
Using Model-Theoretic Invariants for Semantic Integration

Michael Gruninger

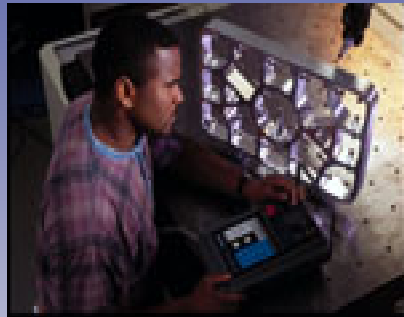
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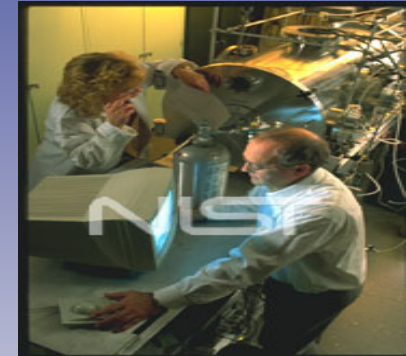
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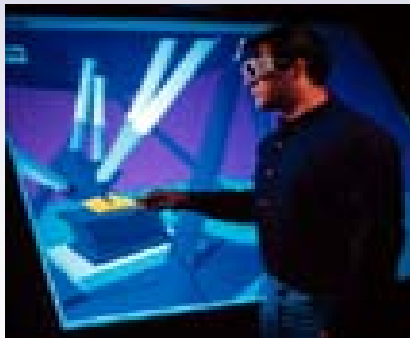
Interoperability



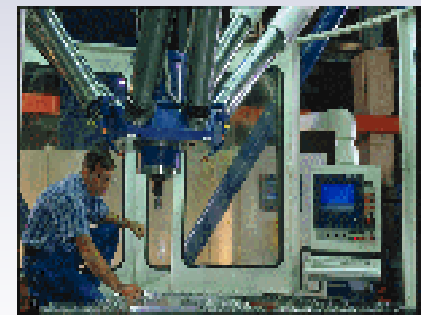
Process Modeler
(ProCAP / KBSI)



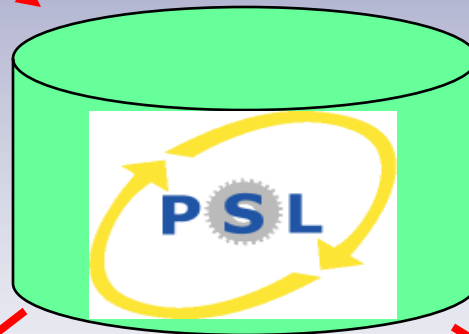
Process Planner
(MetCAPP/Agiltech)



Simulator (Quest / Dessault)



Scheduler
(ILOG Scheduler)



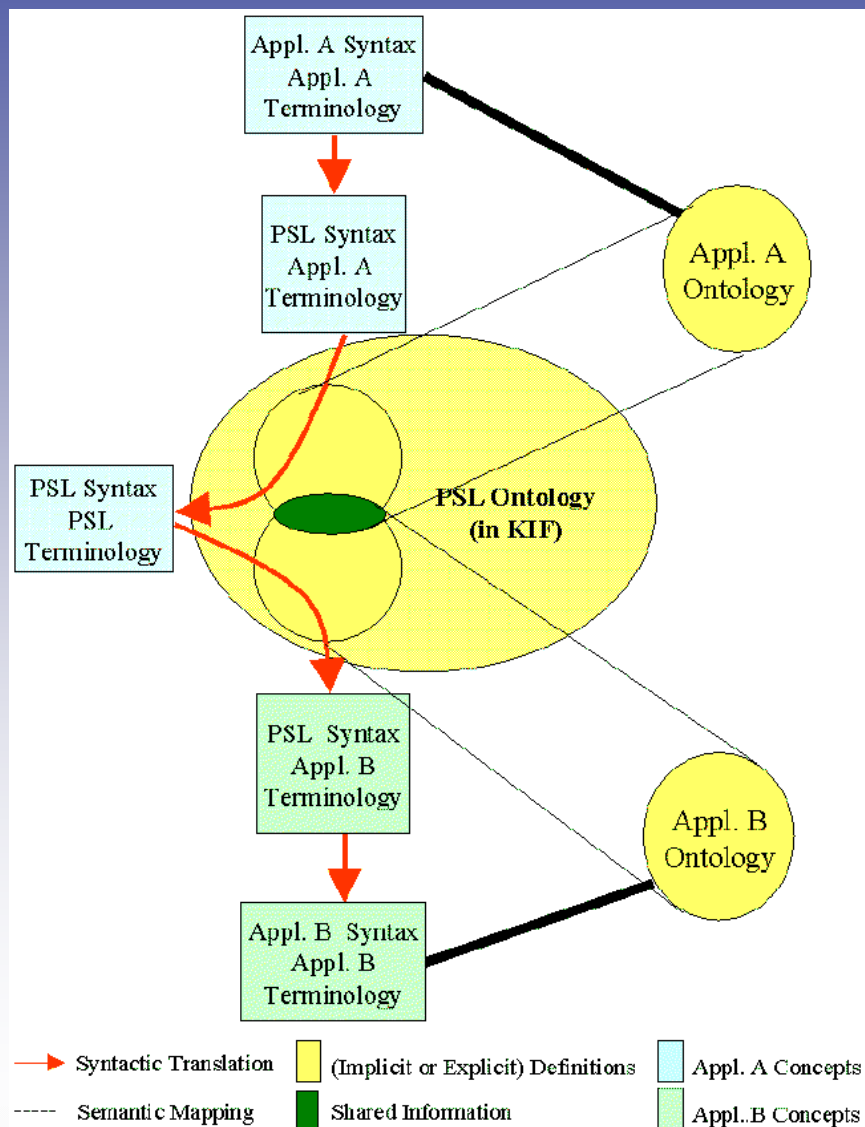
Semantic Translation

Translation definitions specify the mappings between PSL and application ontologies.

Example: The *AtomicProcess* in OWL-S maps to the *activity* concept in PSL only if the activity is atomic and its preconditions and effects depend only on the state prior to the occurrences of the activity.

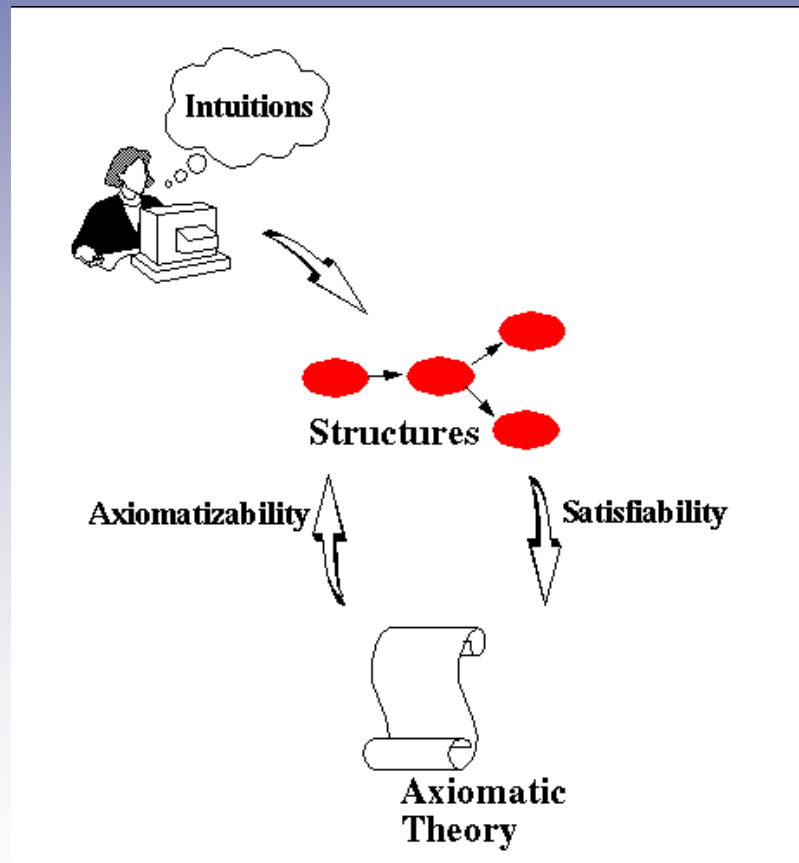
```
(forall (?a)
  (iff (AtomicProcess ?a)
    (and (atomic ?a)
      (markov_precond ?a)
      (markov_effects ?a))))
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Semantic Interchange Protocols



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- What are sufficient conditions for an ontology to support this approach to semantic integration?

Verified Ontologies

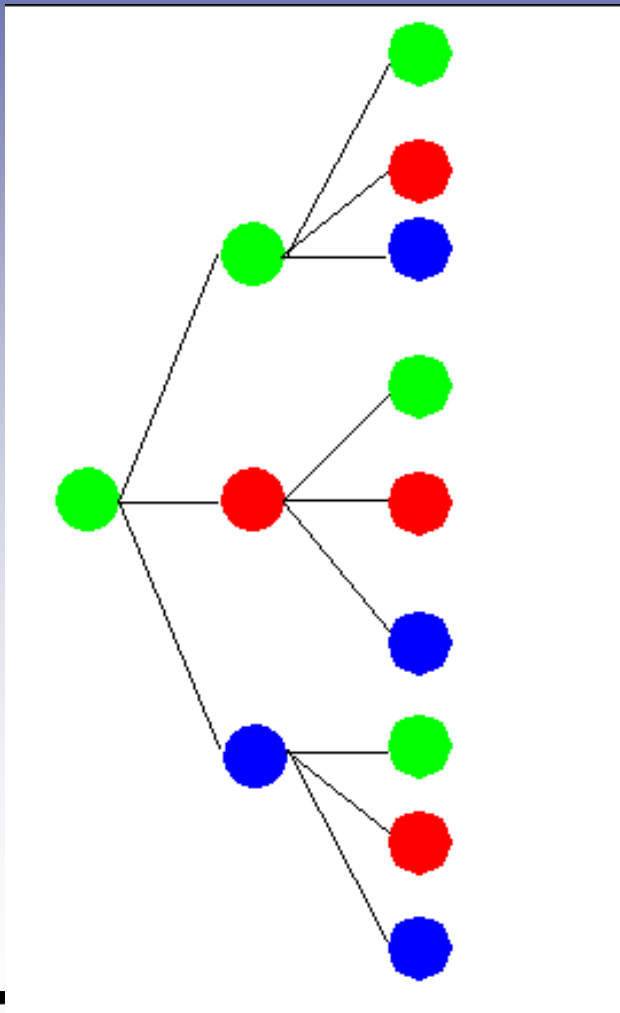


- The meaning of terms in the ontology is characterized by models for first-order logic.
- The ontology provides a first-order axiomatization of the class of models

Definitional Extensions

- Preserving semantics is equivalent to preserving models of the axioms.
 - *preserving models = isomorphism*
- We classify models by using *invariants* (properties of models that are preserved by isomorphism).
 - automorphism groups, endomorphism semigroups
- Classes of activities and objects are specified using these invariants.

Models in PSL



- Occurrence trees
- Fluents (state)
- Activity trees

Twenty Questions

How can we generate translation definitions?

- Each invariant from the classification of models corresponds to a different question.
- Any particular activity or object will have a unique value for the invariant.
- Each possible answer to a question corresponds to a different value for the invariant.

Limitations

- Not all theories have complete sets of invariants
- Invariants may not be first-order definable
- How do we determine the correctness of the translation definitions?

Interoperability Hypothesis

- We are considering interoperability among complete first-order inference engines that exchange first-order sentences.
- *Why first-order logic?*
 - Soundness and completeness guarantees that a sentence is provable from a theory if and only if it is satisfied in all models of the theory.

Ontological Stance



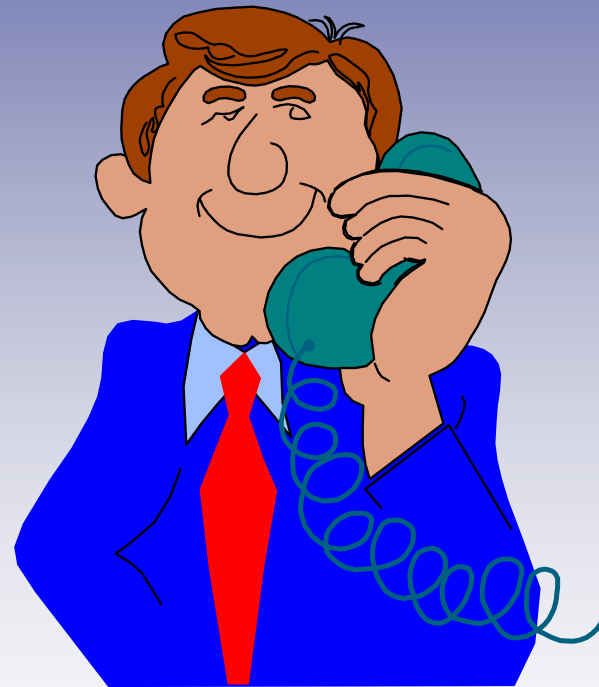
$$\Sigma \cup \text{Ontology} \models \Phi$$

Summary

- The meaning of terms in the ontology is characterized by models for first-order logic.
- The PSL Ontology has a first-order axiomatization of the class of models.
- Identify invariants of the models
- By axiomatizing these invariants, translation definitions can be shown to preserve semantics between software applications.

Further Questions?

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