# *Knowledge Representation for Reconfigurable Automation Systems*

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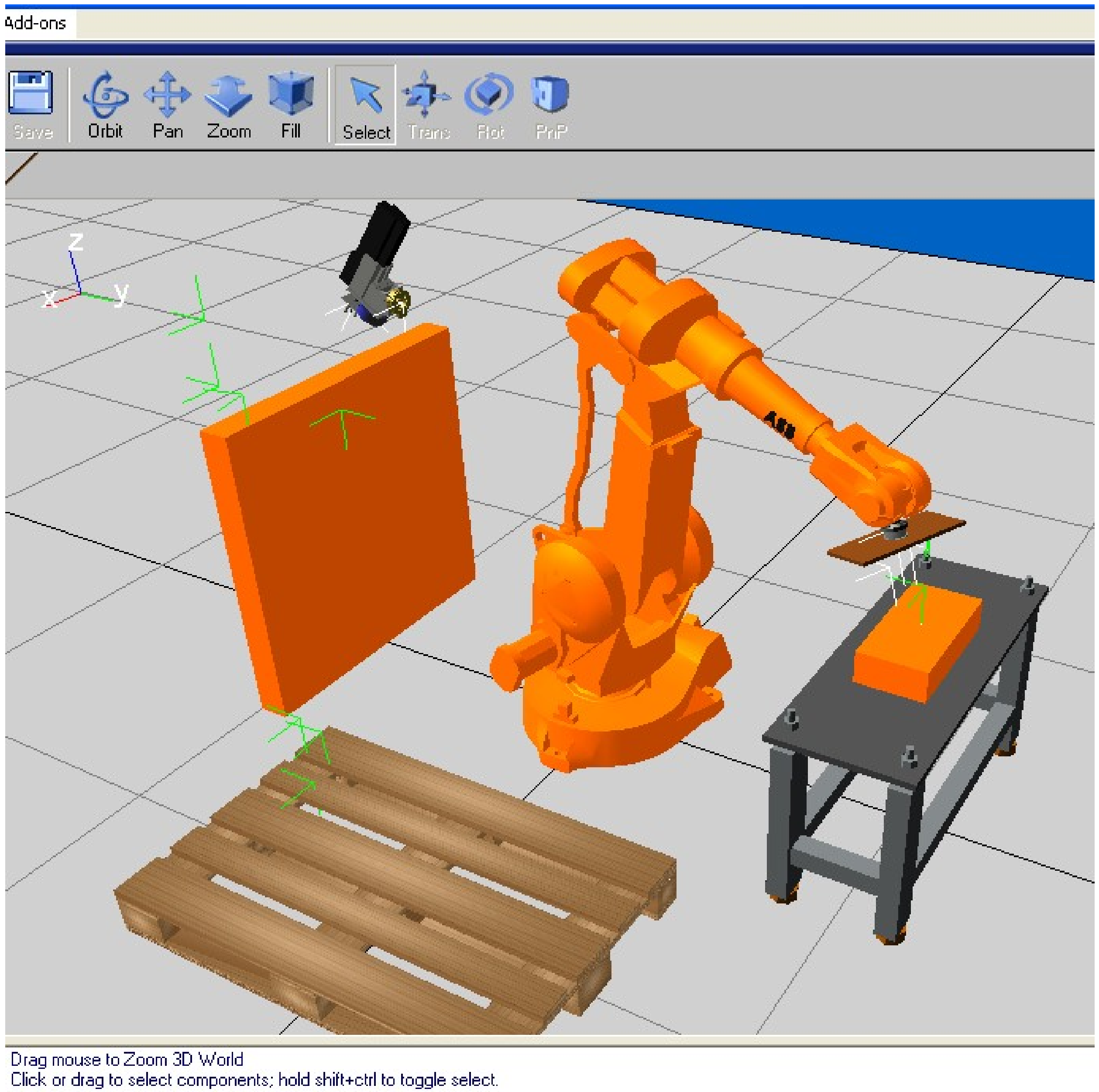
>> SIARAS >>

# *SIARAS*

SIARAS: Skill-Based Inspection and Assembly for Reconfigurable Automation Systems.

Problem: given an existing, feasible task description, change some constraint (e.g., workpiece geometry, or gripping tool, or a quality criterion), and find out whether a reconfiguration is possible, together with a new parametrisation of devices.

Example to the right taken from a simulation of a drilling scenario: simulation tool used here is 3DCreate.



## *Focus of the project: robot-based automation systems*

- Sensor-rich environment

  including intelligent vision sensors, smart cameras, triangulation sensors, ...

- Robots equipped with exchangeable tools

  like grippers, drills, welding guns, ...

- Question: **How to reconfigure** when requirements change**?**

  What knowledge is needed for such analysis?

# *Knowledge required*

In order to speak about (semi)automatic reconfiguration of a production line, one needs knowledge about:

- Tasks actually performed vs. tasks potentially executable
- Devices actually used vs. devices available
- Skills actually exploited vs. skills offered by the devices
- Scheduled operations and their interdependencies
- Configurations used vs. available configurations
- Quality measures and their applicability

# *Reasoning in AI approaches*

In classical AI planning approach, knowledge is usually hand-coded and hardcoded, typically in a logical formalism with a well defined semantics.

However, such model-theoretical semantics is normally too weak to enable efficient reasoning about the system, in particular, to perform effective reconfiguration of a complex, sensor-rich assembly line of today.

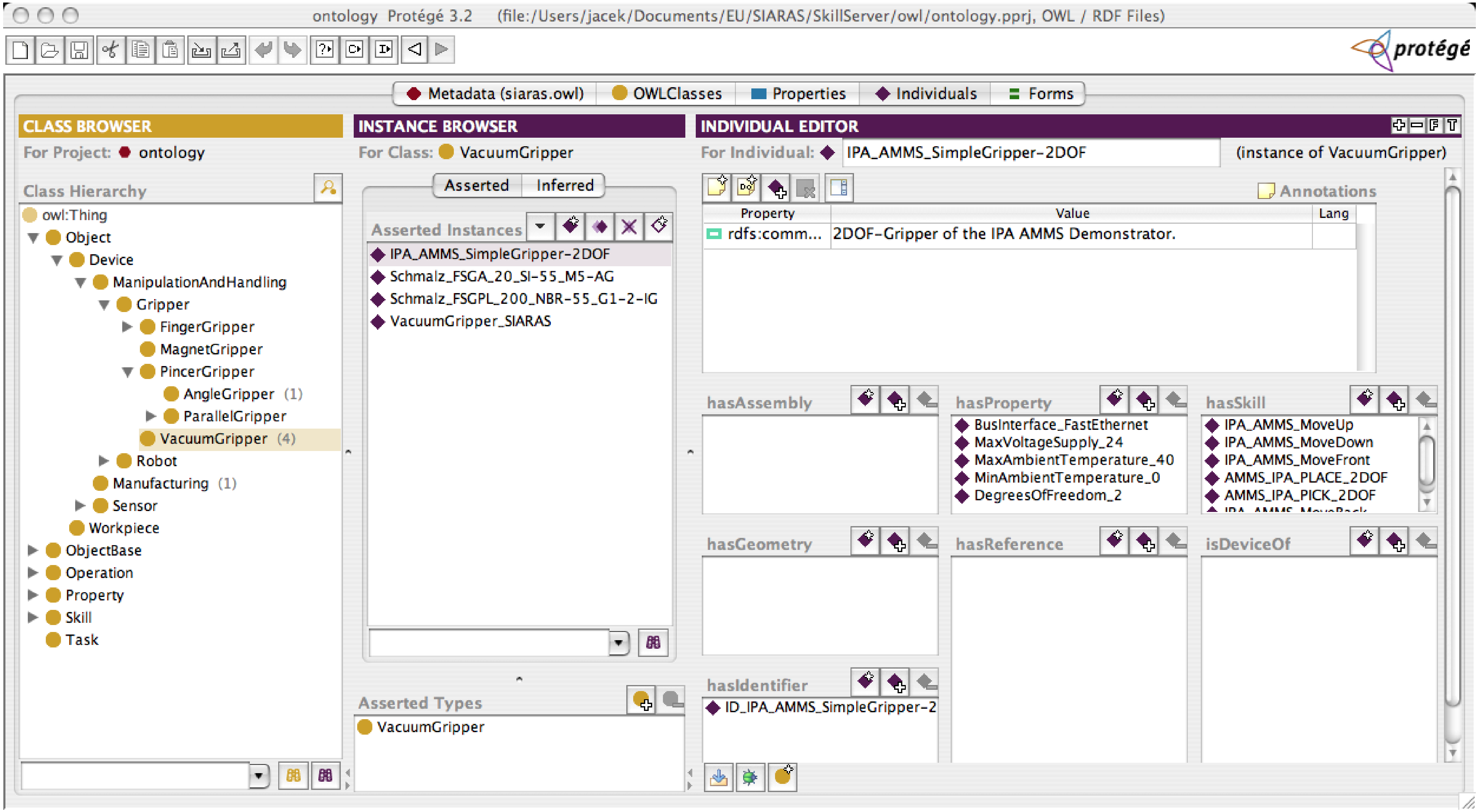
We need much more knowledge about the domain, with models at different levels of granularity, in order to perform in acceptable manner. These models have to be related to each other in a clear, understandable fashion.

# ***Reasoning in SIARAS***

- Simple database/ontology-like querying (Pellet, Racer, SQL)
- Generic reasoning (constraint satisfaction, logic programming)
- Generic optimisation (linear programming, genetic algorithms)
- Domain-specific reasoning (plug-in modules, so called Utility Functions)
- External tools (modelling, simulation, visualisation)

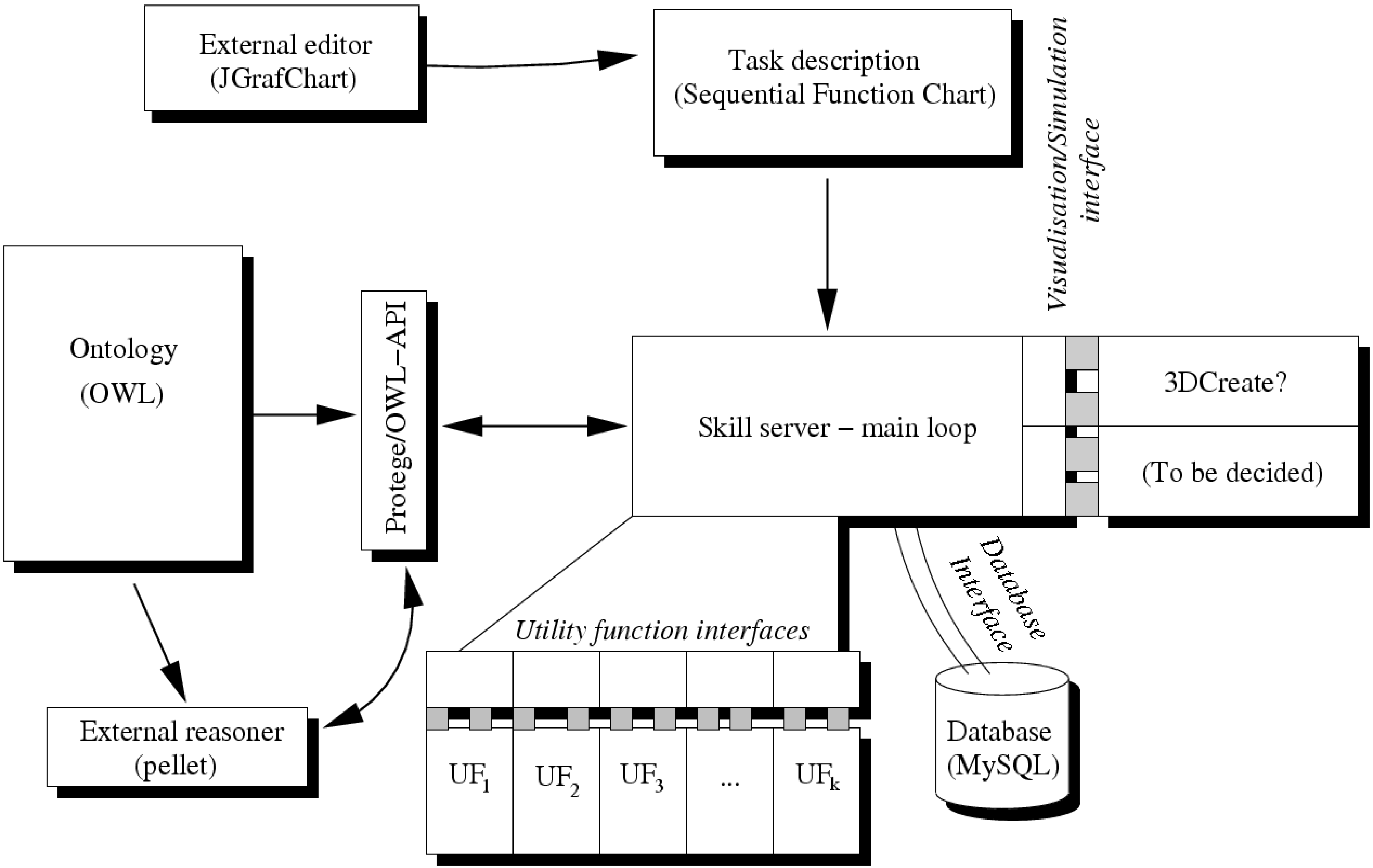
The ***skill server*** coordinates all these listed above.

# Ontology



ontology Protégé 3.2 (file:/Users/jacek/Documents/EU/SIARAS/SkillServer/owl/ontology.pprj, OWL / RDF Files)
protégé
Metadata (siaras.owl)
OWLClasses
Properties
Individuals
Forms
CLASS BROWSER
For Project: ontology
Class Hierarchy
owl:Thing
Object
Device
ManipulationAndHandling
Gripper
FingerGripper
MagnetGripper
PincerGripper
AngleGripper (1)
ParallelGripper
VacuumGripper (4)
Robot
Manufacturing (1)
Sensor
Workpiece
ObjectBase
Operation
Property
Skill
Task
INSTANCE BROWSER
For Class: VacuumGripper
Asserted
Inferred
Asserted Instances
IPA_AMMS_SimpleGripper-2DOF
Schmalz_FSGA_20_SI-55_M5-AG
Schmalz_FSGPL_200_NBR-55_G1-2-IG
VacuumGripper_SIARAS
Asserted Types
VacuumGripper
INDIVIDUAL EDITOR
For Individual: IPA_AMMS_SimpleGripper-2DOF
(instance of VacuumGripper)
Annotations
Property
Value
Lang
rdfs:comm...
2DOF-Gripper of the IPA AMMS Demonstrator.
hasAssembly
hasProperty
BusInterface_FastEthernet
MaxVoltageSupply_24
MaxAmbientTemperature_40
MinAmbientTemperature_0
DegreesOfFreedom_2
hasSkill
IPA_AMMS_MoveUp
IPA_AMMS_MoveDown
IPA_AMMS_MoveFront
AMMS_IPA_PLACE_2DOF
AMMS_IPA_PICK_2DOF
hasGeometry
hasReference
isDeviceOf
hasIdentifier
ID_IPA_AMMS_SimpleGripper-2

# Usage of available semantic information



# *Multiple levels of abstraction*

| **Utility level** | **Show** human/machine | **Eval** check/quality | **Find** all/any/best | **Tune** disc/cont optim. | **Make** device config |
|---|---|---|---|---|---|
| ONT Ontology reasoning | Protege graphics | Protégé | Protégé & Pellet | | |
| FOL First Order Logic | Formal text | **Skill-Server Core** | **Skill-Server Core** | | |
| CLP Constraint&Linear Prog. | Standard graphics | **Skill-Server Core** | JaCoP | Simplex, etc. | Generation of native configuration files and device software |
| DES Discrete Event Systems | 3DVisualize, J3D, etc. | 3DCreate | Rinas | Domain-specific know-how/rules | |
| DAE Diff.Algebraic Equation | Standard graphics | Modelica | Optimica (global) | Optimica (local) | |

## *Conclusions*

Semantic information is necessary to perform complex reconfiguration of sensor-rich, robot-based automation systems.

Large portion of this knowledge is declarative:

- Skill definitions (in ontology),
- Device descriptions (partly in ontology),
- Geometric models,
- Dynamic, behavioural models,
- Information-flow models,
- Simulation modules, ...

Some part needs to be procedural in order to achieve effectiveness.