

# A Standard-based approach to interoperability: the Process Specification Language (PSL)

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# Outline

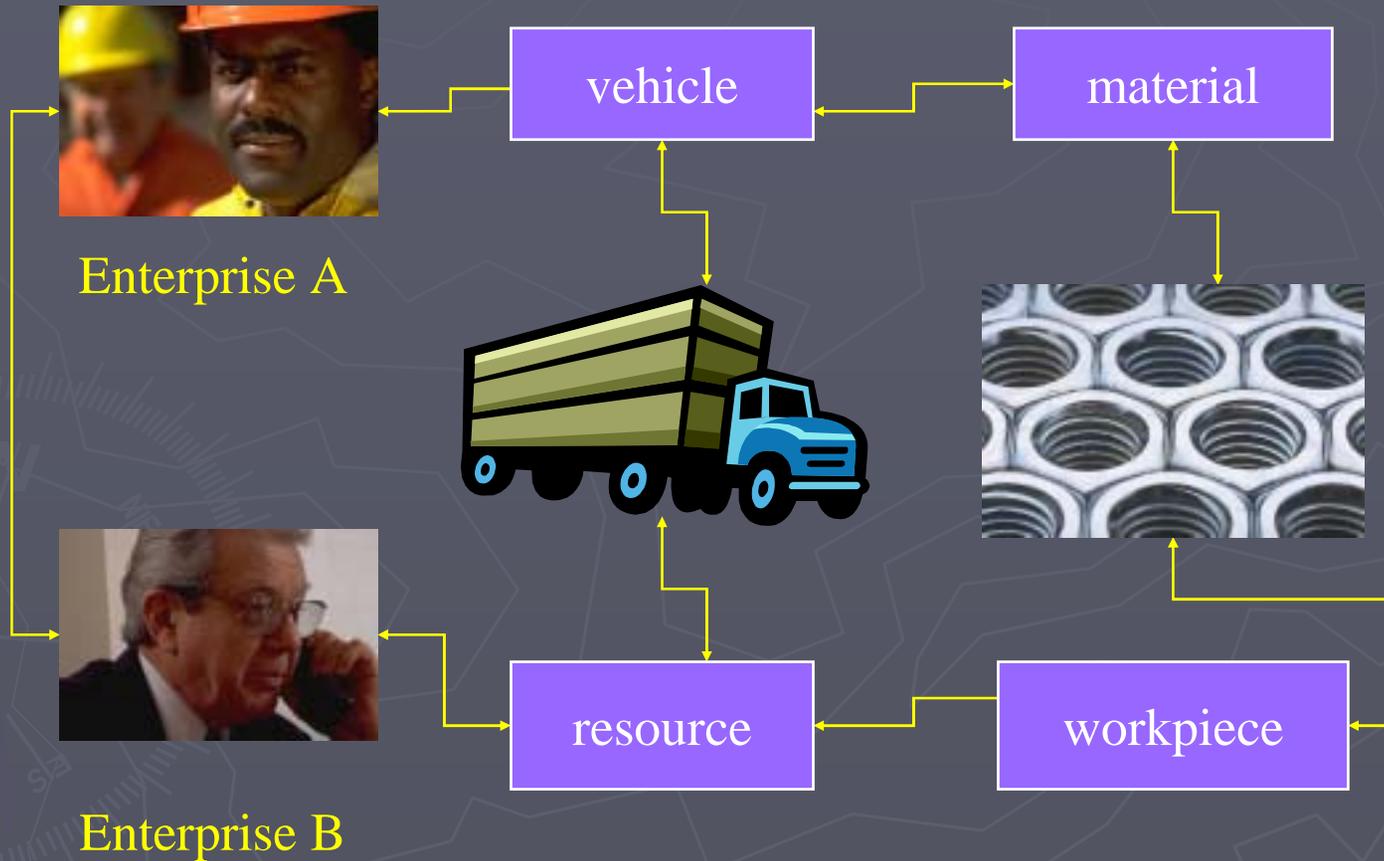
- ▶ Part I: The need for interoperability.
- ▶ Part II: A standard-based approach.
- ▶ Part III: What is the Process Specification Language (PSL)?
- ▶ Part IV: PSL in action.

# Part I: The need for interoperability

# Interoperability: definitions

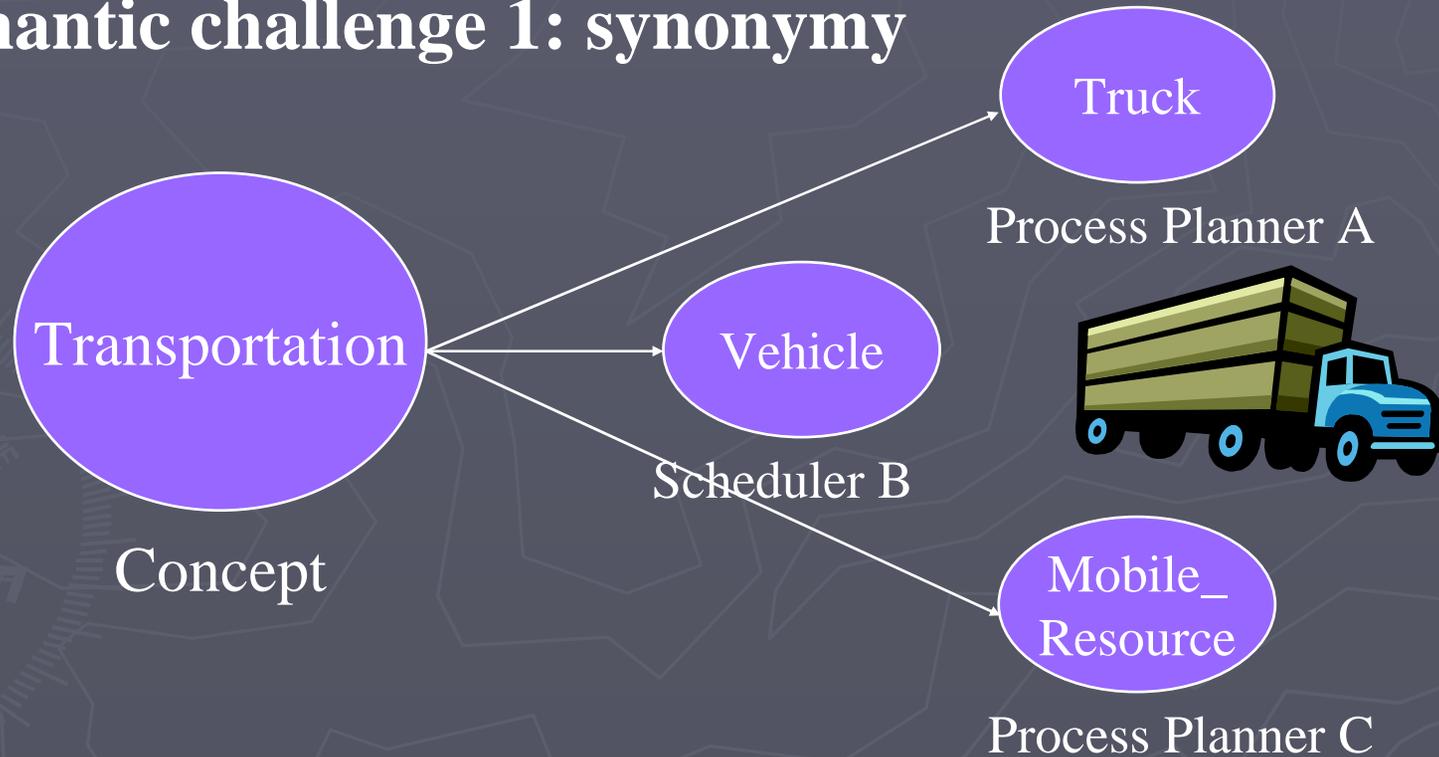
- ▶ The ability to **share technical and business information throughout an extended enterprise** (such as a supply chain).
- ▶ The ability of software on multiple machines from multiple vendors to communicate.
- ▶ The ability to exchange data, processes and information

# Challenges to communication

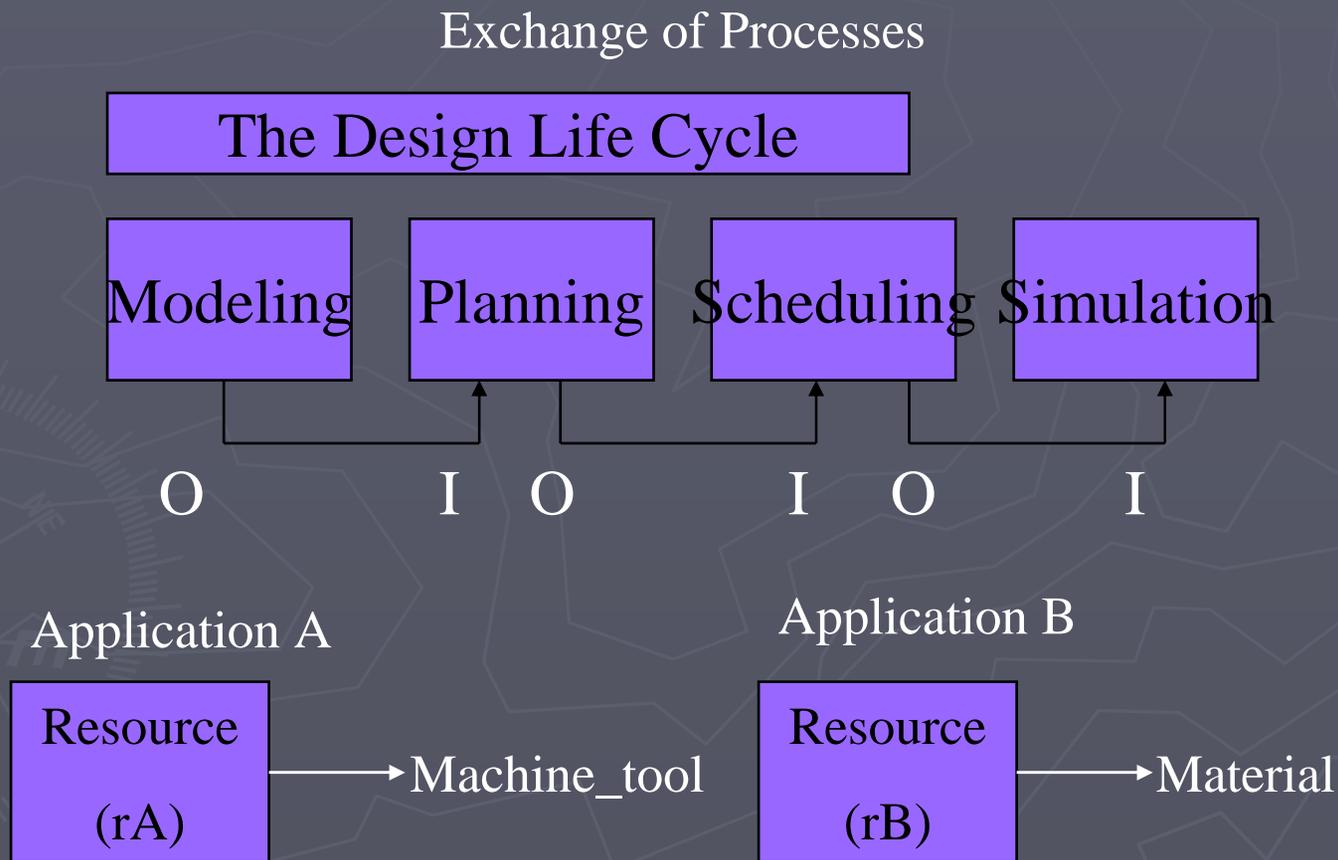


# Challenges to inter-operability

## Semantic challenge 1: synonymy



# The case for manufacturing processes



# Process Specification Language

- ▶ A neutral, standard description of manufacturing processes expressed in KIF
- ▶ A core ontology and extensions for each process domain
- ▶ Translation mechanisms between individual applications and PSL
- ▶ Two pilot implementations completed

<http://www.mel.nist.gov/psl>

# Some axioms in PSL

- ▶ Core concepts
  - activity, object, timepoint
  - activity occurrence
- ▶ Concepts for object
  - resource roles, paths, sets, usage, etc...
  - states
- ▶ Relations
  - before, begin\_of, participates\_in

<http://www.mel.nist.gov/psl/psl-ontology/>

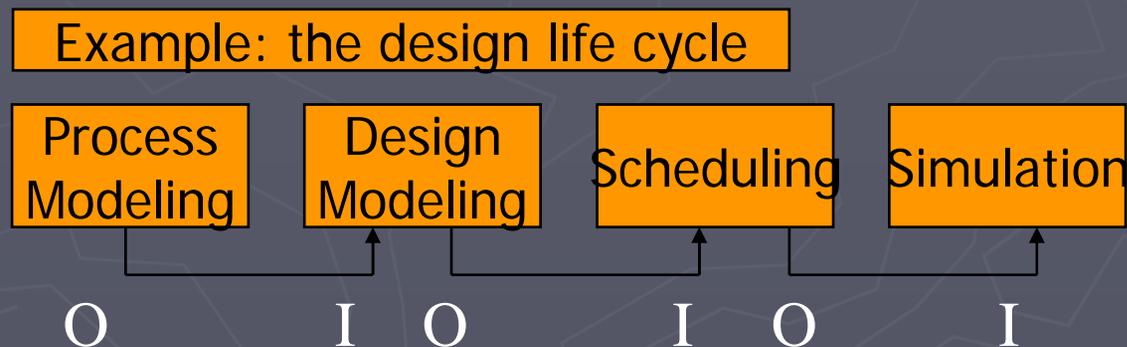
# Process Exchange using PSL

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

# The need for interoperability

- ▶ The ability to **share technical and business information throughout an extended enterprise (supply chain)** implies:

- The ability of software on multiple machines from multiple vendors to communicate, in particular,
- The ability to exchange data, processes and information

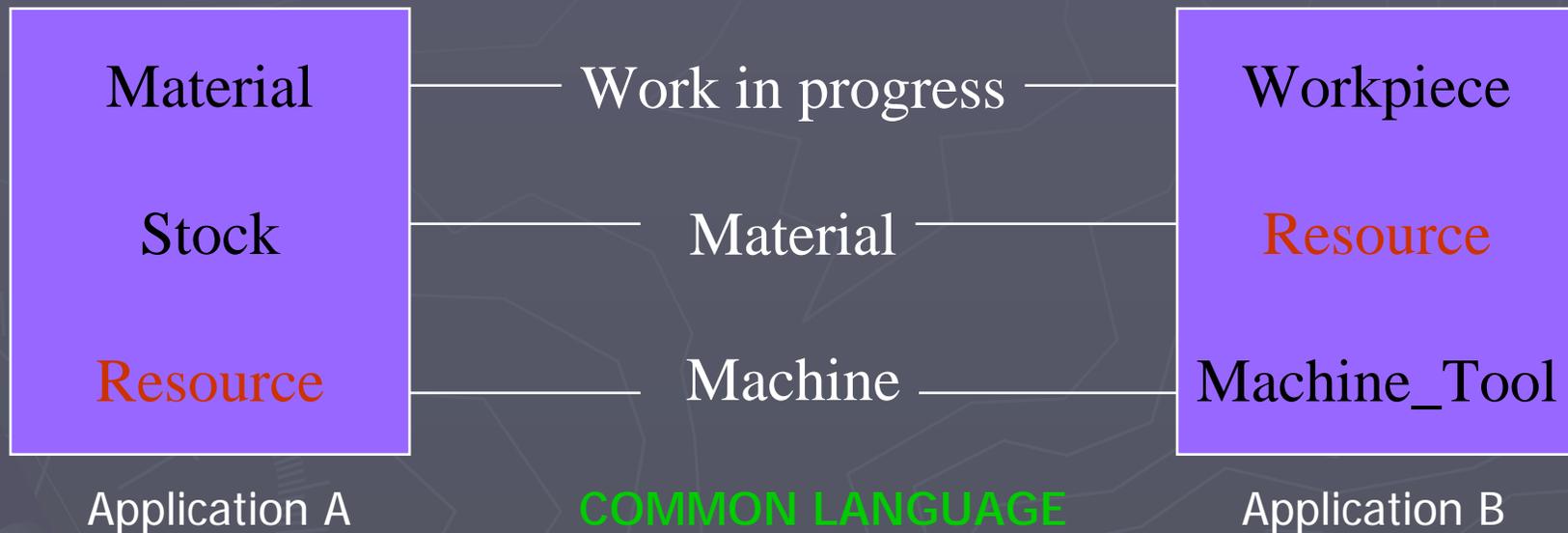


- ▶ The cost of a lack of interoperability:

- The US automotive sector expended **\$ 1 billion per year in 1999 to resolve interoperability issues**
- 50% of this cost attributed to data file exchange.
- Study commissioned by the National Institute of Standards and Technology

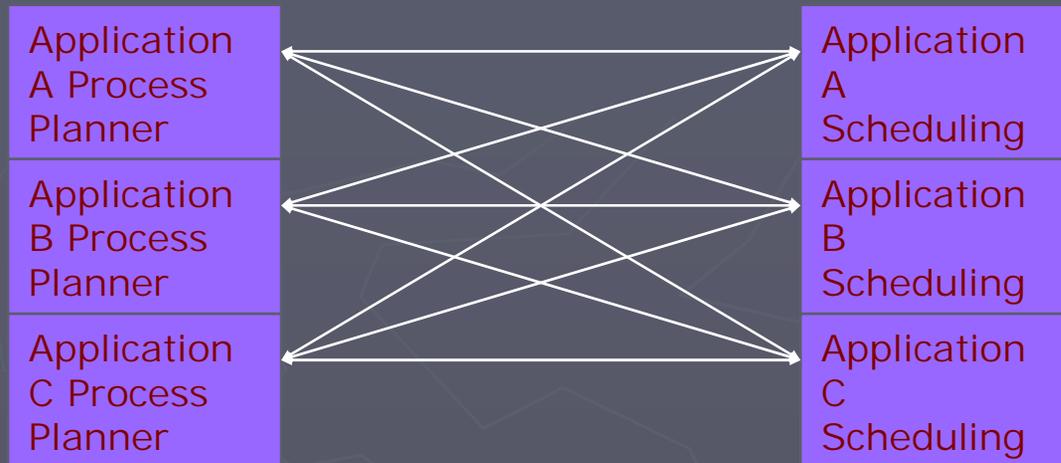
# Challenges to interoperability

- ▶ 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

# When should we use the Process Specification Language?



## Scenario 1

- n planners,
- m schedulers,
- $m * n$  translators

## Scenario 2: use of PSL

- n planners,
- m schedulers,
- $m + n$  translators



# Who is the target audience for PSL?

## ► End users

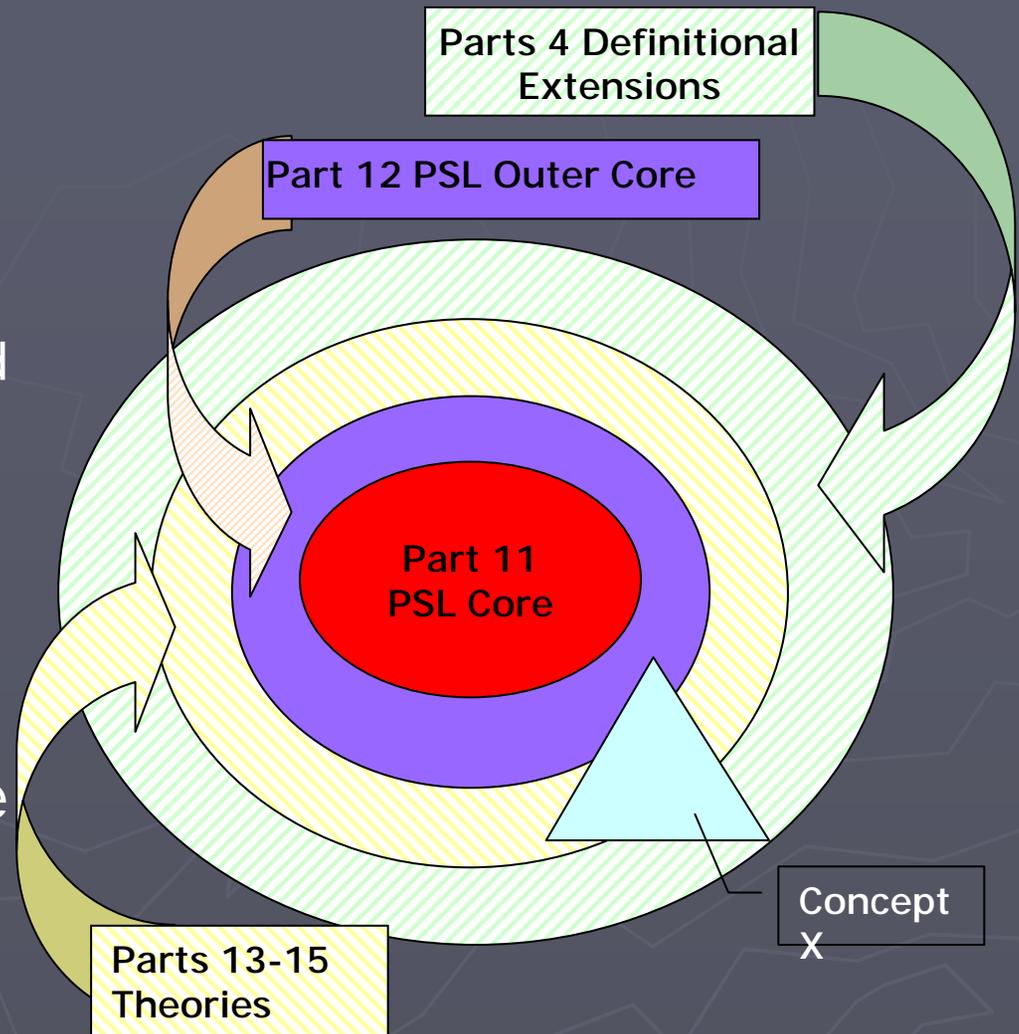
- Engineers, staff, anyone who needs to exchange process information among applications within their company
- Collaborators from partnering companies
- Suppliers and customers in vertical integration

## ► Prescribers

- Software developers and vendors who produce the design tools, such as CAD, project planning softwares, etc...need to incorporate PSL translators into their tools
- Make design tools PSL compliant.

# The Architecture of PSL

- ▶ A computer-readable language
  - specifies entities such as concepts, terminology, and relationships for manufacturing processes
  - includes axioms constraining the use of entities and relationships between them
- ▶ Structure of the language
  - A core and outer core
  - Theories
  - Definitional extensions



# 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

# *Some definitions*

- ▶ Definitions [in an ontology] associate the names of entities of discourse (i.e. classes, relations, functions or other objects) with human-readable text describing what the names mean, and formal axioms that constrain the interpretation and well-formed use of these names. (Huhns and Singh, 1997, "Ontologies for agents")
- ▶ A theory defines its ontology by defining entities which exist in its reality. These entities cannot be reduced or eliminated by analysis from the theory.

# Standardization: ISO 18629, SC4, TC 184

## ▶ 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 2X: External Mappings

- EXPRESS, XML, UML

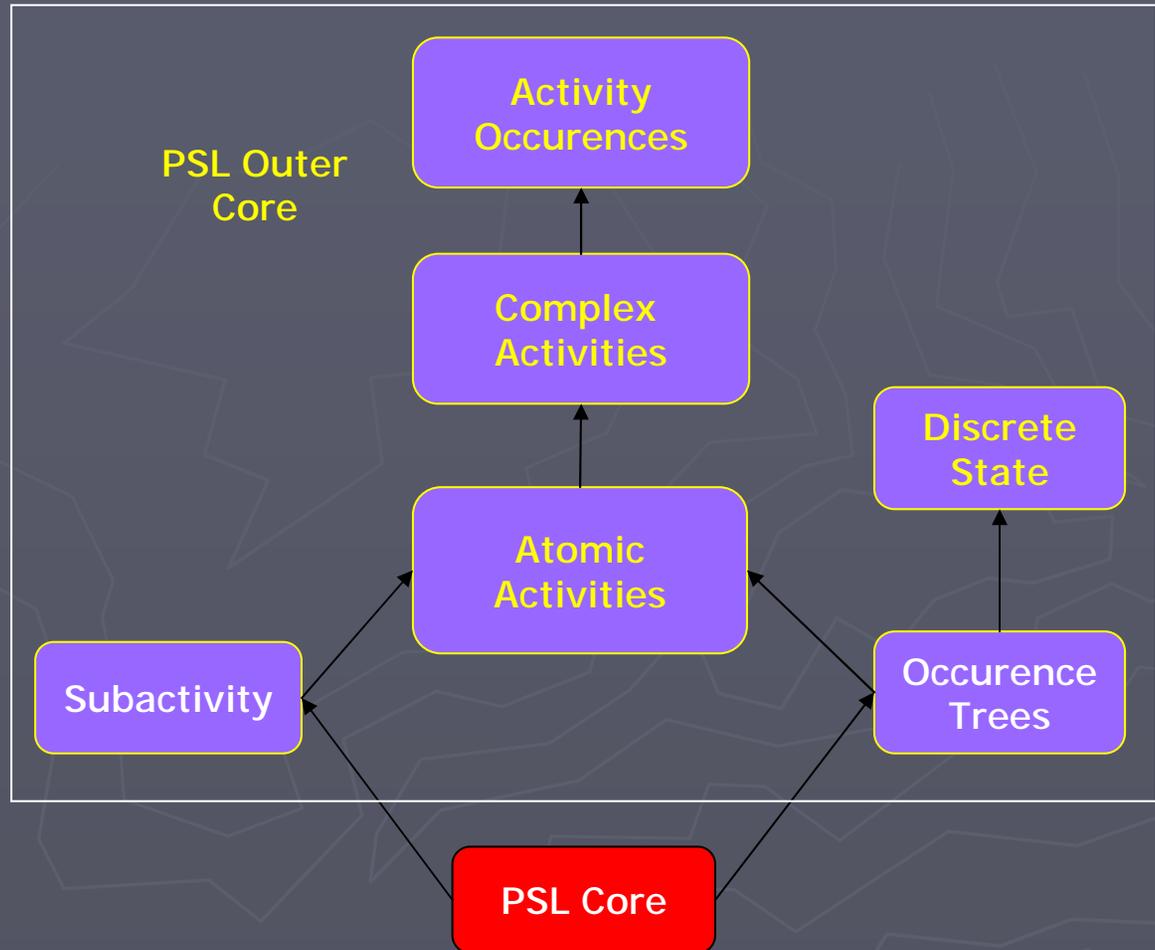
## ▶ Part 40 Series: Definitional Extensions of PSL

- 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

# PSL Core, Outer-core, and Dependencies

## PSL Core

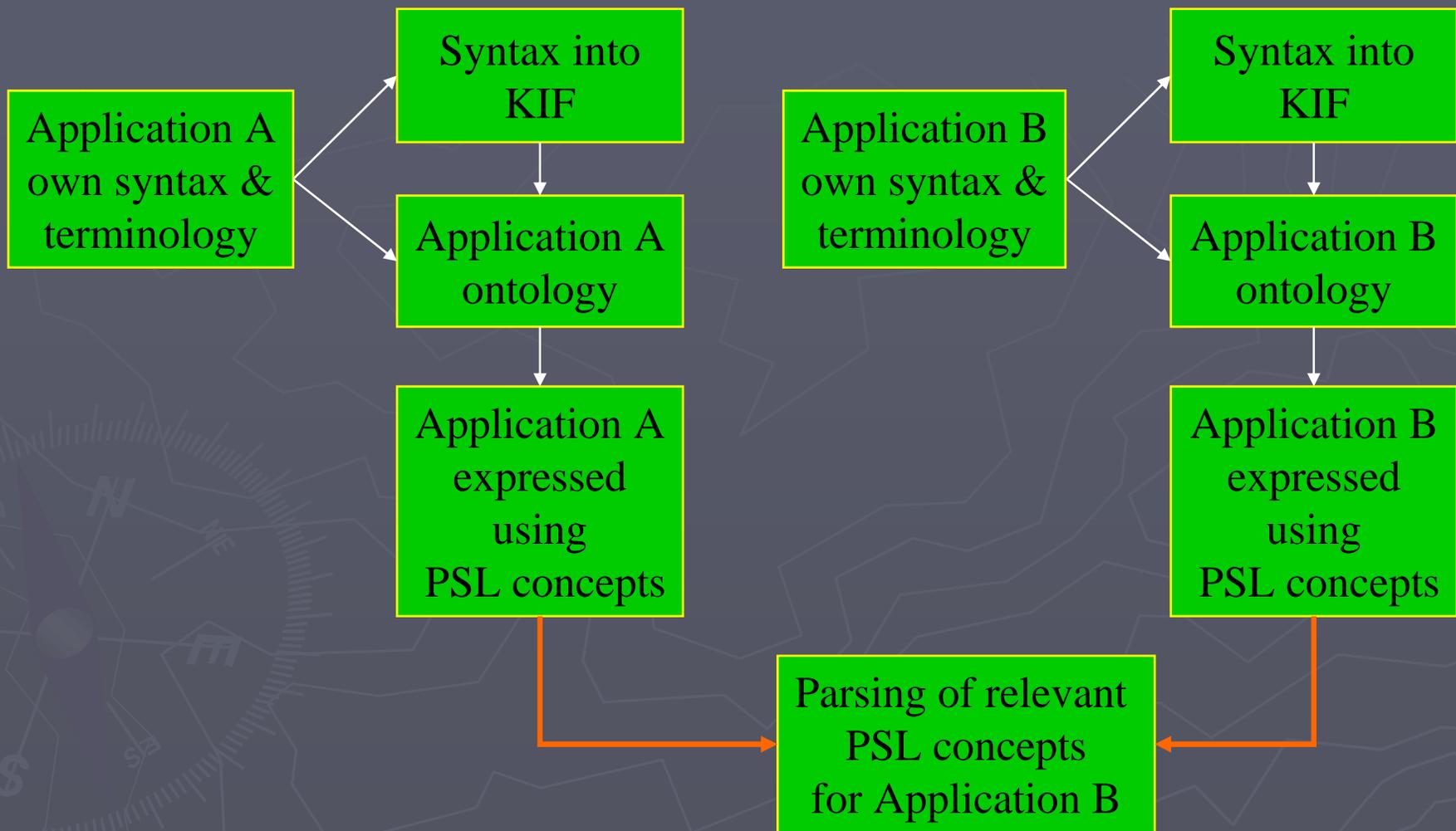
- ▶ Activity
- ▶ Activity\_occurrence
- ▶ Timepoint
- ▶ Object
- ▶ Before
- ▶ Occurrence\_of
- ▶ Participates\_in
- ▶ Beginof
- ▶ Endof
- ▶ Inf+, Inf -



# Using PSL for translating between two applications

- ▶ Syntactic translation for two applications
  - Application native syntax is parsed to PSL syntax
  - Application concepts are expressed in KIF
- ▶ Semantic translation
  - KIF definitions are written for application concepts using PSL reserved terminology and relations
  - A 20-question wizard assists in the process
- ▶ Application A concepts are translated to PSL
- ▶ Application B concepts are translated to PSL and a reverse index is created.

# Process Exchange using PSL



# Expressing Application A concepts using PSL

1

```
(forall (?r)
  (=> (inject_mold)
      (rA ?r)))
```

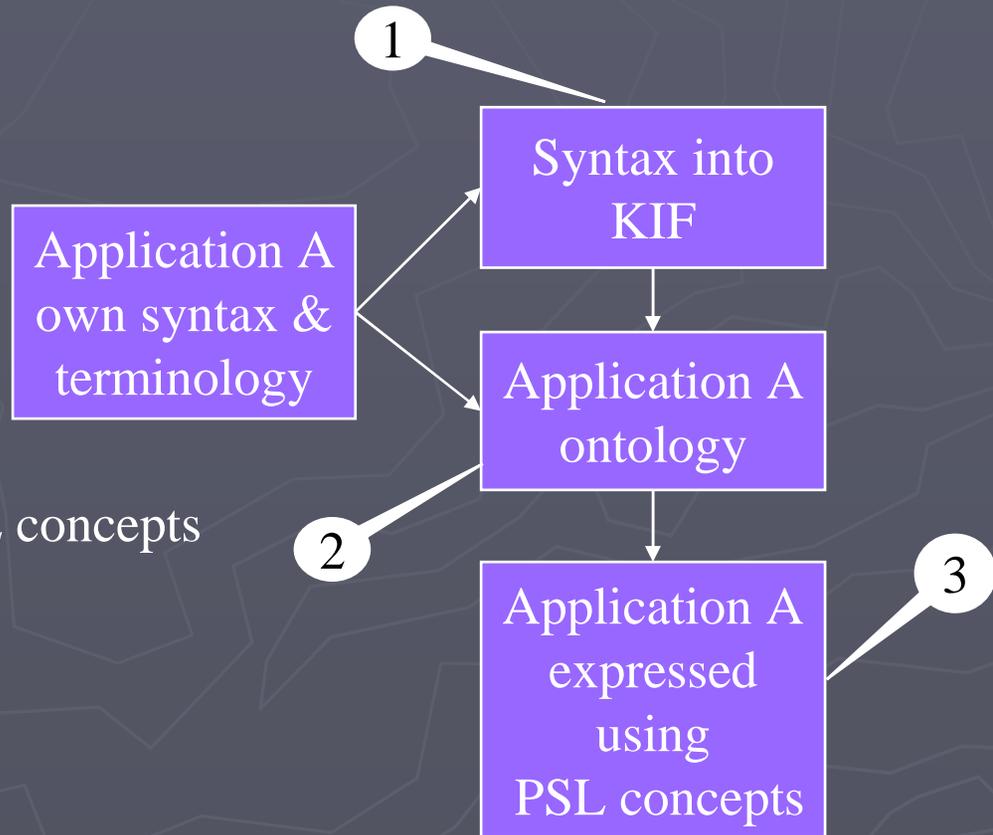
2

```
(forall (?r ?a)
  (<=> (rA ?r)
      (exists (?a)
        (reusable ?r ?a))))
```

3

Unconditional mapping to PSL concepts

```
(forall (?r)
  (<=> (rA ?r)
      (and resource ?r)
      (reusable ?r)))
```

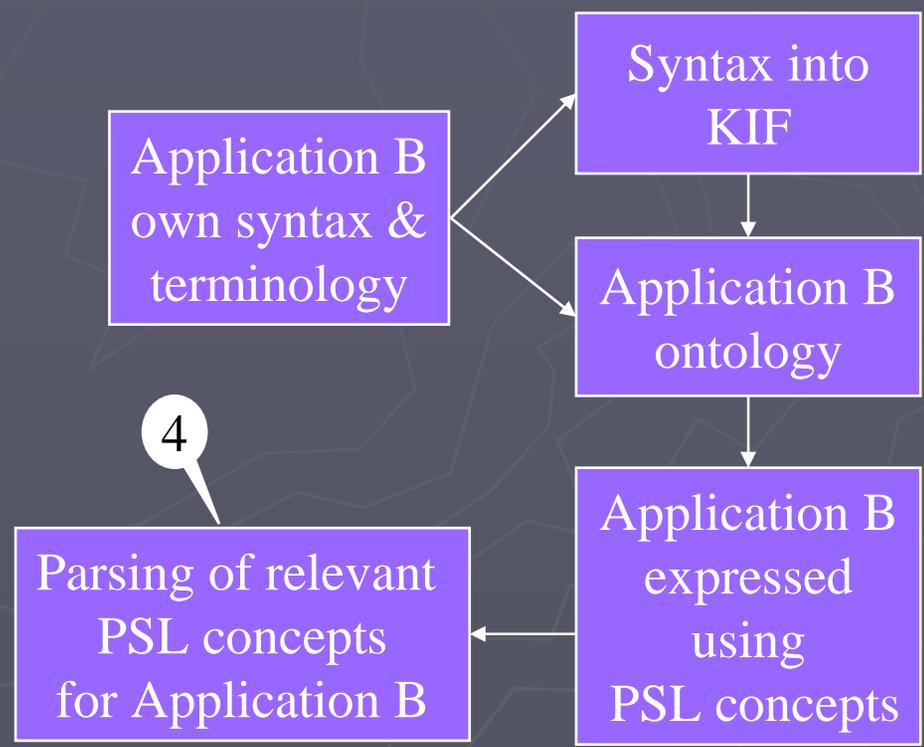


# Expressing Application B concepts using PSL

4

One additional step:  
inverting the table

(Application B => PSL)  
(PSL => Application B)



4

# Twenty Question Wizard

The screenshot shows a web-based wizard interface. At the top, there is a header with the 'PSL' logo on the left, 'Manufacturing Systems Integration Division' in the center, and the 'NIST' logo on the right. Below the header, a blue banner contains the text '20 Questions'. A breadcrumb trail reads 'home >> 20 questions >> atomic activities'. The main content area is titled 'Classes of Atomic Activities' and features a 'Class Name' input field. Below this, the section 'Constraints on Atomic Activity Occurrences' is introduced with a descriptive paragraph. Two numbered questions are presented, each with a checkbox and a text description. The first question asks about unconstrained occurrences, and the second asks about state-based constraints. A sidebar on the left contains various navigation links, and a footer at the bottom left includes a privacy notice and technical contact information.

PSL Manufacturing Systems Integration Division NIST National Institute of Standards and Technology

20 Questions

home >> 20 questions >> atomic activities

### Classes of Atomic Activities

Class Name:

#### Constraints on Atomic Activity Occurrences

The first set of questions characterizes the conditions under which atomic activities can possibly occur; these are often referred to as the preconditions for the activity.

- 1. Unconstrained Atomic Activity Occurrences**

Are there any constraints on the occurrence of the atomic activity?

  - There are no constraints on the occurrences of the atomic activity; the activity is always possible.
  - There are constraints on the occurrences of the atomic activity, but the activity is always possible after occurrences of certain other activities.
  - There are constraints on the occurrences of the atomic activity, there are circumstances under which the activity is not possible and cannot occur, no matter what other activity occurrence preceded it.
- 2. Constraints on Atomic Activity Occurrences based on State**

Are the constraints on the occurrence of the atomic activity based only on the state prior to the activity occurrence?

  - Any occurrence of the activity depends only on fluents that hold prior to the activity occurrence.

Privacy/Security Notice/Disclaimer

NIST is an agency of the U.S. Commerce Department's Technology Administration.

Technical Inquiries: PSL Team

PSL

# Interoperability in Construction

- ▶ Scenario: The design and construction of an office building
- ▶ Includes an exchange of data regarding fitting a metal door to a wall frame
- ▶ Use of an AutoCAD software
- ▶ Use of Microsoft Project for the planning phase

Credit: Genet Tesfagaber, Loughborough University

# AutoCAD Process "door frame assembly" using PSL

```
(forall (?a)
  (↔(doorframe_assembly)
    (and (activity ?a)
      (constrained ?a)
      (markov_precond ?a)
      (rigid_time ?a)
      (rigid_mixed ?a)
      (context_free ?a)
      (markov_effects ?a)
      (non-temporal ?a)
      (rigid_mixed effects ?a)
    )))
```

the activity occurrence is  
not possible under  
certain circumstances

the occurrence depends  
on the state of other  
activities

the occurrence does not  
depend on the duration  
of other activities

# MS Project Task “door frame assembly” using PSL

```
(forall (?a)
  (↔(doorframe_assembly)
    (and (activity ?a)
      (constrained ?a)
      (markov_precond ?a)
      (time_precond ?a)
      (mixed_precond ?a)
      (context_free ?a)
      (rigid_state_effects ?a)
      (rigid_time_effects ?a)
      (rigid_mixed_effects ?a)
    )))
```

the activity occurrence is not possible under certain circumstances

the occurrence depends on the state of other activities

the initiation depends on the duration of other activities

# Future challenges and issues

- ▶ Logically defined specification of processes
  - Mathematical operators and logical format
  - Quality/success is measurable (consistency checking)
- ▶ Automation of translation has been prototyped
  - Implemented translation of processes between an IDEF3 planner and a C++ scheduler
- ▶ May serve as an ontology for an agent-based system
- ▶ Implementation of translators in the products of software vendors
  - Socio-cultural issues prevail
- ▶ Need to reach critical mass for design and associated software applications
- ▶ Currently no Web implementation or use of state-of-the-art Web protocol
- ▶ Diffusing and accessing the standard

# Acknowledgements and contacts

- ▶ Pr. Anne-Francoise Cutting-Decelle
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- ▶ Jean-Jacques Michel
  - Idpiconseil, ISO SC4 convener for PSL and Mandate
- ▶ Michael Gruninger (NIST)
- ▶ <http://www.mel.nist.gov/psl>
- ▶ <http://www.csm.ornl.gov/~7lp>

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