Towards a Unified Assembly System Design Ontology using Protégé

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Aim and Structure

Develop a Unified Ontology that will enable seamless Collaboration and use of Top-of-its-Class tools within the area of Assembly System Design.

- Motivation
- Related Projects
- Methodology Overview
- Knowledge Representation Approach
- Assembly System Design Ontology
- Application Example
- Conclusions and Future Work

Motivation

- Challenges:
  - Shorter Product Lifecycles
  - Increasing Product Complexity
  - Assembly forms 80% of a Products Manufacturing Cost
- Enabling Factors:
  - Rapid Design and Manufacturing on Demand
  - Integration of all Stakeholders in the Decision Making Process
  - Unified Assembly Domain Ontology

Related Projects

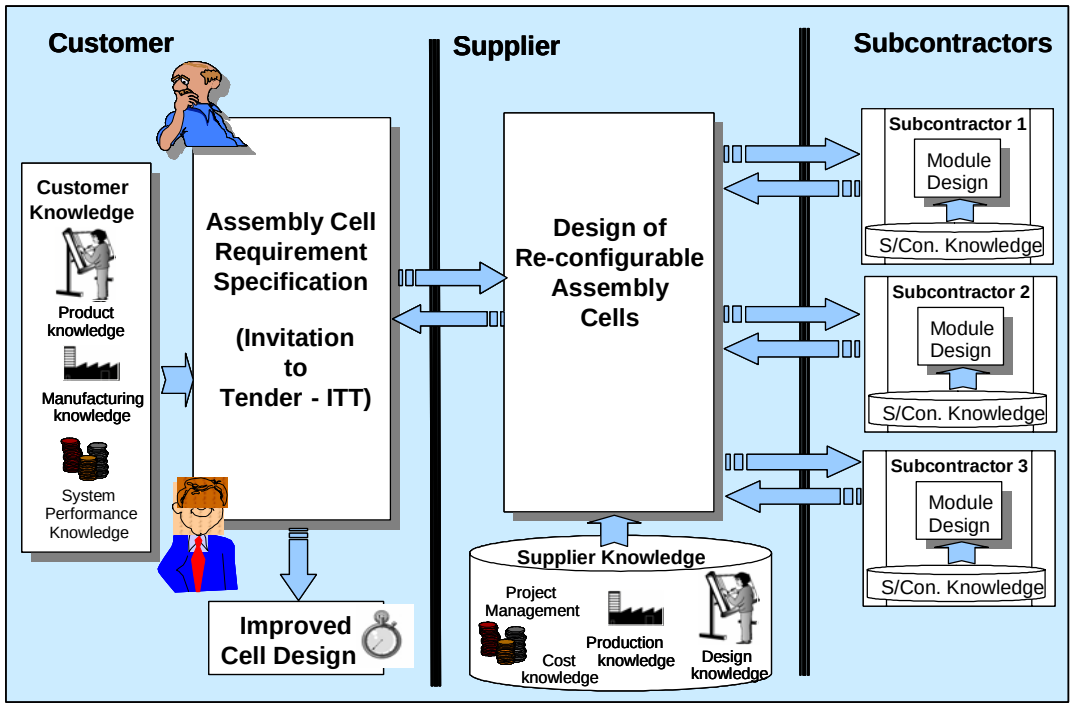
E-Space for Collaborative Design of Reconfigurable Assembly Cells

www.e-race.info

EUREKA Factory
E!2851

AIM

E-RACE aims to develop a collaborative design e-space consisting of integrated methods, tools, knowledge representation models and training materials to support the distributed requirement capture and conceptual design process for manufacture of reconfigurable assembly cells.



KEY INNOVATIONS

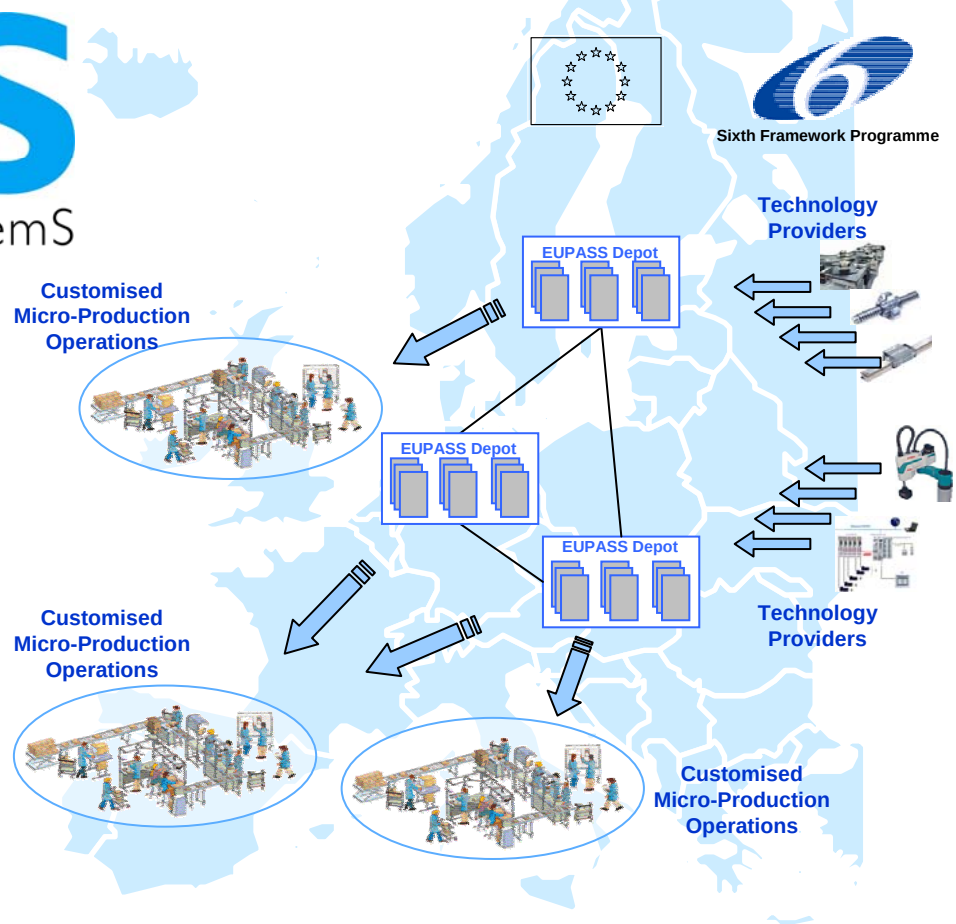
- A **virtual design space** to allow large end users and SME suppliers to collaborate in developing production automation and test systems.
- Overall improvement in equipment specification and response time leading to improved competitiveness of the users and manufacturers involved

CURRENT PARTNERS

UK - TQC Ltd (coordinator), **University of Nottingham**, Southco, Glaxo Smith Kline , British Automation and Robotics Association
Finland – TUT, VTT, Visual Components
Portugal – **Universidade Nova**, Flexcomp
Sweden – **KTH**, FlexLink
Switzerland – EPFL, Mikron

EUPASS

Evolvable Ultra-Precision Assembly SystemS



MISSION STATEMENT

The EUPASS consortium has a mission to facilitate the development, implementation and promotion of affordable, cost effective and sustainable ultra-precision manufacturing solutions by offering rapidly deployable ultra-precision assembly services on demand. This will be achieved by developing and delivering a number of breakthrough technologies and solutions including:

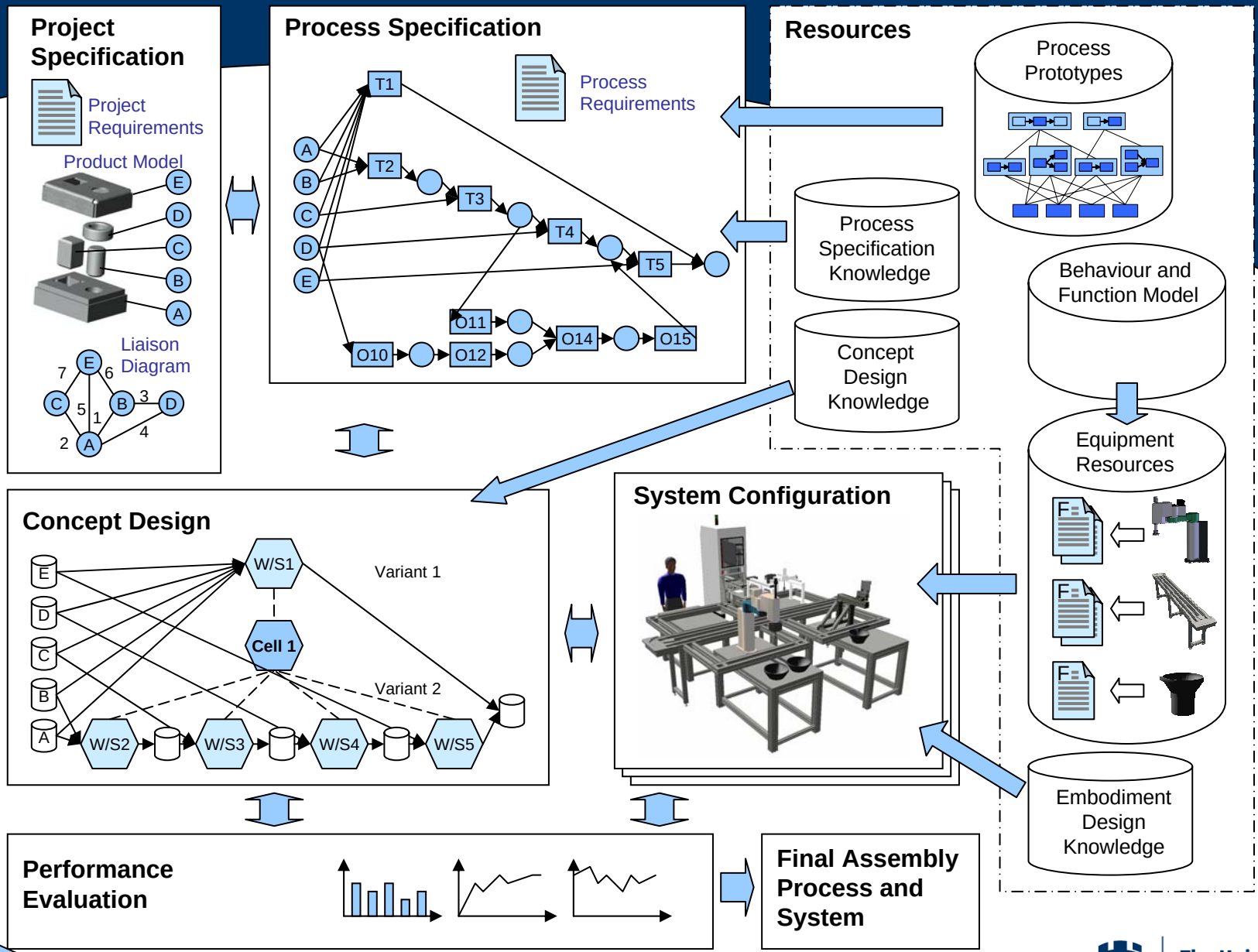
- European wide **pilot infrastructure** of micro-assembly module depots and integration software
- Robust and legacy-compliant knowledge driven **methodology**, **cost models** and **software tools**
- Next **generation ultra-precision enabling technologies** for the realisation of a high-precision assembly cell

PARTICIPANTS

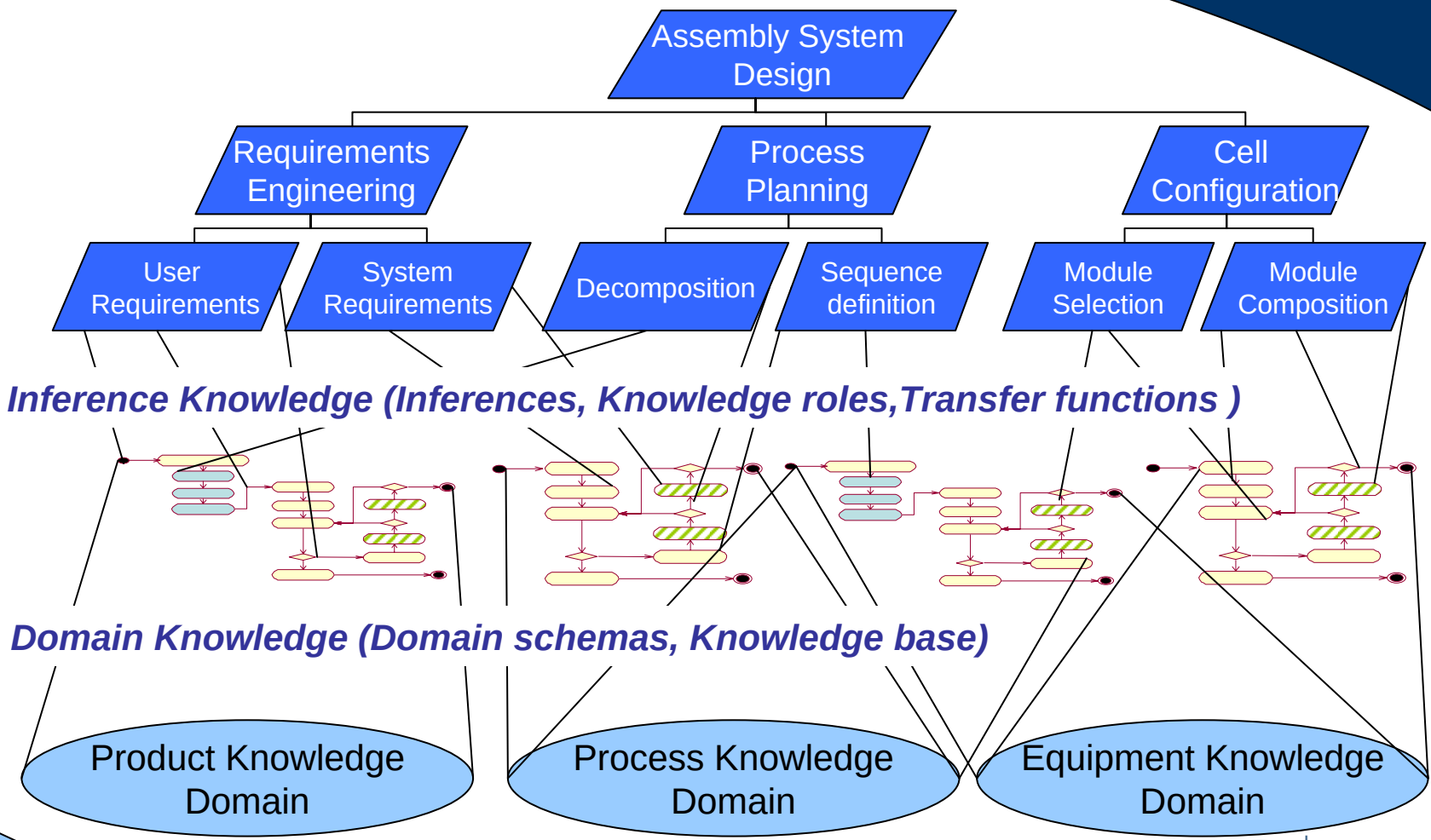
Netherlands - Philips
Germany - Bosch, Festo, Beckhoff, IEF Werner, FZ Karlsruhe
Italy - Electrolux, Masmec, ITIA
Sweden - FlexLink, **KTH**
Switzerland - Feintool Automation AG, FHS Solothurn, EPFL
France - UFC/Besançon
UK - TQC, **University of Nottingham**
Portugal - **Universidade Nova**
Finland - TUT

Methodology Overview

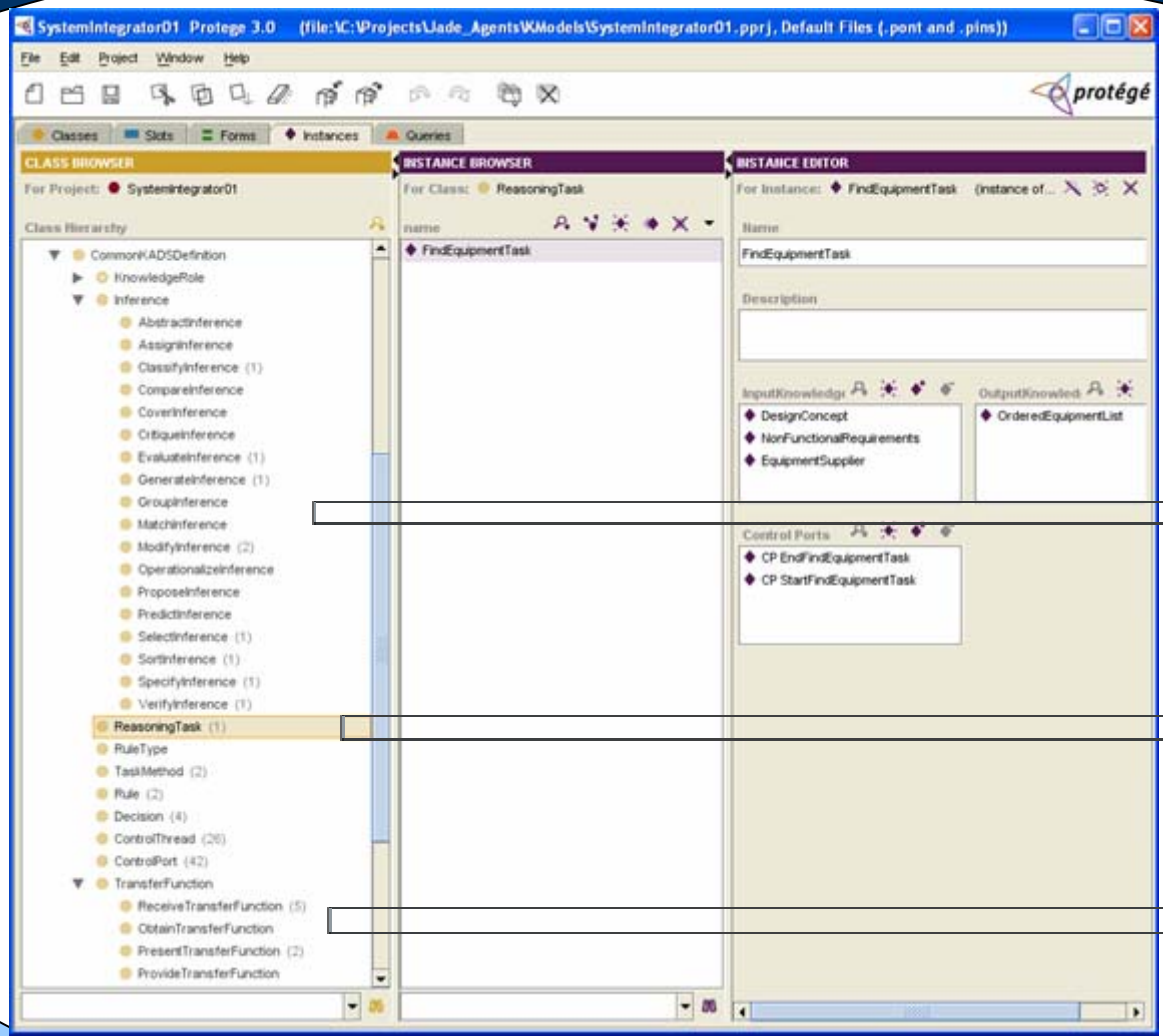
Assembly System Reconfiguration Methodology



CommonKADS Framework



Decision Making Model



Inference Structure

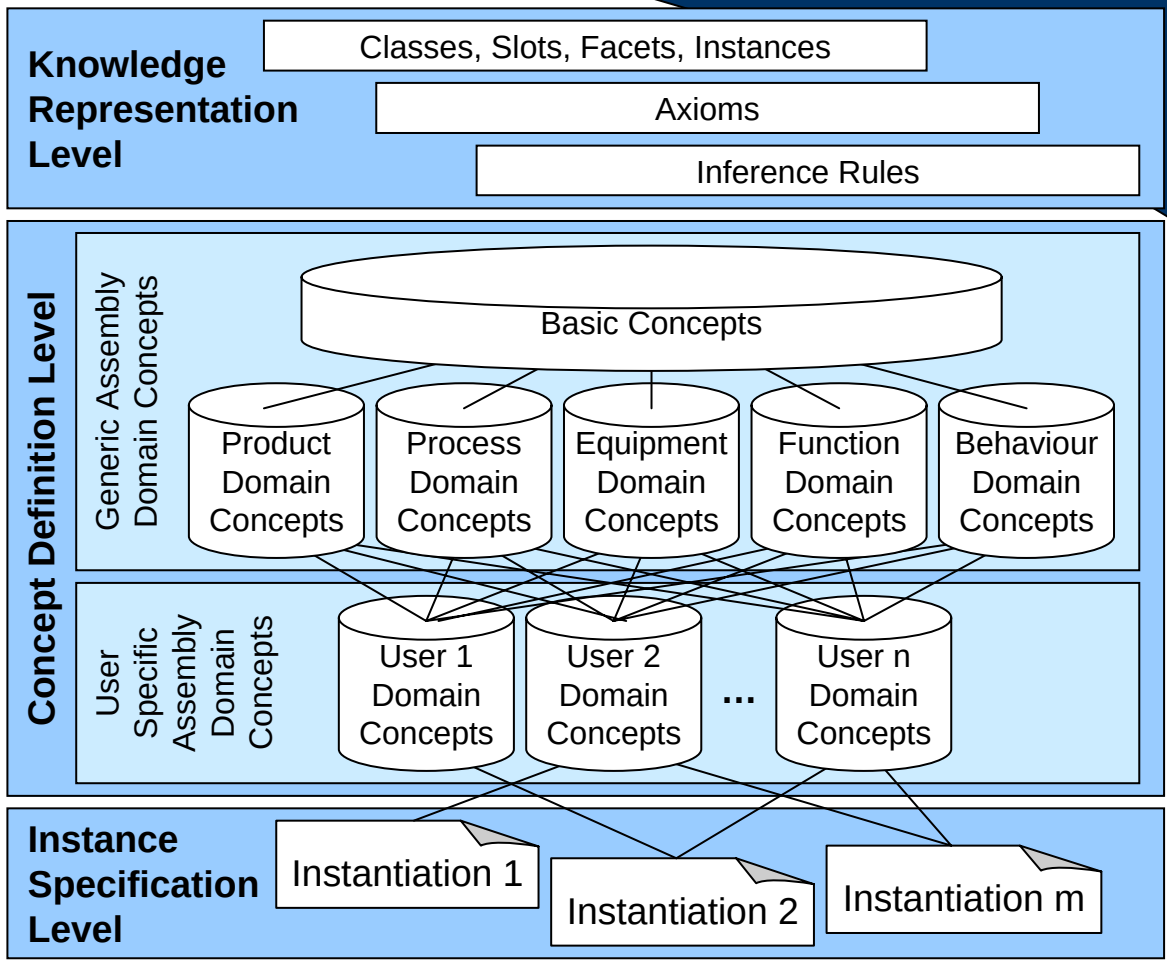
Reasoning Task

Transfer Functions

Ontology Structure

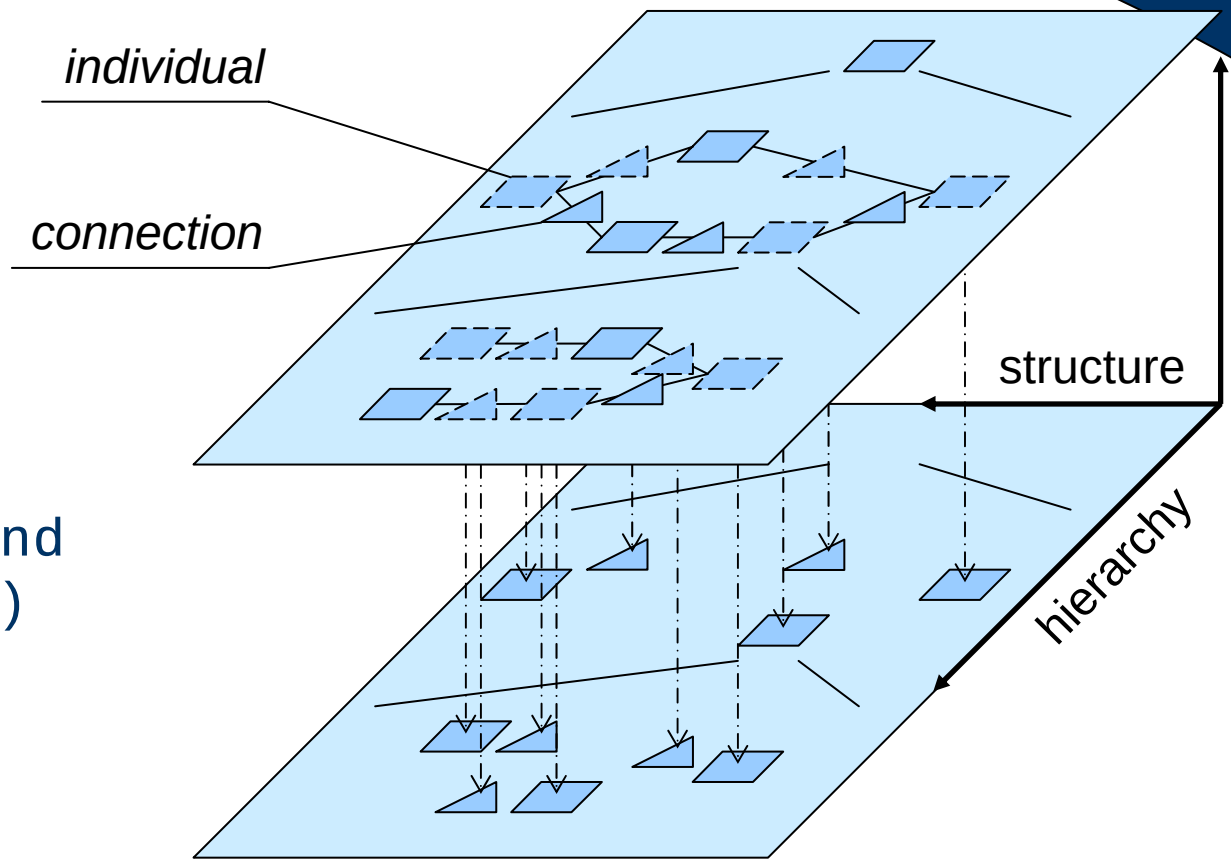
Ontology Structure

- Extendable
- Traceable
- Abstraction
  - Incomplete Definitions
- Multi Disciplinary
- Exchangeable
- Human Readable
- Computer Interpretable
- Information Redundancy



Basic Concept Structure

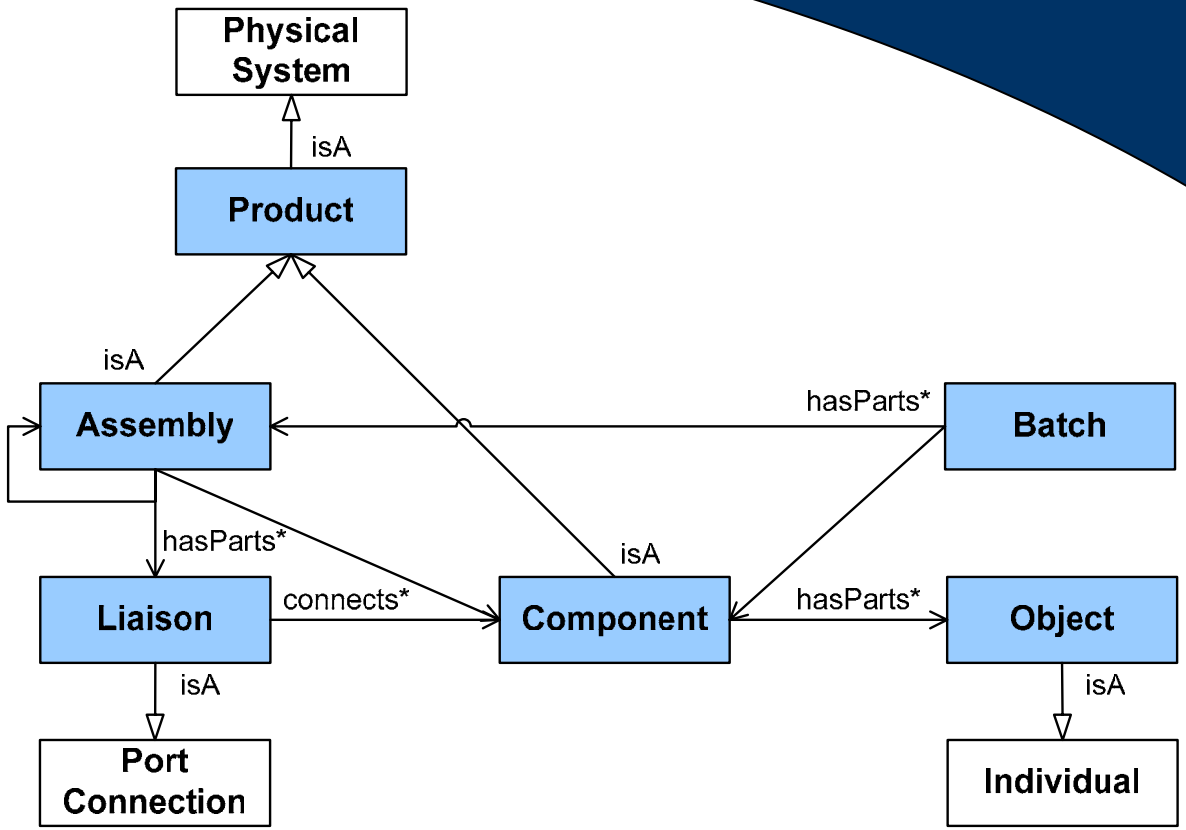
- Mereology
  - Defines the hierarchy
- Topology
  - Defines the structure
- Taxonomy
  - Defines the classification (abstraction and generalisation)



Domain Concept Models

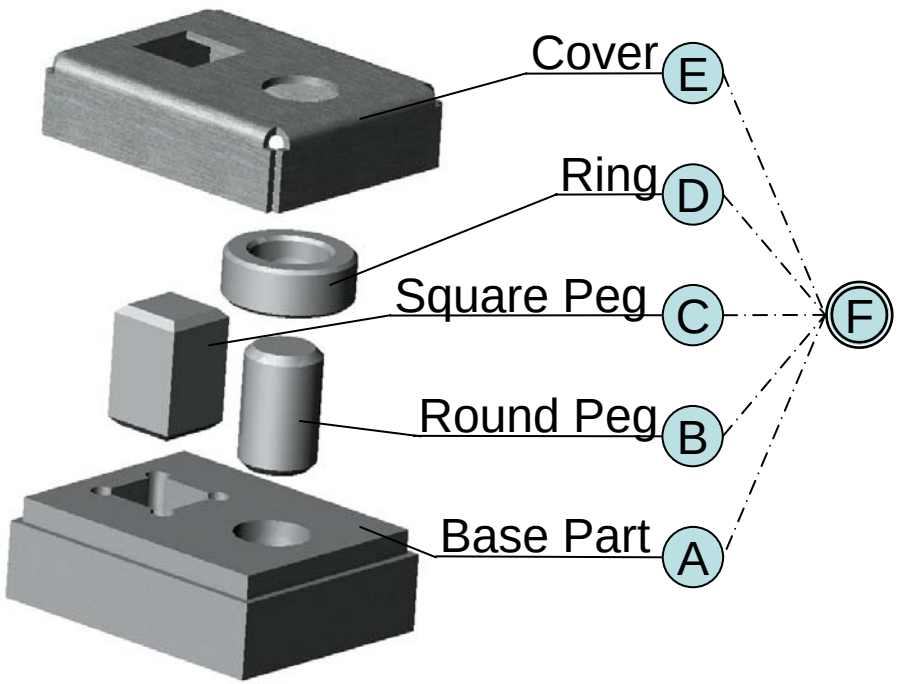
Product Domain Concepts

- Spatial Structure
- Logical Structure
  - Hierarchy
  - Liaisons
- Assembly Characteristics
- Process History
- Design Status

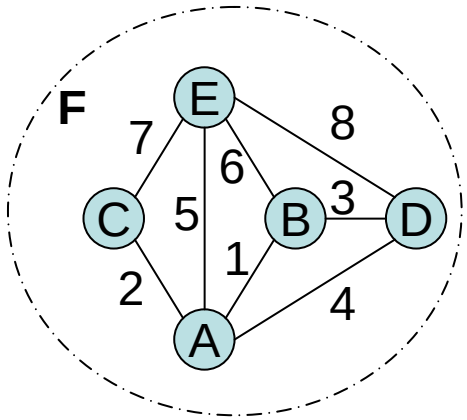


Example: Simple Assembly

Logical Structure

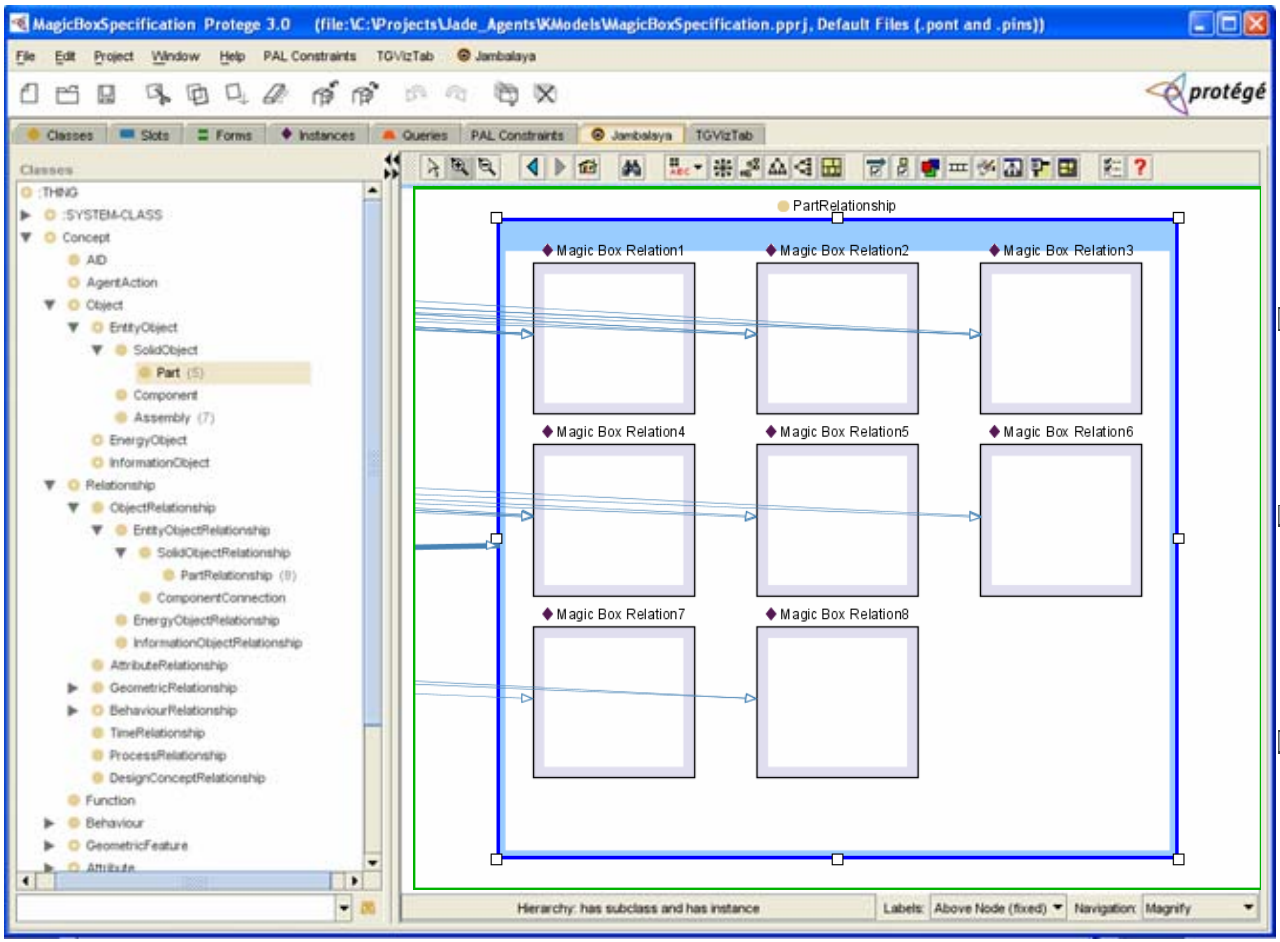


Spatial Structure



1 = <LooseFit> and contact between A and B
2 = <LooseFit> and contact between A and C
3 = <LooseFit> between B and D
4 = <Contact> between A and D
5 = <TightFit> and contact between E and A
6 = <LooseFit> between E and B
7 = <LooseFit> between E and C
8 = <Contact> between E and D

Product Domain Concept



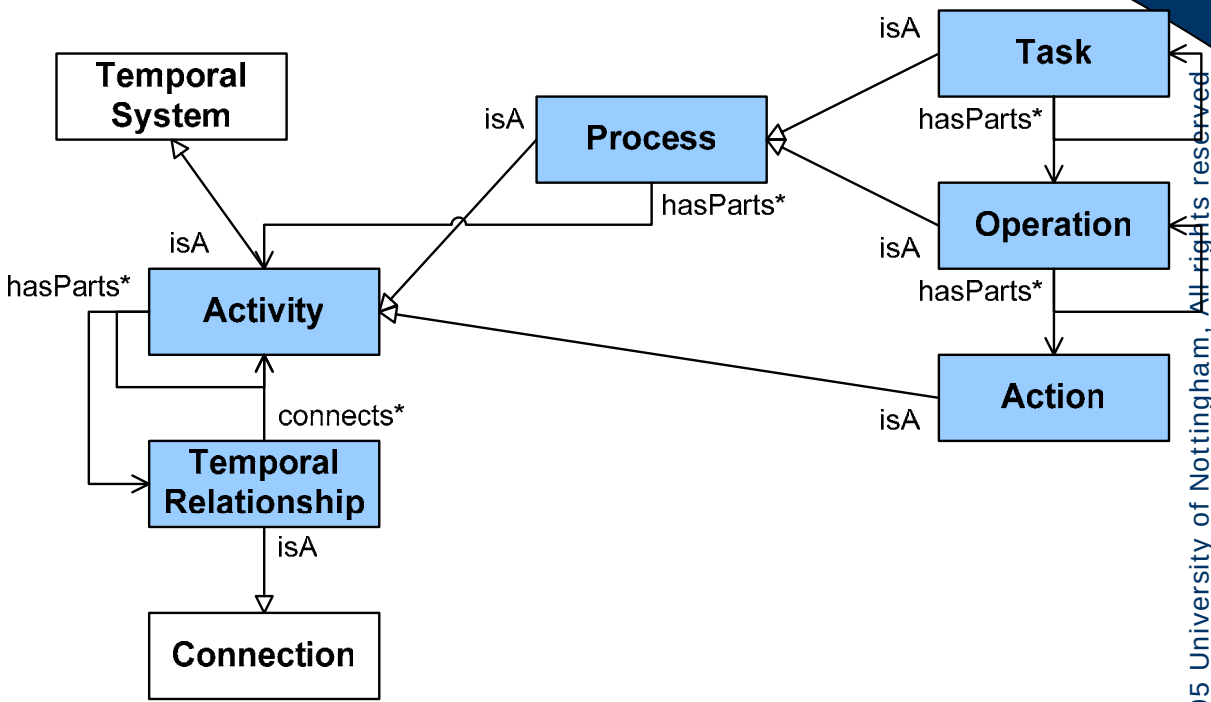
Parts Structure

Assembly Structure

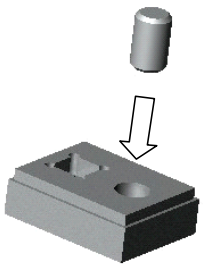
Liaisons Structure

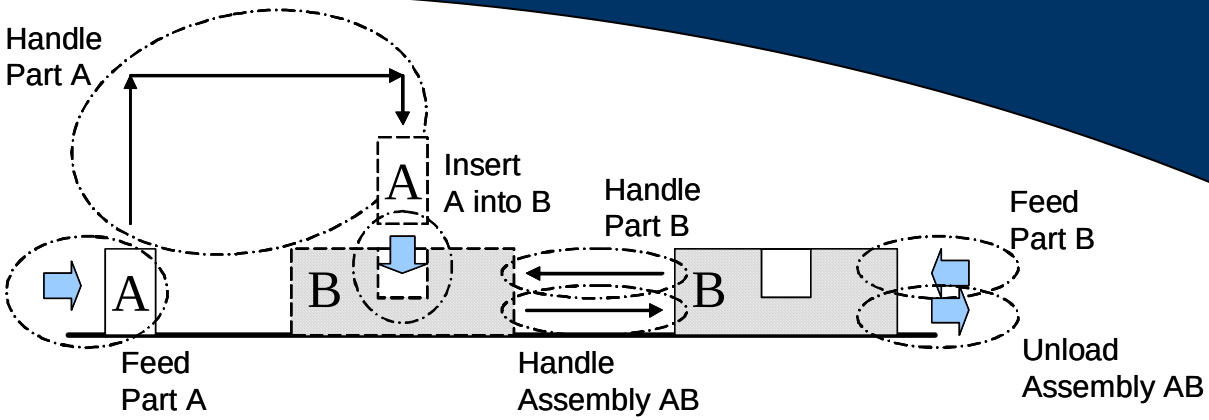
Assembly Process Domain Concepts

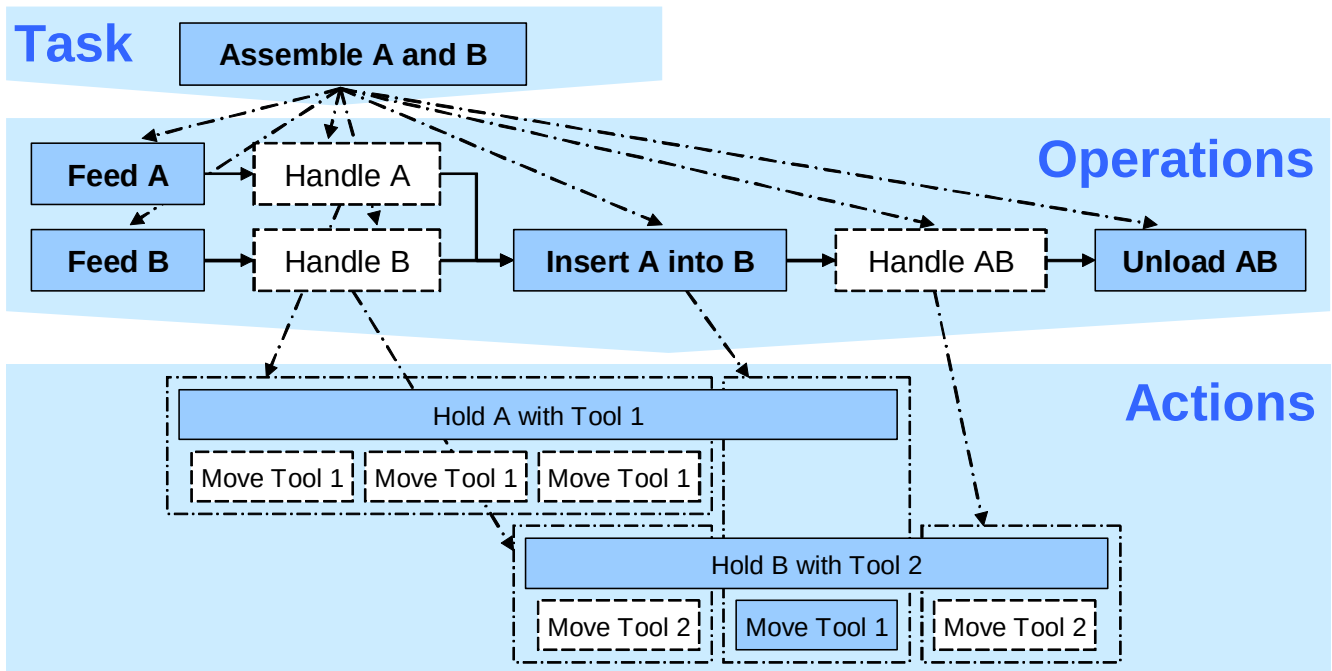
- Temporal Structure
  - Sequences
  - Parallelism
  - Loops
- Logical Structure
  - Hierarchy
  - Alternative Decompositions



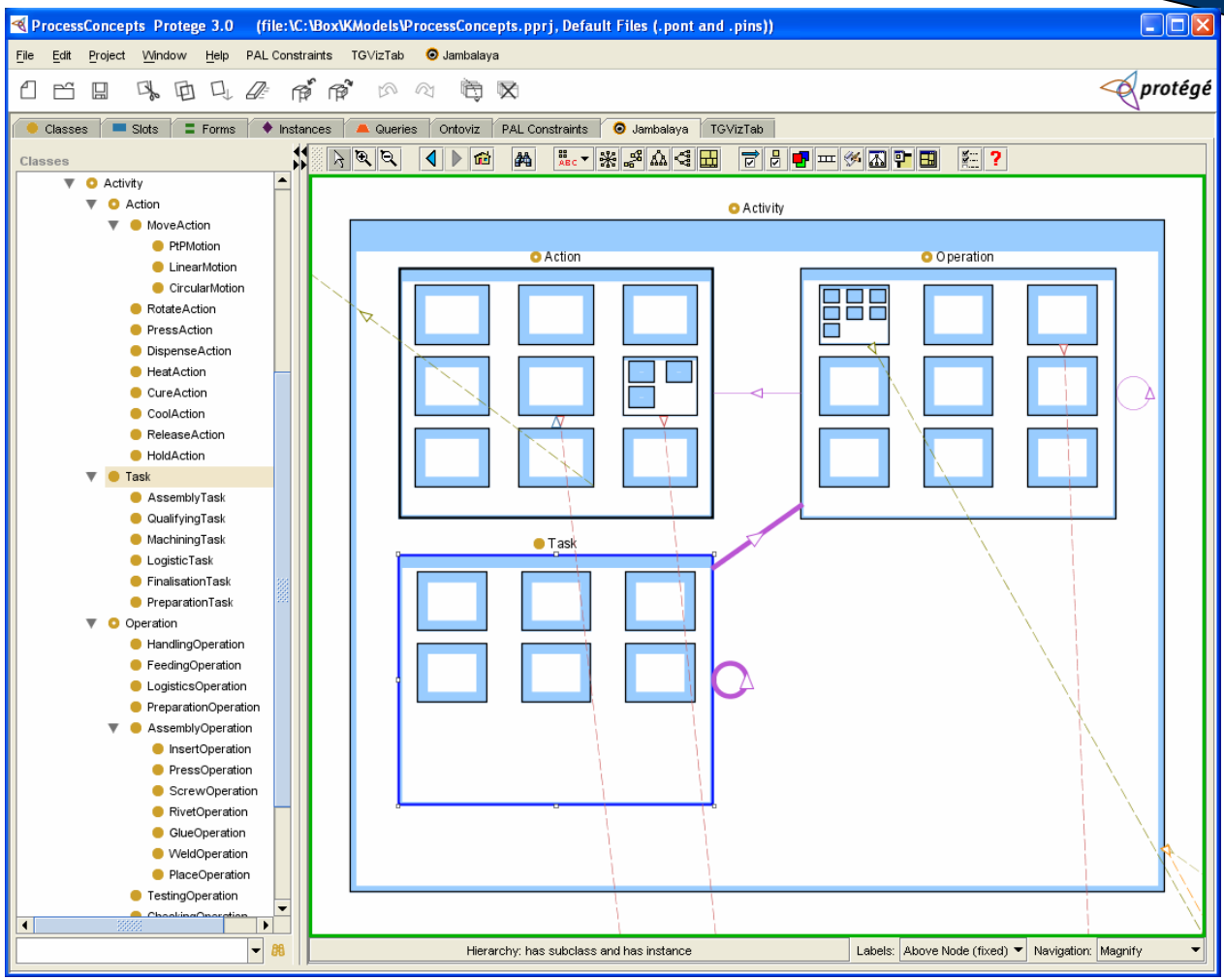
Example: Insertion Task Breakdown





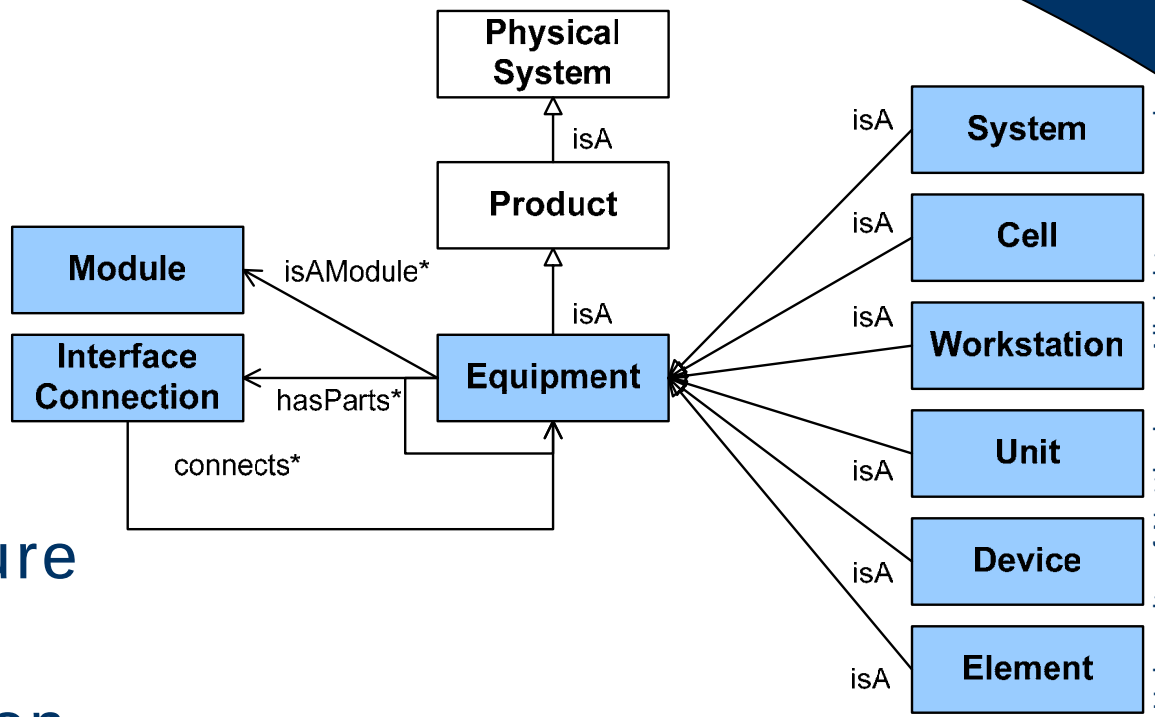


Process Domain Concept

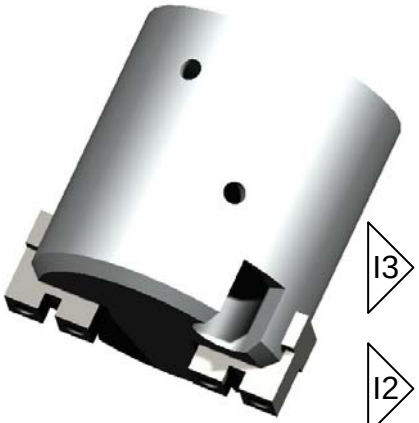


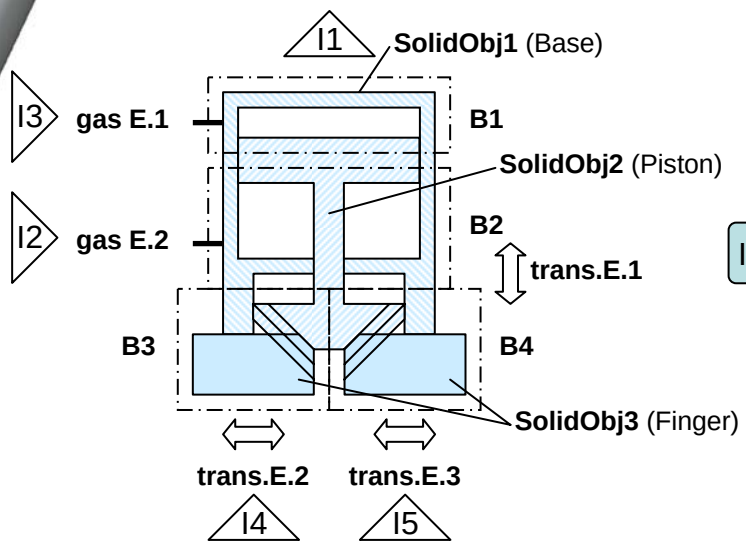
Assembly System Domain Concepts

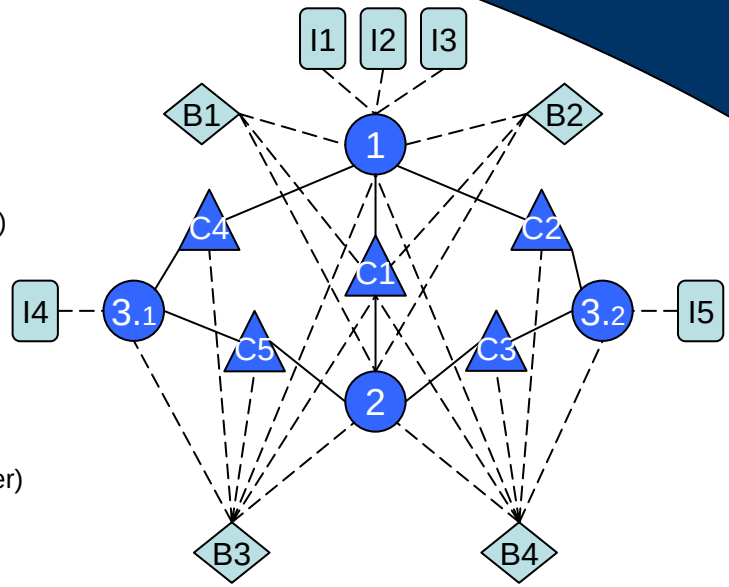
- Spatial Structure
- Logical Structure
  - Hierarchy
  - Connectivity Constraints
- Behavioural Structure
  - Performance Characteristics
- Functional Structure
  - Capabilities
- Costing Information
- Delivery Times

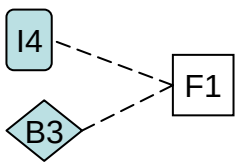


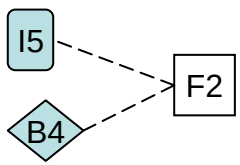
Example: Equipment Device







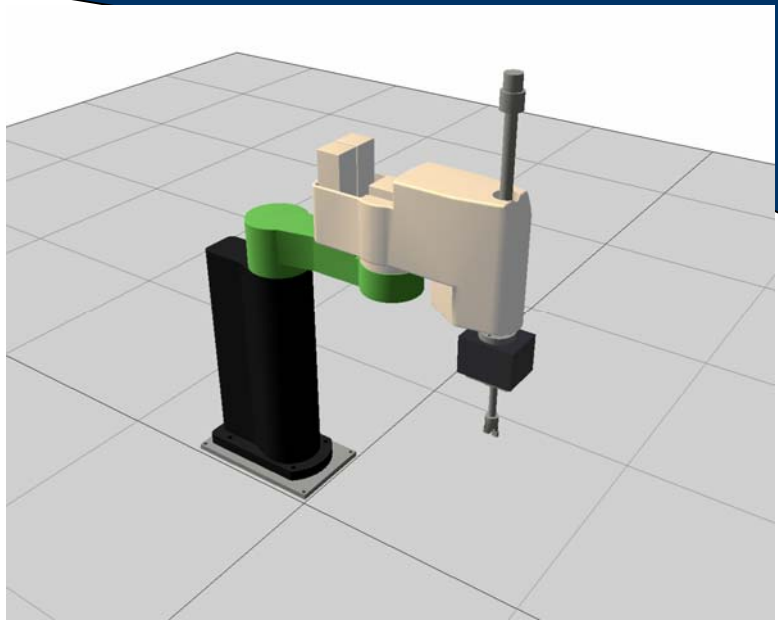


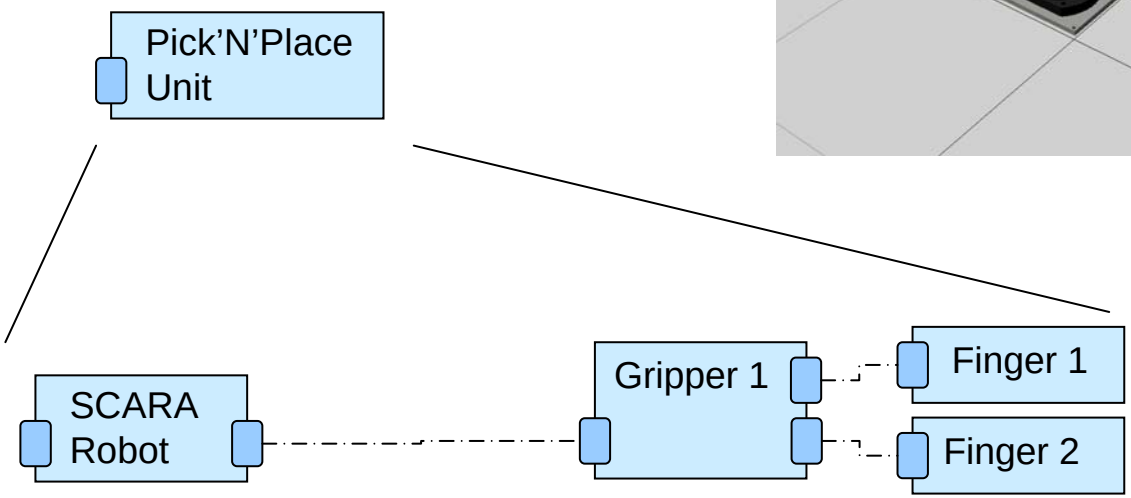


B1: Cylinder Behaviour
B2: Cylinder Behaviour
B3: Wedge Behaviour
B4: Wedge Behaviour

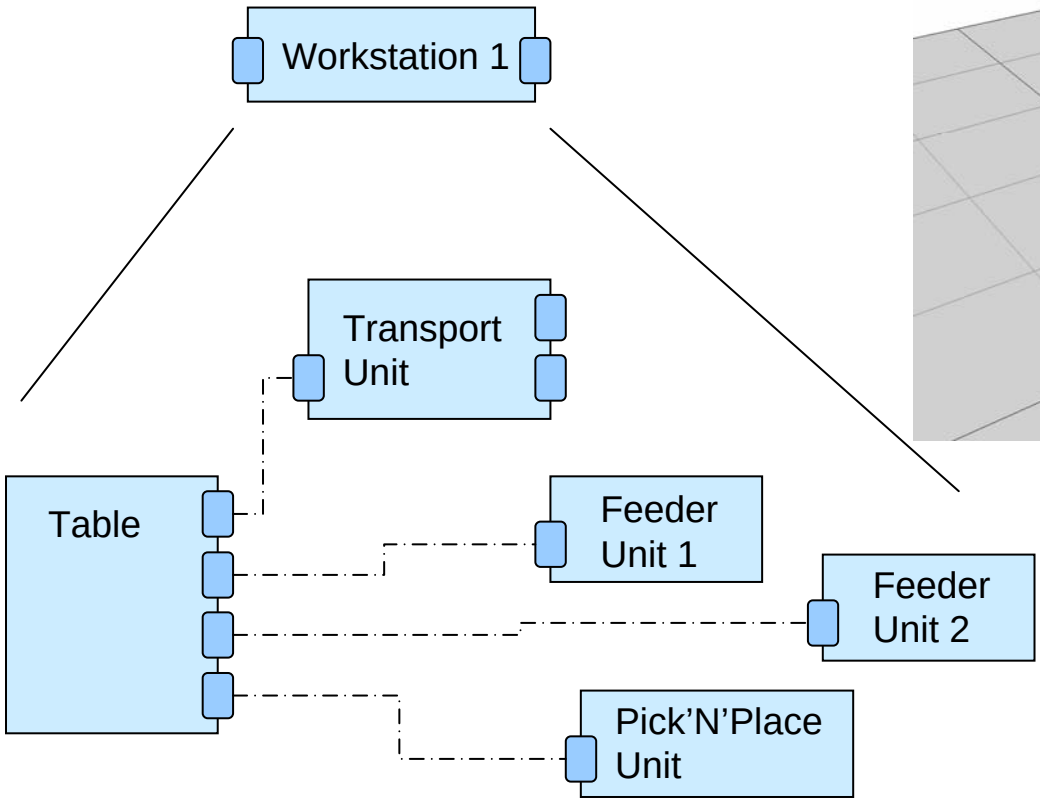
F1: Move Finger
F2: Move Finger

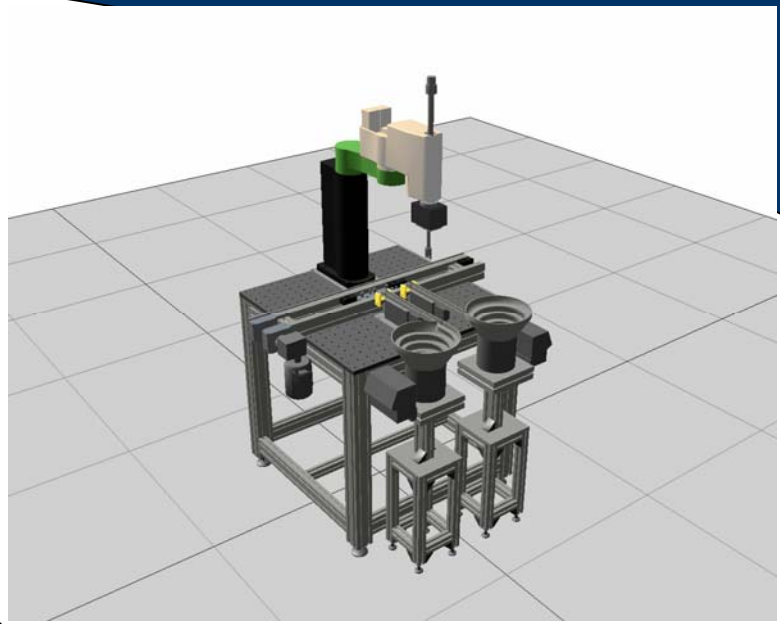
Example: Unit Configuration





Example: Workstation Configuration



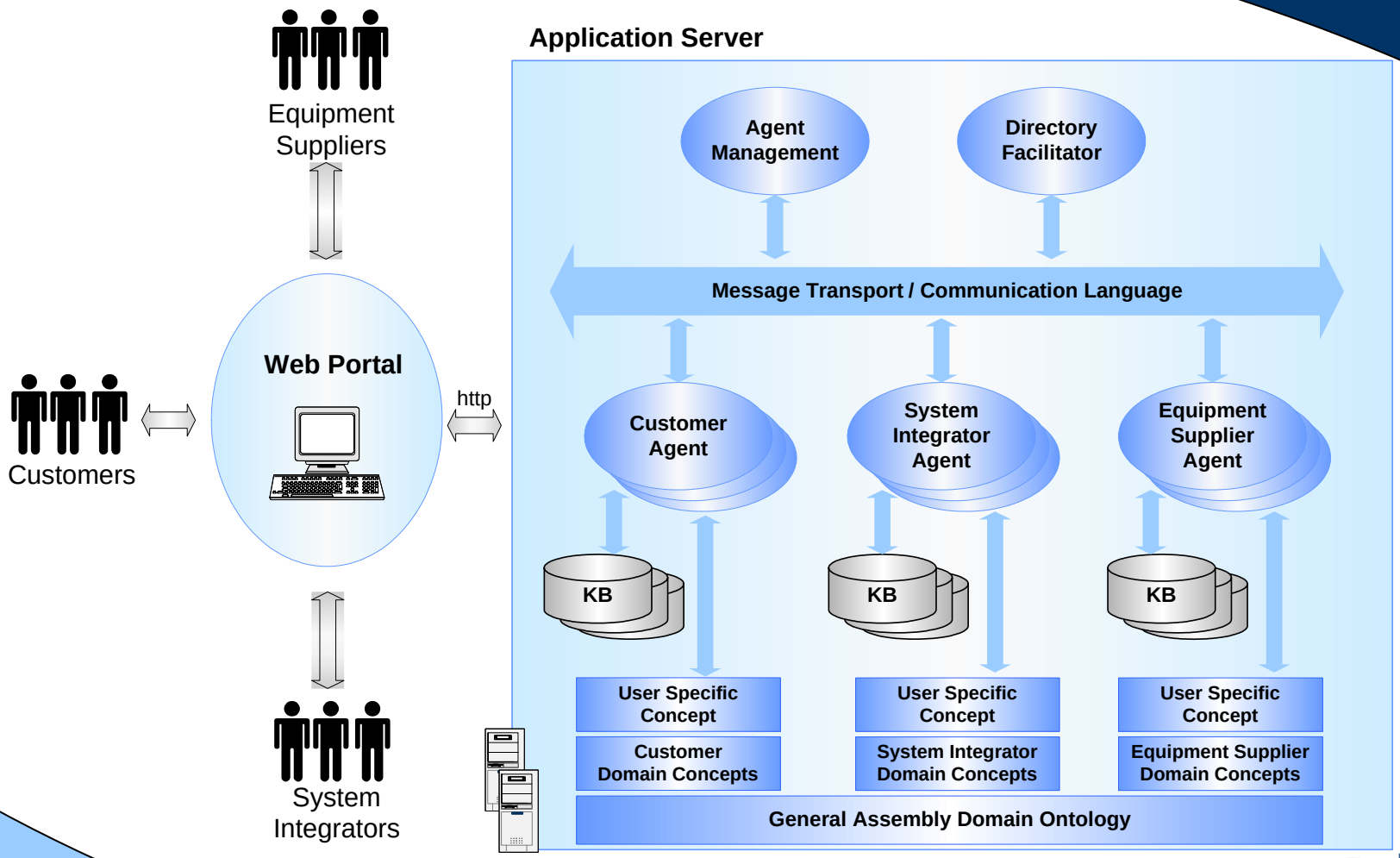


Example: Cell Configuration

Application Example

University of Nottingham

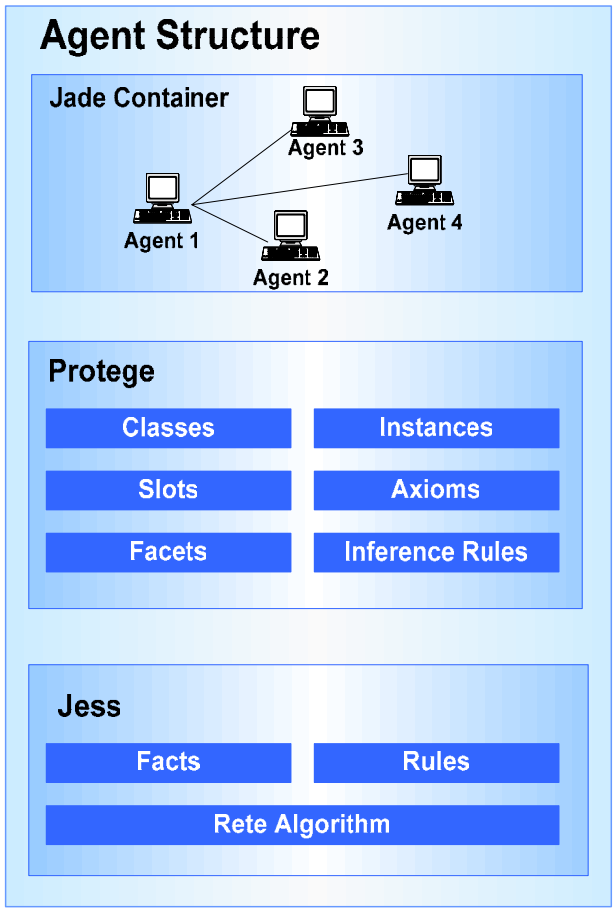
Agent-based Approach



Application of Protégé

- Knowledge Base
- Knowledge and Ontology Visualisation
- Knowledge Acquisition during testing
- Constraint Checker (PAL plug in)
- Message Content Validation
- Storing of the Decision Making Model in CommonKADS notations

Agent Structure

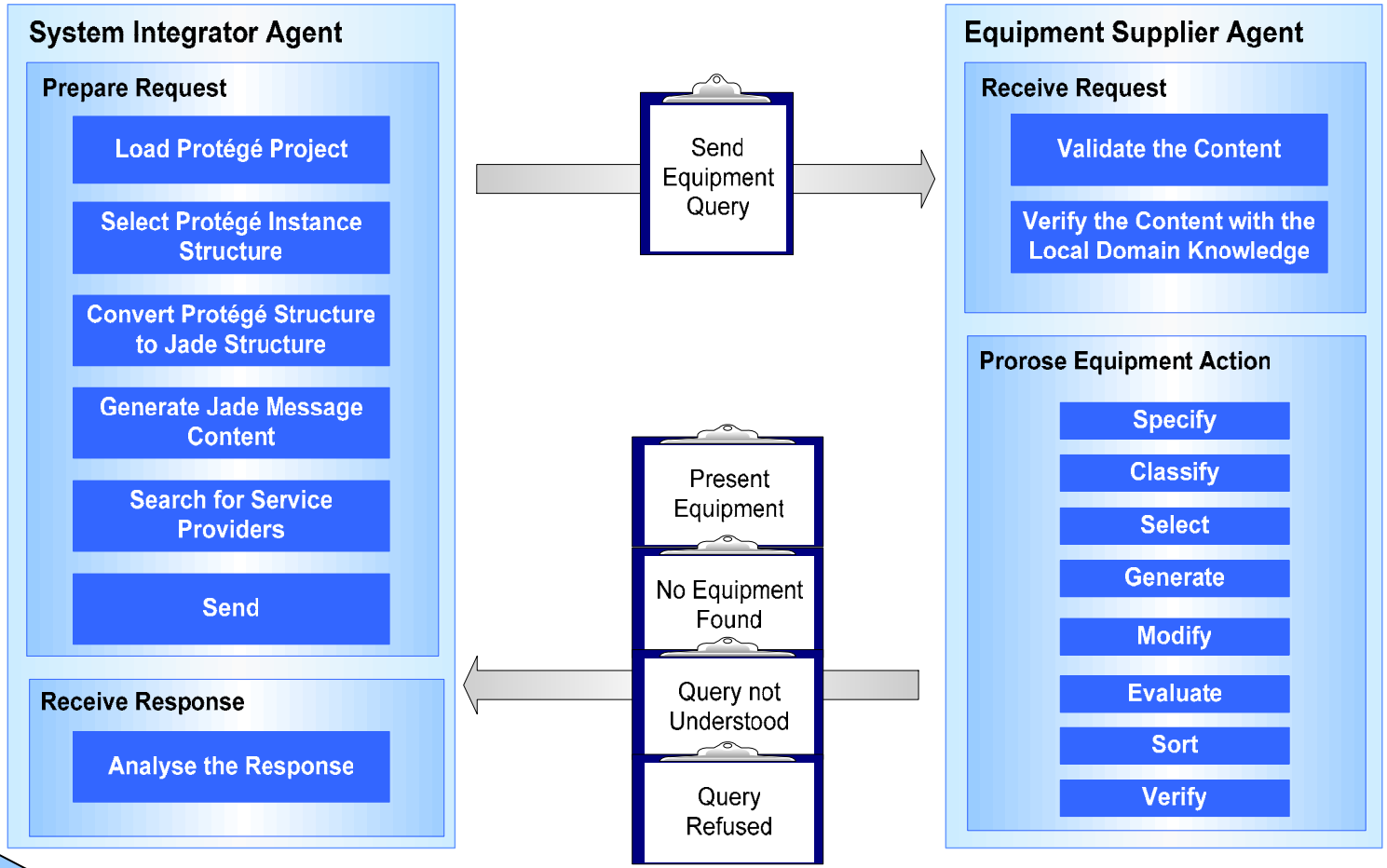


- Message transport
- Agent communication languages
- Interaction protocols (dialogues, conversations)
- Platform management (white and yellow pages)

- Use of Frame based knowledge representation
- Domain Ontology Maintenance
- Knowledge Base Editor
- Customized Data Entry Forms

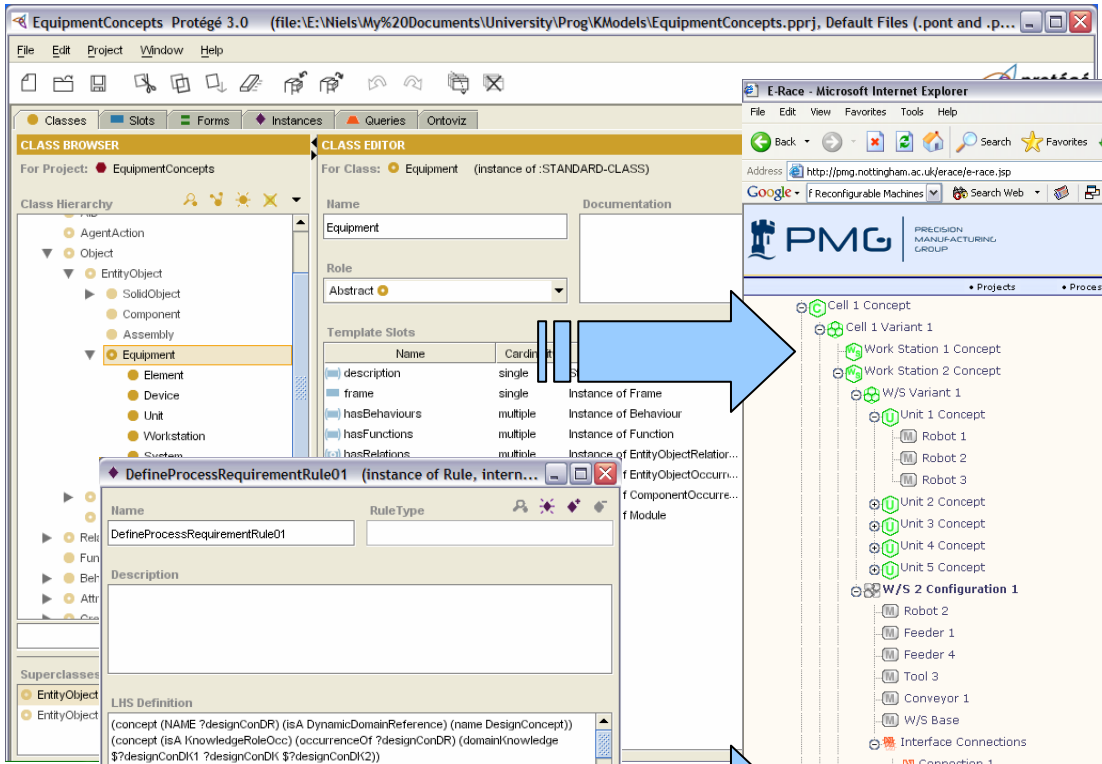
- Java Expert System Shell
- Rule based reasoning engine

Example Agent Communication Scenario

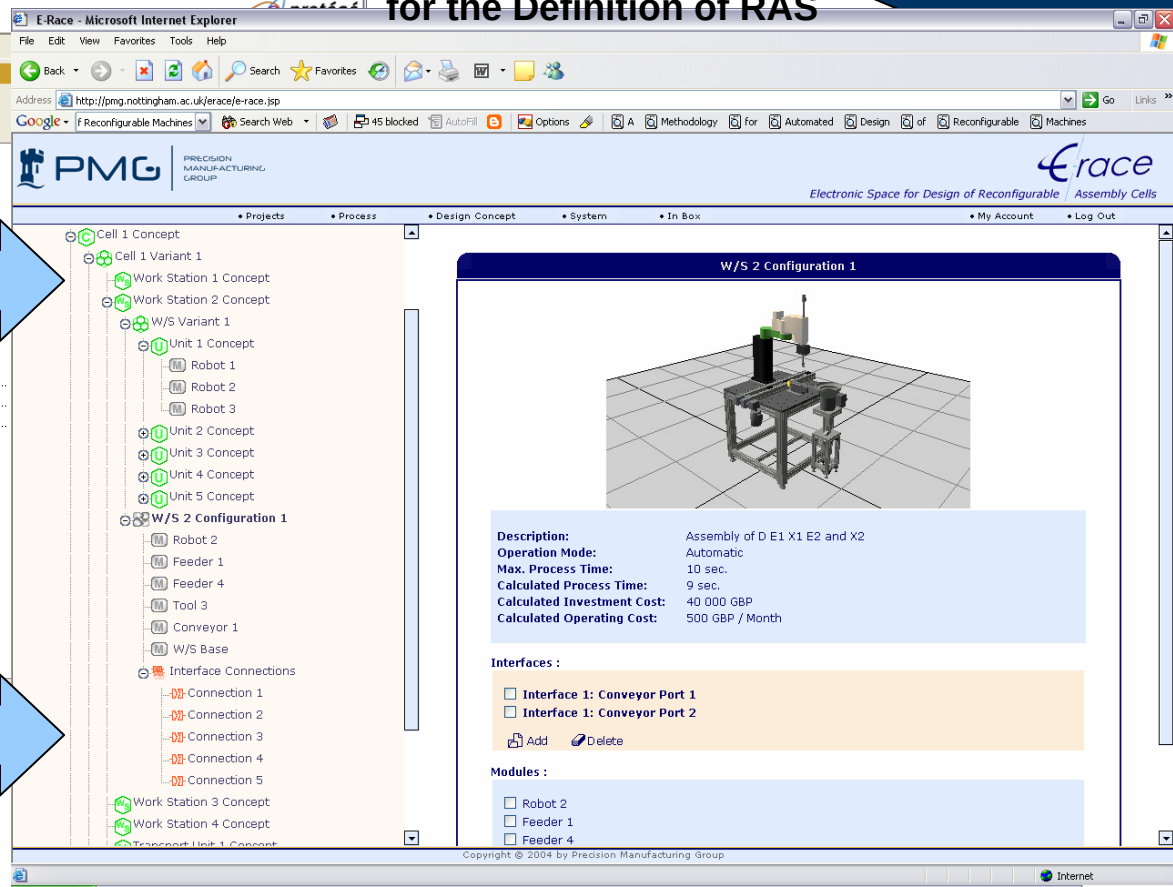


Application Example (cont.)

Protégé Frame Based Ontology Specification



Online Environment for the Definition of RAS



Inference Rule

Conclusions

Conclusions and Future Work

Conclusions

- Strong need for a Unified Assembly System Design Ontology
- Demonstration of Proposed High Level Assembly System Design Ontology Modelled in Protégé

Future Work

- Verification in More Extensive Industrial Case Studies
- More Extensive Classification of Concepts in the different Domains

Open Issues

- Speed of Protégé as Knowledge Base Backend needs to be improved.
- Management of large knowledge Bases