Organic Computing Middleware for Ubiquitous Environments OCμ

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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)

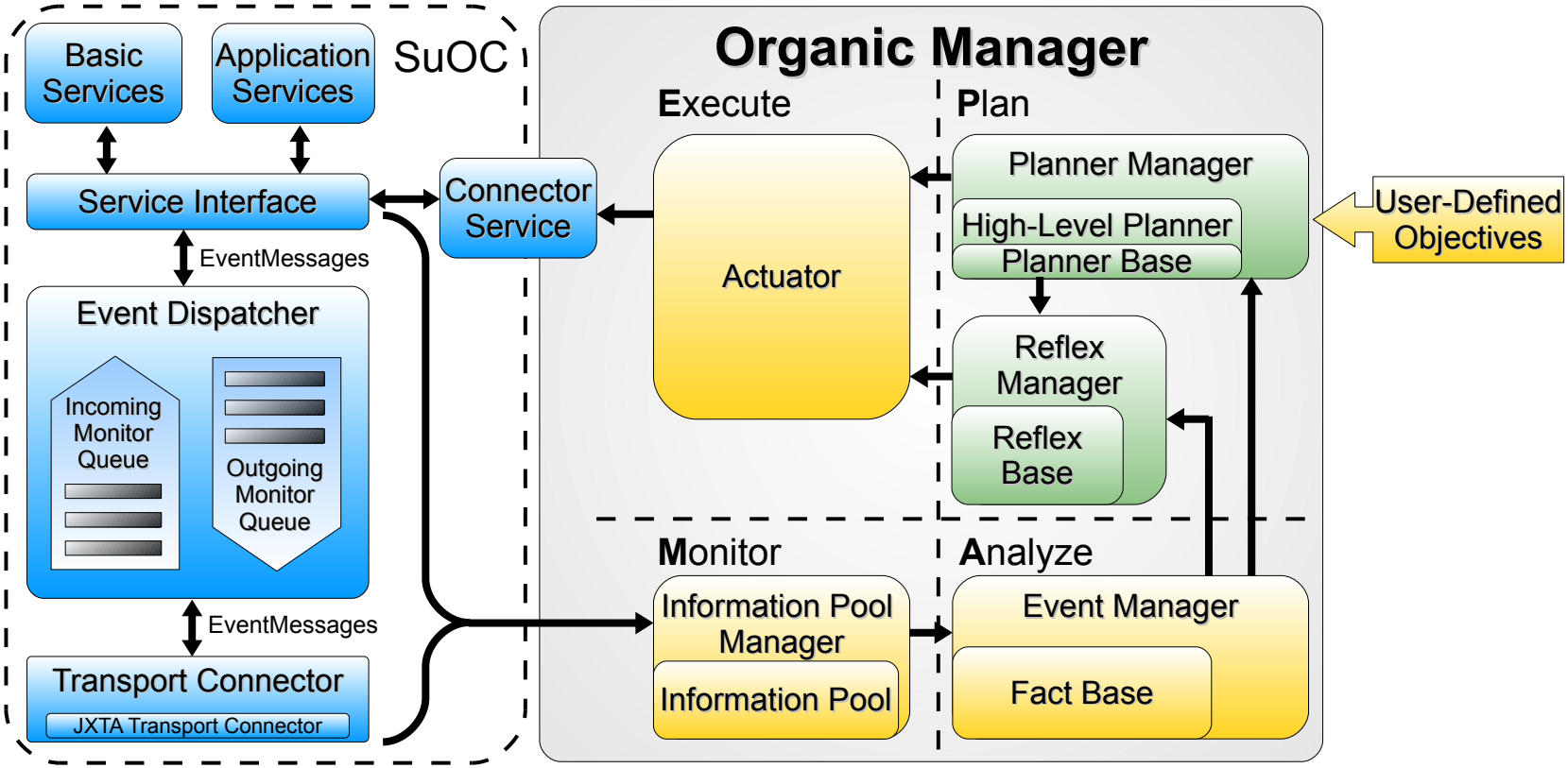
OCμ Phase 1 & 2

- 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

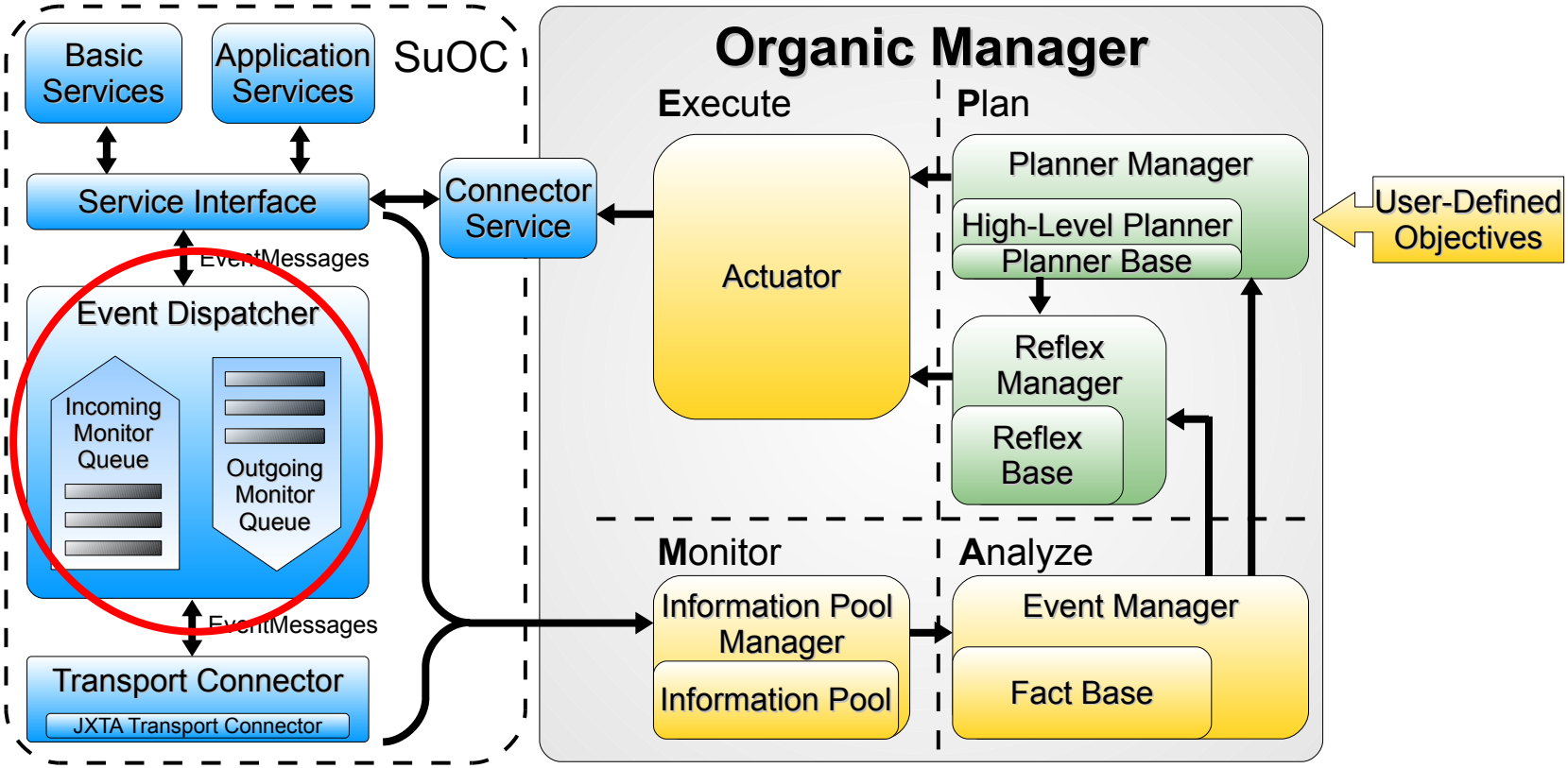
OCμ Phase 3

- 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

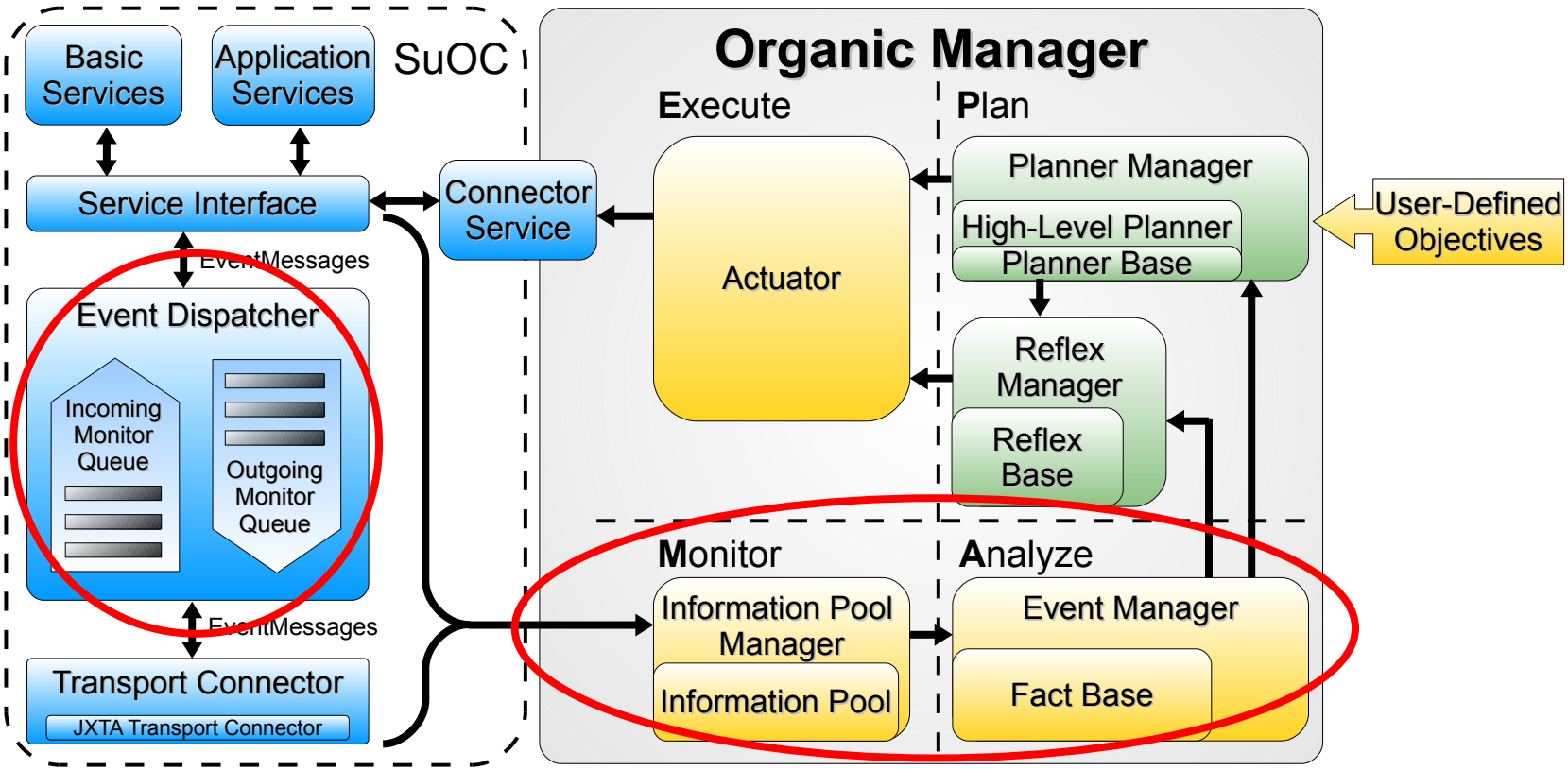
OCμ Architecture



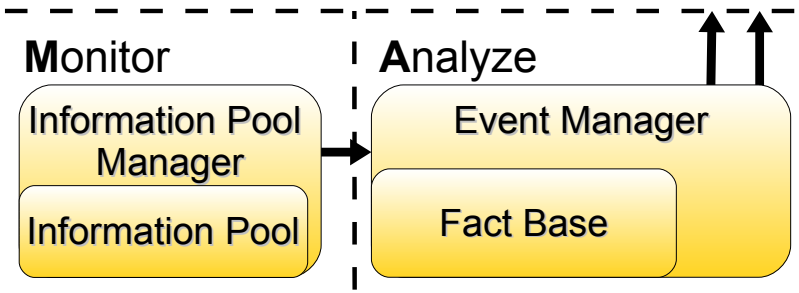
OCμ Architecture



OCμ Architecture

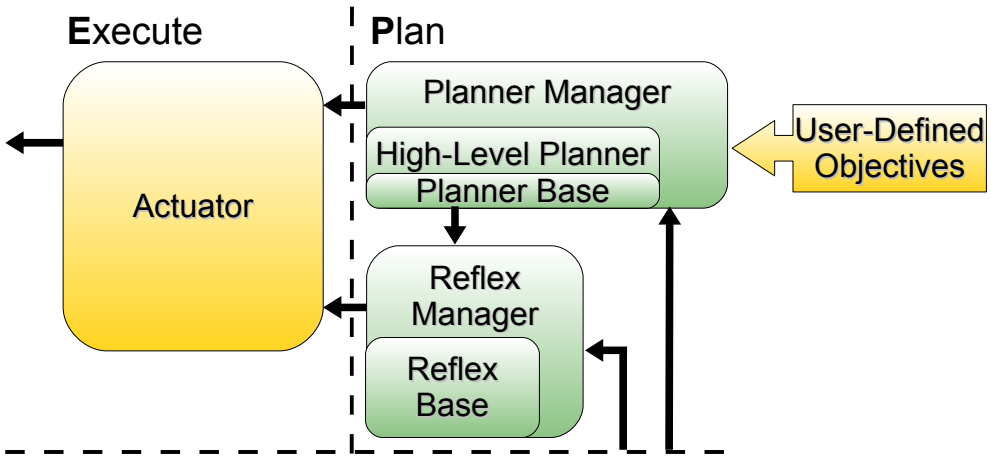


Monitor and Analyze



- 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

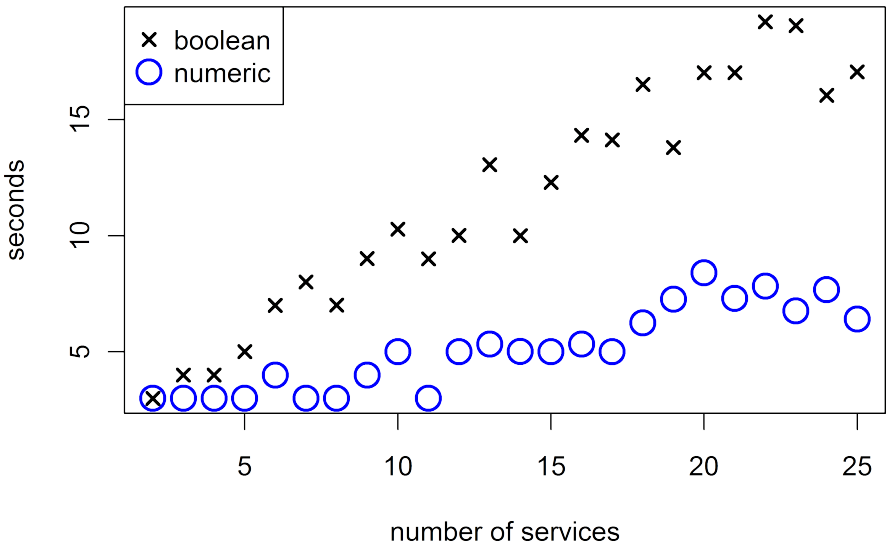
Planning Models

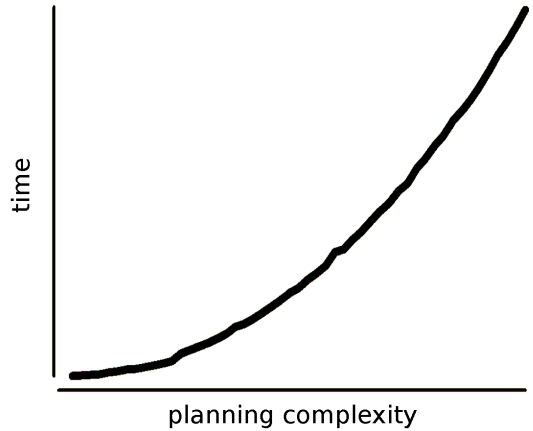
- Planner Language: PDDL (M. Ghallab, 1998)
- Planning round

	Boolean Model	Numeric Model
values	only boolean	also numeric
start	one instance / round	arbitrary instances / round
complexity	low	high
rounds needed	many	often only one

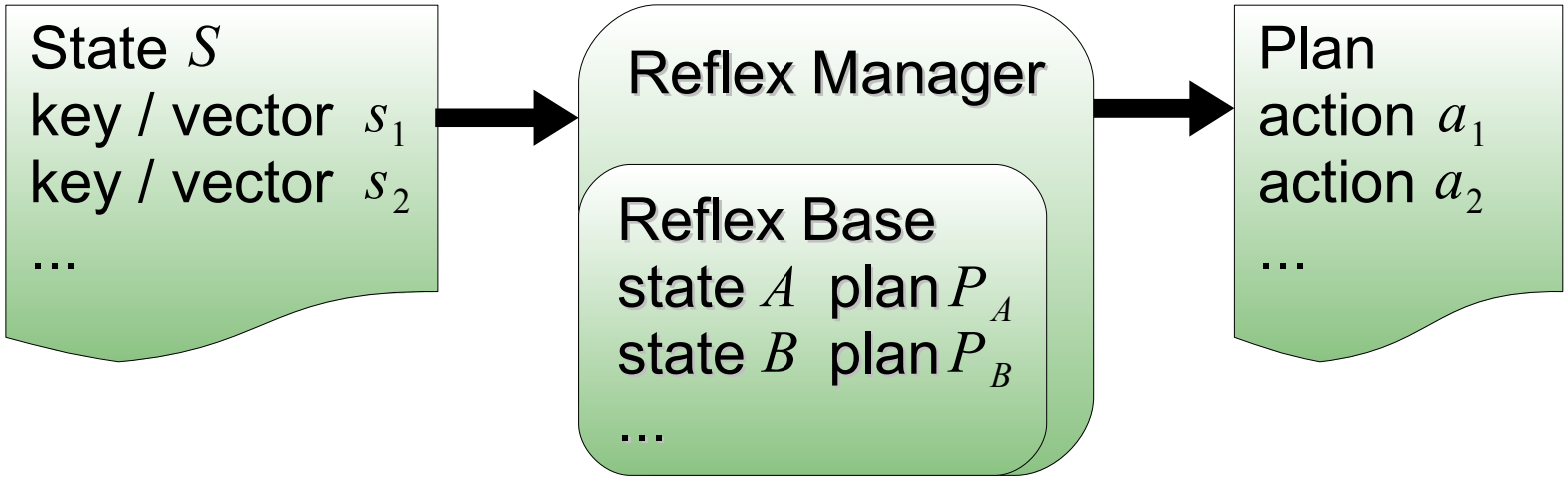
Self-Optimization Evaluation

- 10 nodes
- Start n services on one node
- Time until services are distributed and no relocation happens anymore



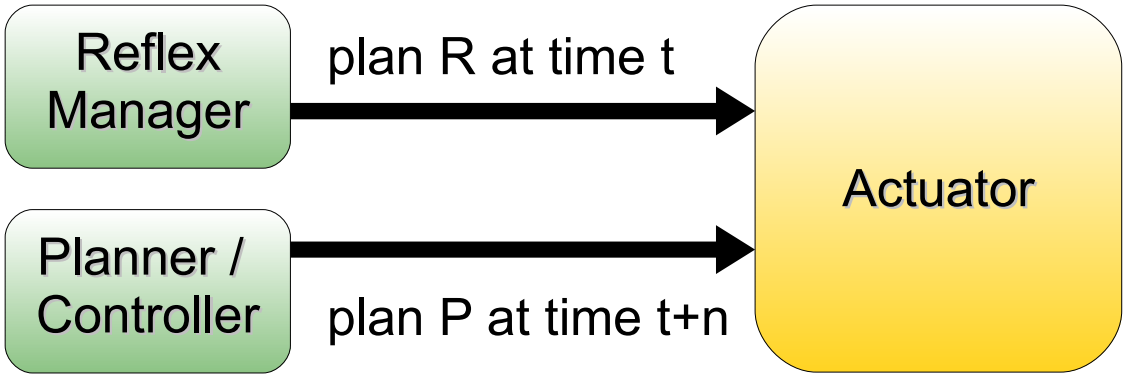


Reflex Manager



- 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



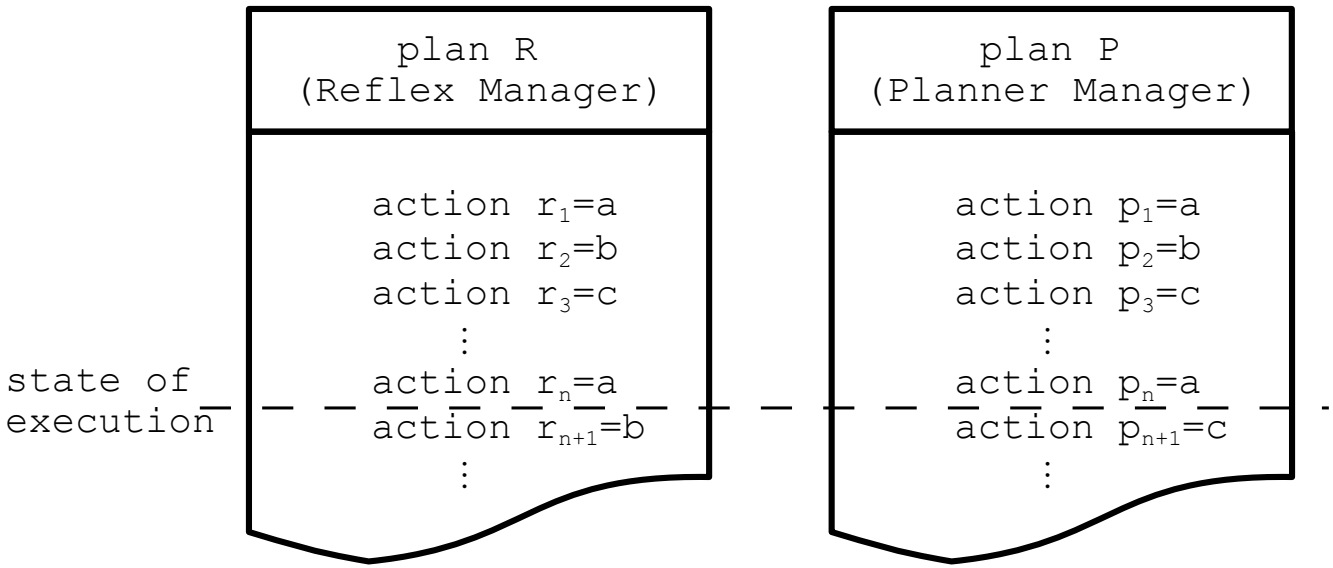
Three cases:

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