system

- Organic Manager implements MAPE cycle

- Automated Planner
  - Self-configuration
  - Self-optimization
  - Self-healing
  - Start, stop, relocate services

- Reflex Manager
OCµ Architecture

Basic Services
Application Services
Transport Connector
JXTA Transport Connector

Event Dispatcher
Incoming Monitor Queue
Outgoing Monitor Queue

Transport Connector
JXTA Transport Connector

Service Interface
Connector Service

Organic Manager
Execute
Plan
Monitor
Analyze

Actuator
Planner Manager
High-Level Planner
Planner Base

Reflex Manager
Reflex Base

Information Pool Manager
Information Pool

Event Manager
Fact Base

User-Defined Objectives

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OCμ Architecture

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**Basic Services**
- Service Interface
- Event Dispatcher
- Event Messages
- Transport Connector
- JXTA Transport Connector

**Application Services**
- Connector Service
- Information Pool
- Information Pool Manager

**Organic Manager**
- Execute
  - Actuator
- Plan
  - Planner Manager
  - High-Level Planner
  - Planner Base
- Monitor
  - Reflex Manager
  - Reflex Base
- Analyze
  - Event Manager
  - Fact Base

User-Defined Objectives

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OCµ Architecture

SuOC

Event Dispatcher

- Incoming Monitor Queue
- Outgoing Monitor Queue

Transport Connector

- JXTA Transport Connector

Basic Services

- Service Interface

Application Services

- Connector Service

Organic Manager

- Execute
  - Actuator
  - Planner Manager
  - High-Level Planner
  - Planner Base

- Plan
  - Reflex Base
  - Reflex Manager

- Monitor
  - Information Pool Manager
  - Information Pool

- Analyze
  - Event Manager
  - Fact Base

User-Defined Objectives

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Monitor and Analyze

- Piggy-back of node information on application messages
- Store information in Information Pool
- Extract important information
- Aggregate and analyze information
Plan and Execute

- Online planning by Automated Planner
- Fast reaction by Reflex Manager
- Actuator
  - Execute plans
  - Handles conflicting plans
### Planning Models

- **Planner Language**: PDDL (M. Ghallab, 1998)
- **Planning round**

<table>
<thead>
<tr>
<th></th>
<th>Boolean Model</th>
<th>Numeric Model</th>
</tr>
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<tbody>
<tr>
<td><strong>values</strong></td>
<td>only boolean</td>
<td>also numeric</td>
</tr>
<tr>
<td><strong>start</strong></td>
<td>one instance / round</td>
<td>arbitrary instances / round</td>
</tr>
<tr>
<td><strong>complexity</strong></td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td><strong>rounds needed</strong></td>
<td>many</td>
<td>often only one</td>
</tr>
</tbody>
</table>
Self-Optimization Evaluation

- 10 nodes
- Start n services on one node
- Time until services are distributed and no relocation happens anymore
Reuse of plans for similar states
  ▶ Metric on states
  ▶ Two proposed metrics

Conflicting plans of Reflex and Planner Manager
  ▶ Switching plans if possible
Conflicting Plans

Three cases:

1. Reflex Manager has no plan
2. Reflex Manager was first and the plan is already executed
3. Reflex Manager was first and the plan is partly executed
Possibilities for Conflicting Plans

- Plan R of Reflex Manager already executed
  - Roll back and execute plan P - not applicable
    - Store plan P in Reflex Base if necessary for future use

- Plan R of Reflex Manager partly executed
  - Stop further execution by Actuator
    - Compare plans
    - Switch to plan P if possible
Comparing Plans

IF \((r_1 = p_1, \ldots, r_n = p_n)\)
OR (Actions mixed AND Order of actions unimportant)
THEN: switch from plan R to plan P
ELSE: complete execution of plan R
Conclusion and State of Project

- New OCμ architecture developed
- Two-level approach for Organic Manager
- Automated Planner to realize self-x
- Concept
  - Reflex Manager for fast reactions
  - Actuator handles conflicting plans
- Already implemented in OCμ:
  - Basic Middleware
  - Automated Planner with two planning models
Future Work

- Data distribution / analyze / aggregation techniques
- Optimize and implement Reflex Manager
- Adapt Actuator to new architecture
- Evaluation of complete new architecture
- OCµ applied in OC Trust project
  - Energy grid
  - Computing grid
Publications

Outcome of Phase 1 & 2

- 24 publications
- 3 dissertations

Publications concerning new architecture

- **Organic Computing Middleware for Ubiquitous Environments**
  Michael Roth, Julia Schmitt, Rolf Kiefhaber, Florian Kluge, Theo Ungerer
  Organic Computing — A Paradigm Shift for Complex Systems,
  Springer Verlag Zürich, 2011, pages 339-351

- **Realizing Self-x Properties by an Automated Planner**
  Julia Schmitt, Michael Roth, Rolf Kiefhaber, Florian Kluge, Theo Ungerer
  Poster at the 8th International Conference on Autonomic Computing (ICAC), Karlsruhe, 2011

- **Concept of a Reflex Manager to Enhance the Planner Component of an Autonomic/Organic System**
  Julia Schmitt, Michael Roth, Rolf Kiefhaber, Florian Kluge, Theo Ungerer
  8th International Conference on Autonomic and Trusted Computing (ATC),
  Banff, Canada, 2011, pages 19-30

- **Using an Automated Planner to Control an Organic Middleware**
  Julia Schmitt, Michael Roth, Rolf Kiefhaber, Florian Kluge, Theo Ungerer
  Fifth International Conference on Self-Adaptive and Self-Organizing Systems (SASO),
  Ann Arbor, 2011, accepted for publication