Semantic Web Technology as a Basis for Planning and Scheduling Systems

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Mission Planning

- Crisis Management Support: THW missions at River Oder and Danube
- Size and complexity demand for system support for strategic decision support, for training, etc.
- Application properties:
  - Incomplete, mostly procedural knowledge
  - Resource usage mission critical: time, personnel...

Requirements

Planning and scheduling software systems in mission critical applications should feature:

- Declarative, automated system configuration and verification
  - ...for deployment and maintenance
- Scalability, including transparency with respect to system distribution, access mechanisms, concurrency, etc.
  - ...for computational power on demand, ubiquitousness
- Standards compliance
  - ...for interfacing services and environments, re-use of libraries and 3rd-party components, etc.

A Formal Framework

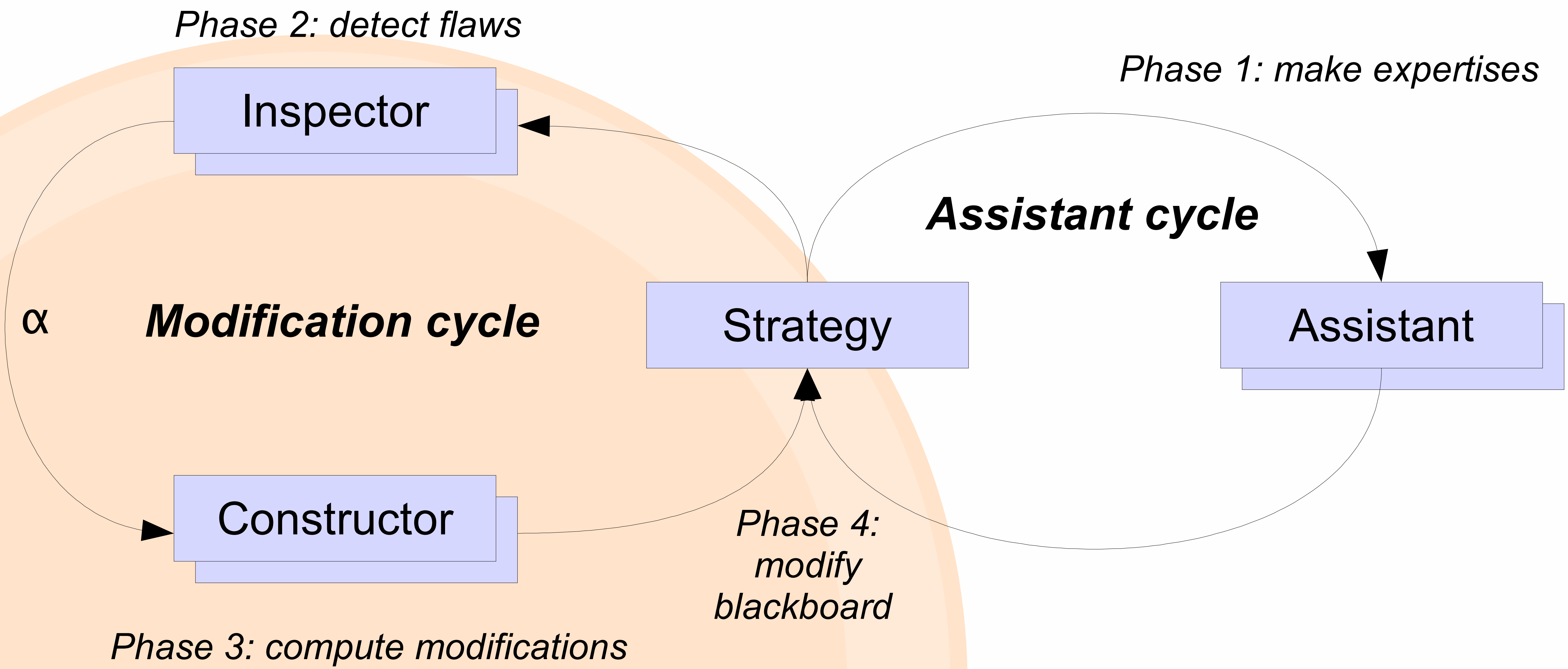
The *Panda* approach performs hybrid planning: HTN combined with POCL planning

- Action representation: primitive and complex tasks $t(\bar{\tau}) = (prec(t(\bar{\tau})), add(t(\bar{\tau})), del(t(\bar{\tau})))$
- Plans and task networks $(TE, \prec, VC, CL)$
- Methods relate complex tasks and task networks: Implementations $m = (t(\bar{\tau}), d)$
- Problem specification $(d, T, M, s_{init}, s_{goal})$
- Solution criteria: plan obtained form d by *plan refinements* and primitive, constraint sets consistent, and causal support complete and un-threatened

Planning by Refinement

- Flaws: explicit representation of solution criteria violations and deficiencies in the plan
  - E.g.: causal threat $(\texttt{Threat}, \{\langle \mathsf{te_i}, \phi, \mathsf{te_j} \rangle, \mathsf{te_k}\})$
- Modifications: explicit representation of plan refinement steps - elementary additions and deletions
  - E.g.: adding an ordering constraint $(\texttt{AddOrdConstr}, \{\oplus(\mathsf{te_i} \prec \mathsf{te_j})\})$
- Modification triggering function: which modification class addresses which flaw class, e.g. $\alpha(\mathcal{F}_{\texttt{Threat}}) = \mathcal{M}_{\texttt{ExpandTask}} \cup \mathcal{M}_{\texttt{AddOrdConstr}} \cup \mathcal{M}_{\texttt{AddVarConstr}}$

The Planning Process



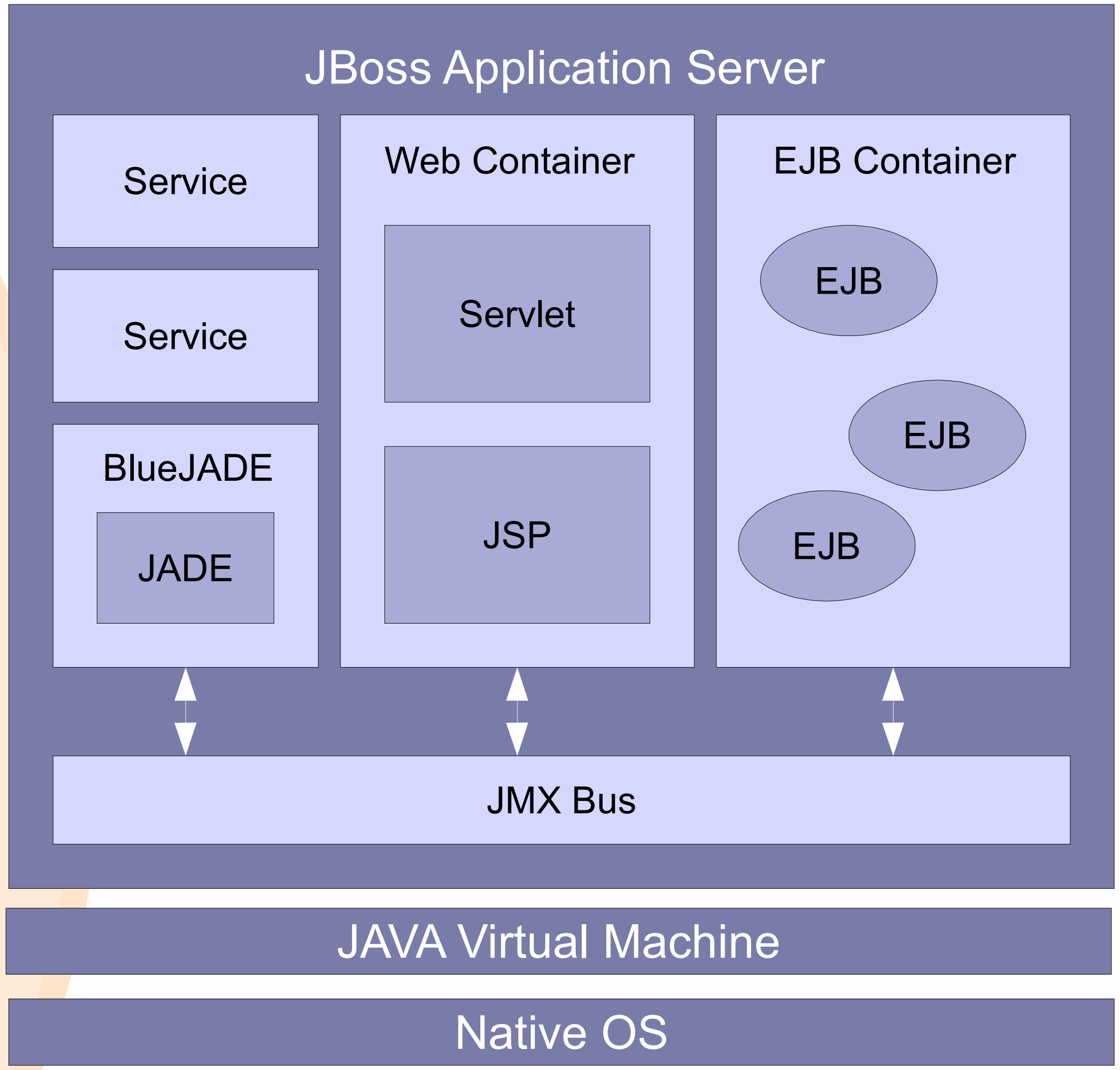
- Planning Strategy
  - Selects modifications for execution and plans
  - Independent from Inspectors and Constructors

The Architecture

- Modules should be flexibly configurable and robust
  - ➡ Agent technology: BlueJADE
- System should be transparently scalable
  - ➡ Application server middleware: JBoss
- System configuration and „verification“
  - ➡ Semantic web ontologies and reasoning facilities: DAML and RACER
- Components should be standards compliant
  - ➡ FIPA, J2EE, and W3C

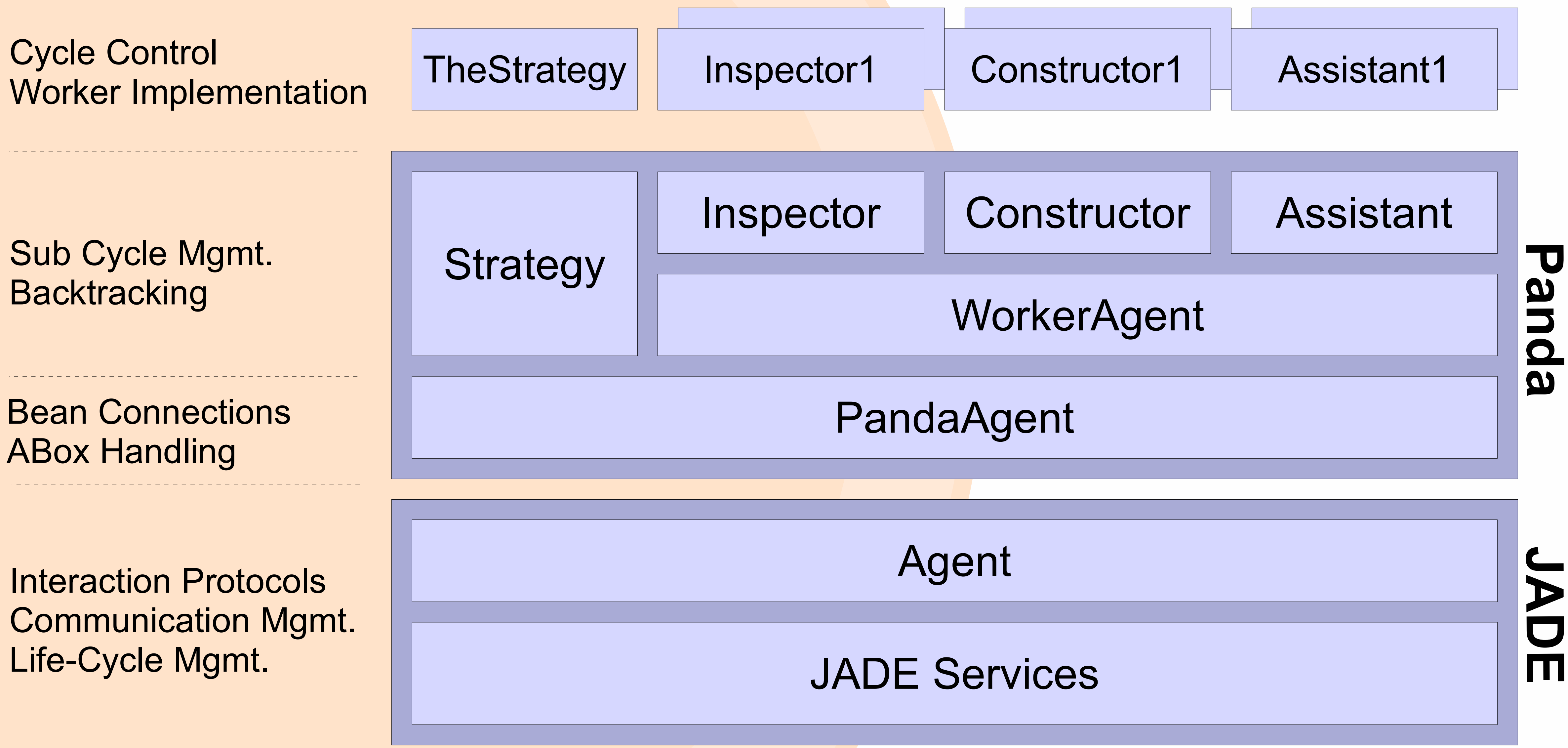
Middleware Components

- Application server *JBoss* delivers
  - Location transparency
  - Scalability transparency
  - Access transparency
  - Handles concurrency
  - Provides messaging service, etc.
- Integrates *BlueJADE* multi-agent framework as a service



Multi-Agent Support

- BlueJade: putting a MAS under J2EE control
  - Agent distribution, remote access, etc.



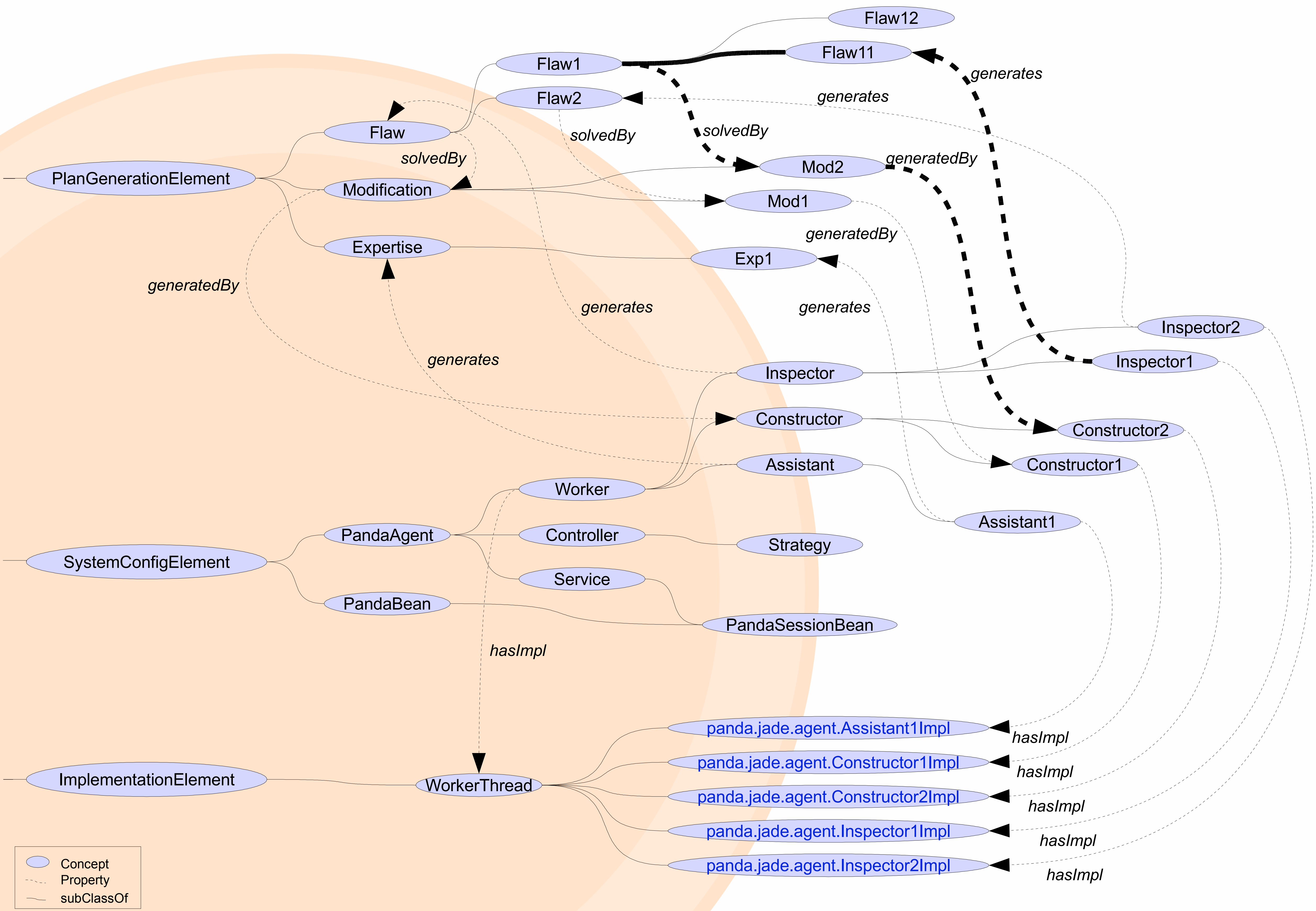
Lingua Franca: DAML

- DAML
  - Expressive knowledge representation language
  - Powerful reasoner support available (here: RACER)
  - Suitable content language for FIPA ACL
  - Standardized by the W3C
- Used for *agent communication* and representation of *system configuration knowledge*

System Configuration

- A DAML ontology describes
  - Agents to deploy (Inspectors, Constructors, Assistants, and Strategy)
  - Agent computation products
  - Flaw - Modification relationships
- RACER derives
  - Concrete implementations
  - Inspector - Constructor assignment
  - Missing implementations, unassigned Constructors…

System Configuration Ontology



Conclusions

- Architecture implements a proper formal framework for hybrid planning using standardized middleware and knowledge representation techniques
- The presented approach is a platform for implementing and evaluating planning techniques and strategies that
  - effectively supports distribution and concurrency
  - performs a knowledge-based configuration
  - allows planning process validation by Petri-Net transformation