## OPEN TECHNICAL FORUM : Key SC4 development activities

# Benefits of the use of AI techniques for process specification : Application to the PSL language

Pr. A.F. CUTTING-DECELLE
**University of Evry, EVRY (F) and University of Loughborough (UK)**
Dr. L. POUCHARD, **ORNL (Oak Ridge National Labs), Oak Ridge, (USA)**
Dr. M. GRUNINGER, **NIST, Gaithesburg, (USA)**
J.J. MICHEL, **Idpiconseil, Paris (F)**

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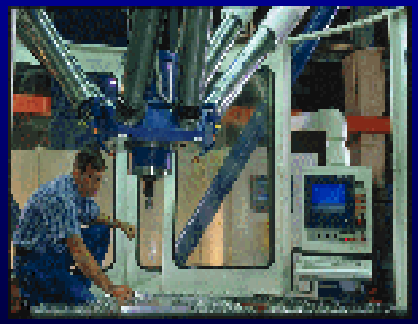
# Interoperability of process information

Process Modeler

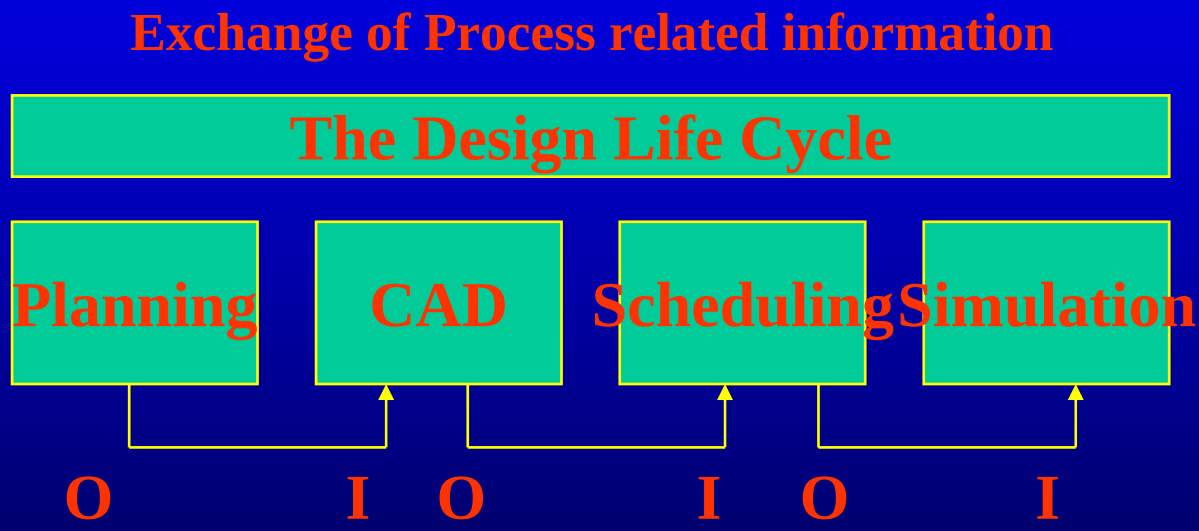
Design Modeler


Simulator



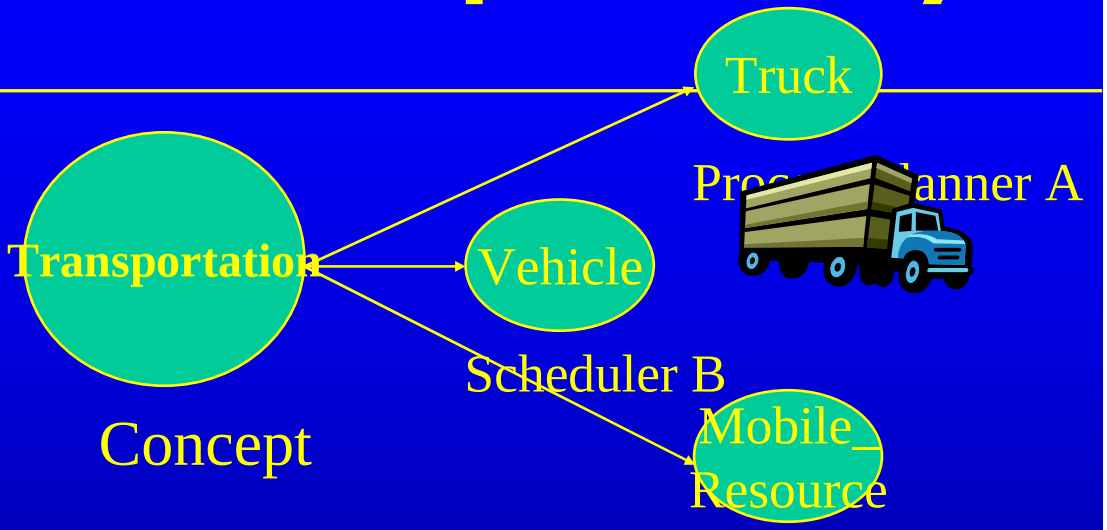
Scheduler

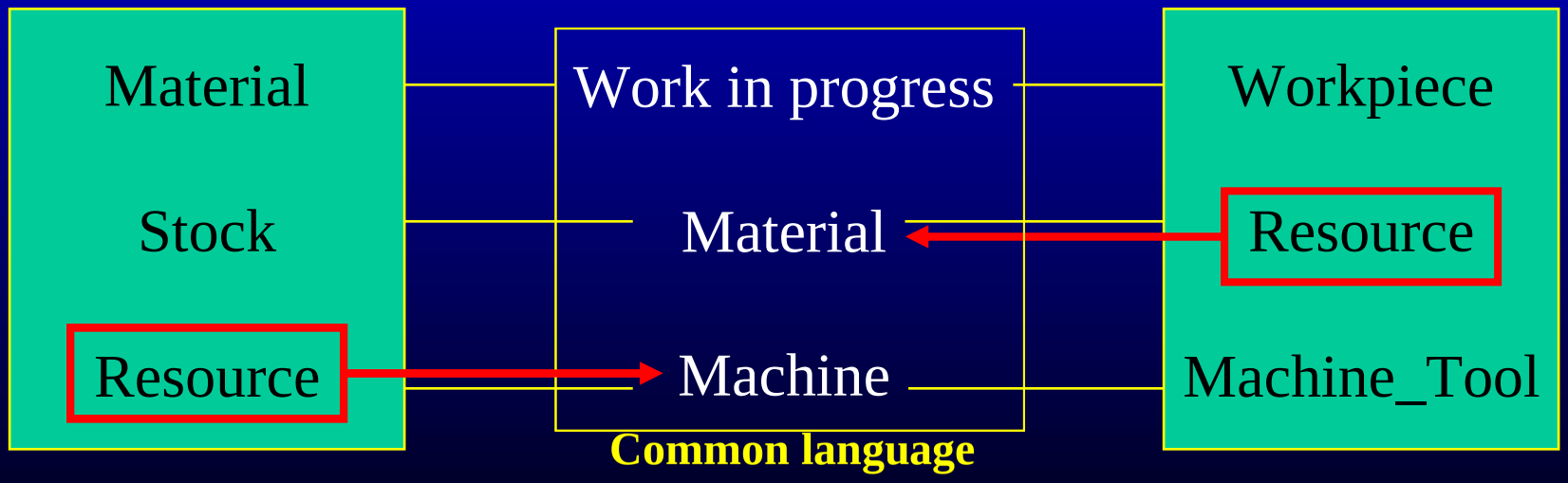
# Example of design process



# Challenges to inter-operability

**Semantic challenge 1 :**
**synonymy :**
**possibility of conflicts**

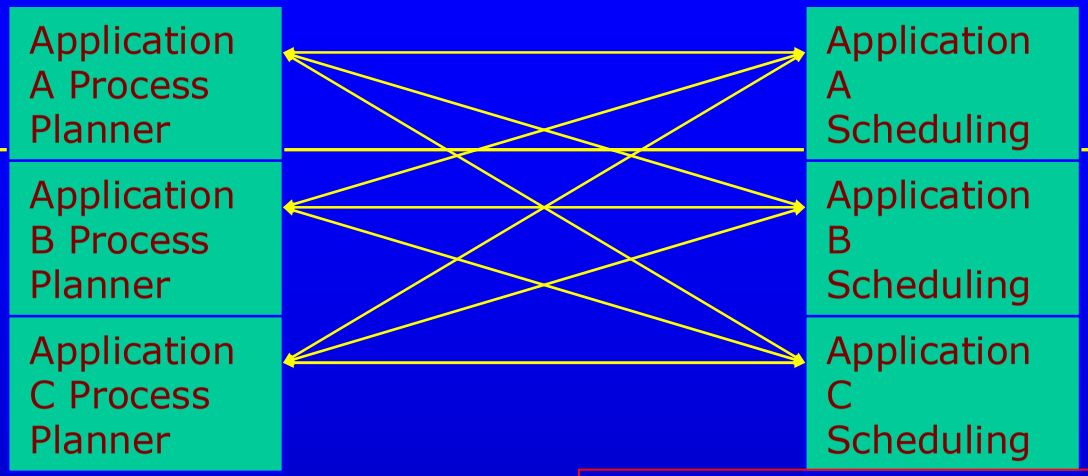


# Another challenge : Virtual enterprises, global enterprises

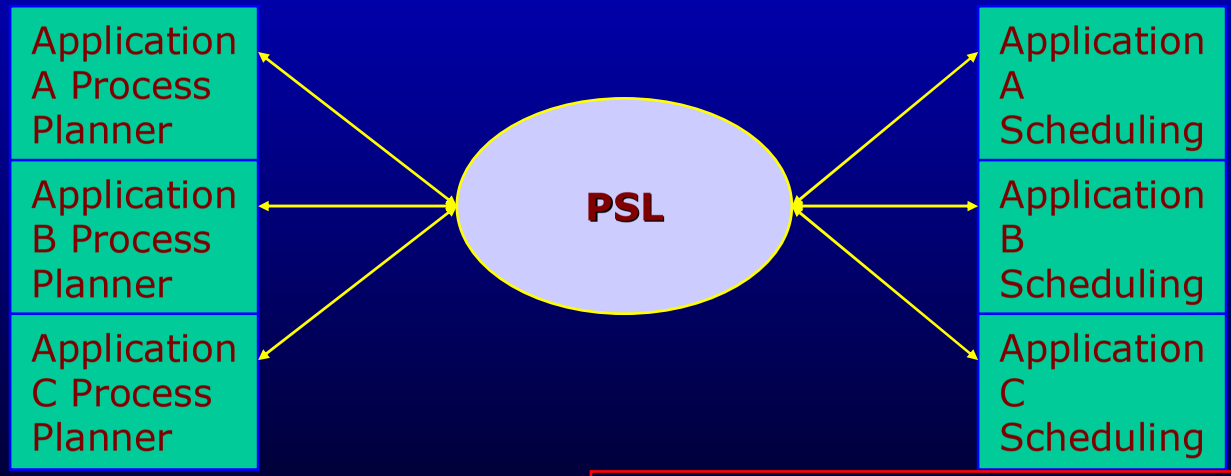
- Creation and support of virtual enterprises hindered by the lack of a common understanding of their business processes
- A common language for processes enables the integration of the business practices of partners within the virtual enterprise

# Scenario 1 : Point-to-point translation



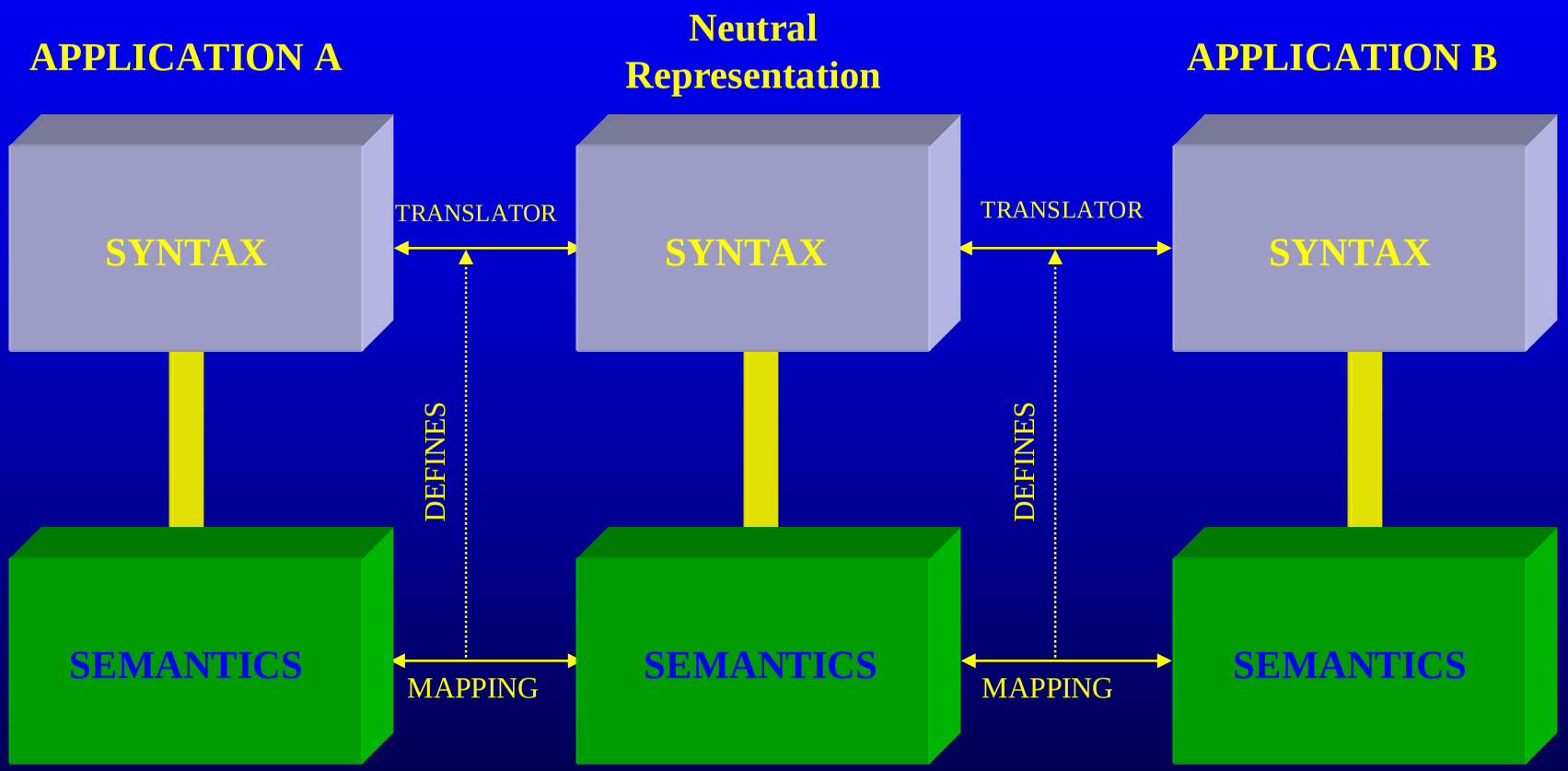

n planners, m schedulers → n*m translations

# Scenario 2 : translation using PSL




n planners, m schedulers → n + m translations

# Exchange Scenario

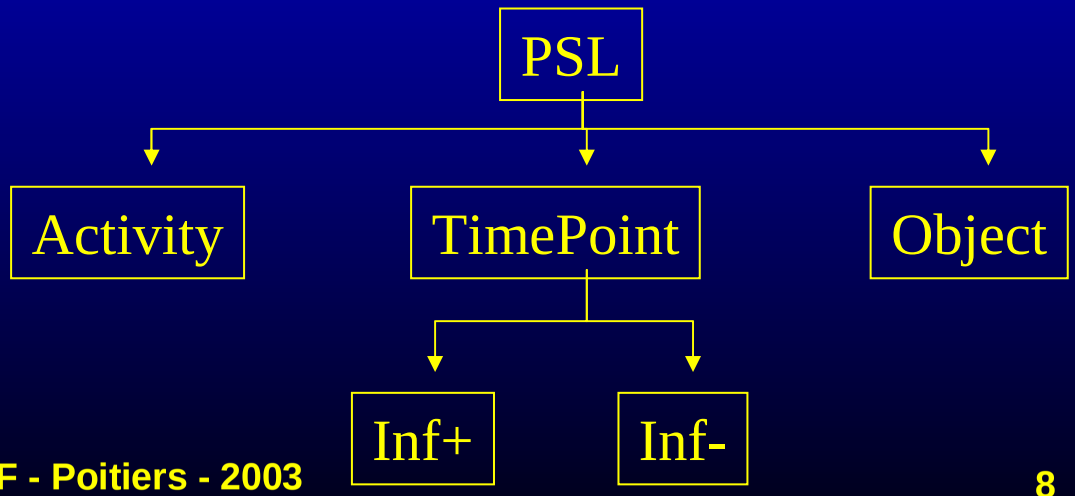


# What is Process Specification Language ?

- **What PSL currently is : a seven-year effort at NIST to develop a neutral representation of manufacturing process information, a modular, extensible data model (ontology) capturing concepts inherent to process specification**

- **What PSL will be : a language enabling interoperability of process information among industrial applications**

What is a process ?
A process is one or more activities
that occurs over a period of time
in which objects participate



# Background : requirements gathering

- **Goals :**
  - common set of manufacturing requirements for specifying processes ?
  - If so, identify and define those concepts
- **Results :**
  - Significant overlap in requirements necessary
  - supposition that a common process specification is feasible
  - Abstract process requirements : general applicability to applications outside of manufacturing

# Background : requirements gathering analysis of process representations

- **Goals :**
  - Identify how process requirements are captured within existing representations
  - Understand what types of representations provide the best coverage of certain requirements
- **Results :**
  - Numerous ways of representing the same concept, depending on the approach
  - Nearly all representations focus on the syntax, rarely specify the exact meaning
  - Object-based and constraint-based representation provide the best overall coverage

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# Process Representations Studied

- ACT
- A Language for Process Specification
- AP213
- Behavior Diagrams
- Core Plan Representation (CPR)
- Entity-Relationship (E-R)
- EPFL Petri Net Representation
- Functional Flow Block Diagrams
- Gantt Charts
- Generalized Activity Networks (GAN)
- Hierarchical Task Networks (HTN)
- IDEF0
- IDEF3
  - AND/OR Graphs
  - Data Flow Diagrams
  - Directed Graphs
  - State Transition Diagrams
  - Tree Structures
- <I-N-OVA> Constraint Model
- Knowledge Interchange Format
- O-Plan Task Formalism
- OZONE
- PAct
- PAR2
- Part 49
- PERT Networks
- Petri Nets
- Process Flow Representation
- Process Interchange Format V.1.1
- Quirk Model
- Visual Process Modeling Language

# Pilot Implementations (already developed and on-going)

- The pilot implementations have :
  - driven the growth of the PSL ontology through the identification of concepts needed in various manufacturing fields
  - ensured that PSL was truly addressing the needs of vendors and end users
  - involved writing translators to / from PSL to ensure its usability
- The **first pilot**, completed in September 1998, exchanged process information between the ProCAP process modeler and the ILOG Schedule
- The **second pilot**, completed in September 2000, exchanged process information between the MetCAPP process planner and the Quest simulation package
- **Other on-going developments** : University of Stanford (USA), University of Loughborough (UK) / Evry

# Summary

- Process specification language : used to specify a process or a flow of processes, including supporting parameters and settings

  ---- *not a process modelling language* ---

- Current scope : discrete processes, including : process planning, scheduling, simulation, business processes, software compatibility processes …

  *(not exhaustive !)*

  with one ontology and one or more presentation languages : EXPRESS, XML, …

# What are ontologies ?

- **The basic terms and relations comprising the vocabulary of a topic area**
- **A set of definitions for these terms**
- **The rules for combining terms and relations**

# Why are ontologies useful ?

- Provide definitions and axioms constraining the use of terms that are readable by machines and understandable by humans
- Allow hierarchical classification systems, generalization and inheritance, aggregation, and a greater variety of structural relations than taxonomies and controlled vocabularies

# When should ontologies be used ?

- **by humans: for providing a common frame of reference and some consensus on entities in a domain**
- **by machines : to improve :**
  - **data schemas**
  - **system inter-operability based on semantics**
  - **agent-based systems**

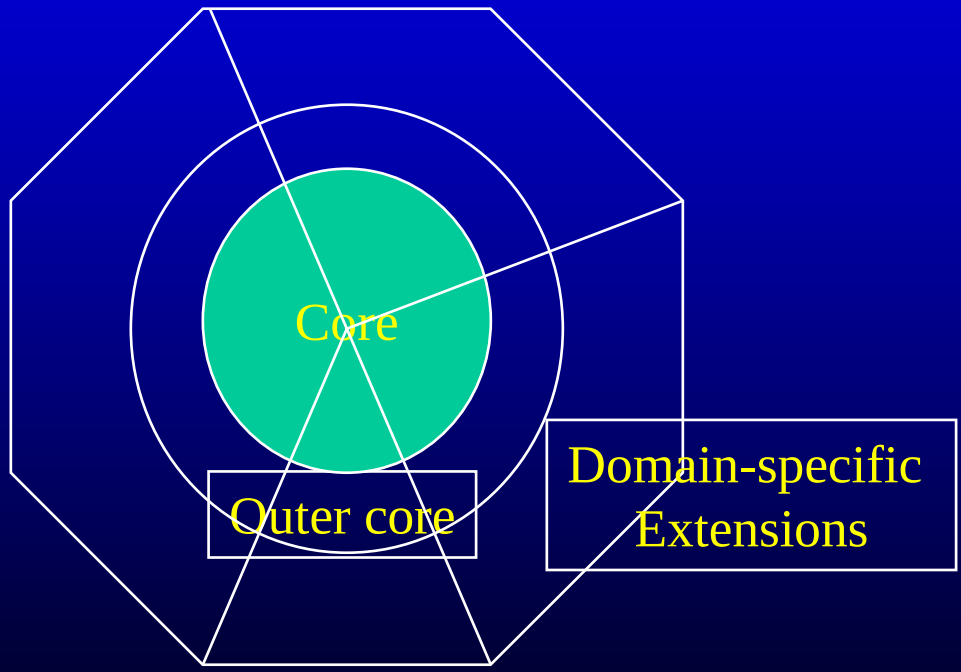
- **Example :** ***The duration of an activity is the difference between its start and end times for all occurrences of the activity***

```
(defrelation duration (?a ?d) :=
(forall (?t1 ?t2)
        (=>    (and    (= ?t1 (Beginof ?a))
                       (= ?t2 (Endof ?a)))
                (= ?d (time_minus ?t2 ?t1)))))
```

# Structure of PSL

- **Objective : define in a rigourous way concepts necessary for specifying manufacturing processes to enable the exchange of process information**

- **Structure : two main layers :**
  - **core**
  - **extensions**



# PSL core

- **Set of process-related concepts common to ALL applications dealing with process information**
- **Formal mathematical language, based on first order logic, with a precise semantics and set of axioms expressing this semantics**

- classes :
  - **OBJECT :** abstract or concrete « thing » participating in :
  - **ACTIVITY**
  - **ACTIVITY_OCCURRENCE :** limited, temporally extended piece of the world, determined by its begin and end :
  - **TIMEPOINT**
- functions : beginof, endof
- relations : is_occurring_at, occurrence_of, participates_in, before, beforeEq, between, betweenEq, exists_at

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# Some axioms of the PSL-Core

**Axiom 10.** Objects, activities, activity occurrences, and timepoints are all distinct kinds of things.

```
(forall (?x)
(and     (=>     (activity ?x)
                 (not (or (activity_occurrence ?x) (object ?x) (timepoint ?x))))
         (=>     (activity_occurrence ?x)
                 (not (or (object ?x) (timepoint ?x))))
         (=>     (object ?x)
                 (not (timepoint ?x)))))
```

**Axiom 11.** The occurrence relation only holds between activities and activity occurrences.

```
(forall (?a ?occ)
        (=>     (occurrence_of ?occ ?a)
                (and     (activity ?a)
                         (activity_occurrence ?occ))))
```

# PSL extensions

- Objectives :
  enables to represent domain-specific concepts that are not part of PSL core
- Contents :
  new constants / predicates, with corresponding axioms and definitions
- Today :
  - about 330 concepts
  - in 46 extensions

# LIST of the Current extensions

## Part 10 Series: Core Theories

Part 11 : PSL-Core
Part 12 : Outer Core
Part 13 : Duration and Ordering Theories
Part 14 : Resource Theories
Part 15 : Actor and Agent Theories

## Part 40 Series: Definitional Extensions of PSL

Part 41 : Activity Extensions
Part 42 : Temporal and State Extensions
Part 43 : Activity Ordering and Duration Extensions
Part 44 : Resource Roles
Part 45 : Resource Sets
Part 46 : Processor Activity Extensions

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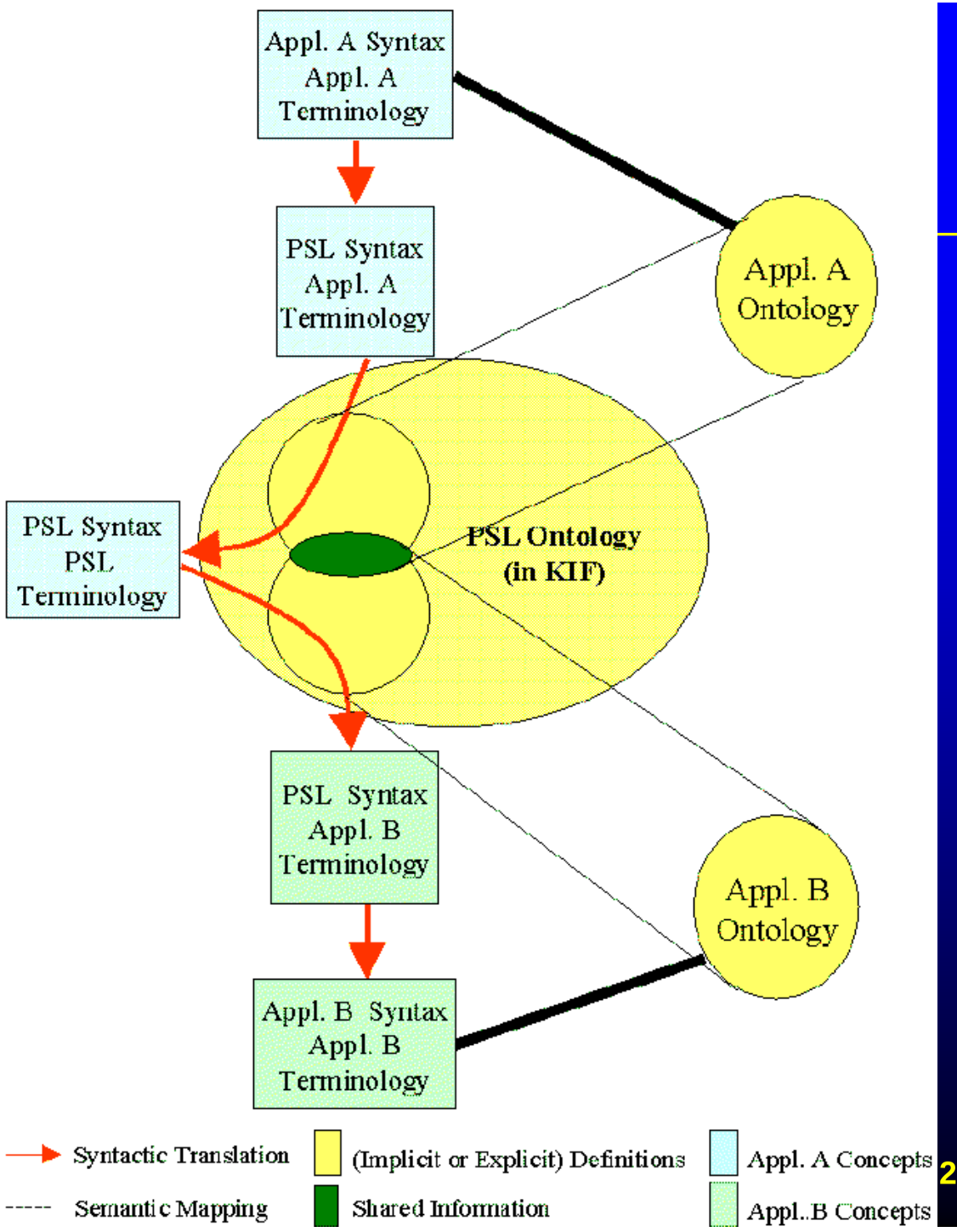
# Process Exchange using PSL

- The ontology for each application is expressed using PSL concepts :
  A direct (unconditional) mapping can occur
- OR the application's term is more restrictive =>constraints on its use
- OR PSL is extended to accommodate a new concept



# Who is PSL's Target Audience ?

- **End users of PSL** : engineers who need to exchange process information among applications within their company (and among partnering companies)
  - originally manufacturing
  - now : construction, software engineering, …
- **First step :** get software developers to incorporate PSL translators in their tools

# Standardisation issues (Sept. 2003)

- **ISO DIS 18629-1** : Draft International Standard (under ballot)
- **ISO DIS 18629-11** : Draft International Standard (under ballot)
- **ISO DIS 18629-12** : Draft International Standard (under ballot)
- **ISO CD 18639-41** : Committee Draft (under ballot)

Developments for : ISO 18629-13, ISO WD 18629-42 (N 323), ISO 18629-43 : work in progress

# Benefits of the PSL approach

- **Consistency checking at every stage** of the language
- **Rigourous definition of the language**
  based on First Order Logic
- The language (and the standard) proceeds further
  on a **"as-needed" basis** :
  **the initial scope of the language may be enlarged to integrate other domains**
  where high semantic level exchanges are needed :
  - construction sector -- current research work done at the University of Loughborough (UK)
  - cross exchanges between industrial sectors (research project, U. of Loughborough (UK))
  - others ….

# ..... Further information .....

Anne-Françoise CUTTING-Decelle : afcd@skynet.be
Michael GRUNINGER : gruning@cme.nist.gov
Jean-Jacques MICHEL : idpiconseil@wanadoo.fr
Line POUCHARD : pouchardlc@ornl.gov

http://ats.nist.gov/psl/

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