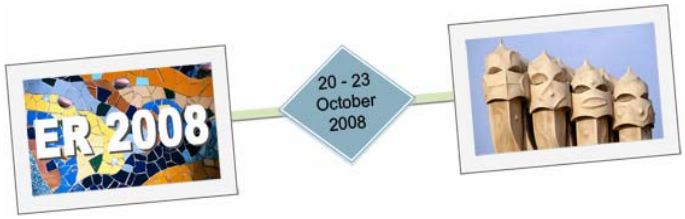

INVENTIVE

An Upper-Level Ontological Model for Engineering Design Performance Domain

Vadim Ermolayev, Natalya Keberle
Zaporozhye National University, Ukraine (100%)

Knowledge engineering

Wolf-Ekkehard Matzke
Cadence Design Systems GmbH, Germany, US

Agents, domain expertise

Oct. 21, 2008, Barcelona

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The Plan

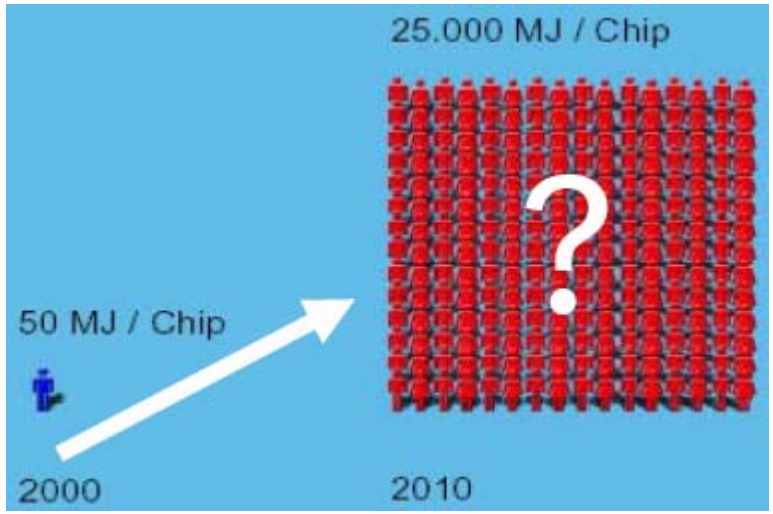
- Material that is important, but not in the paper …
  - Space constraints, or some progress beyond the CR

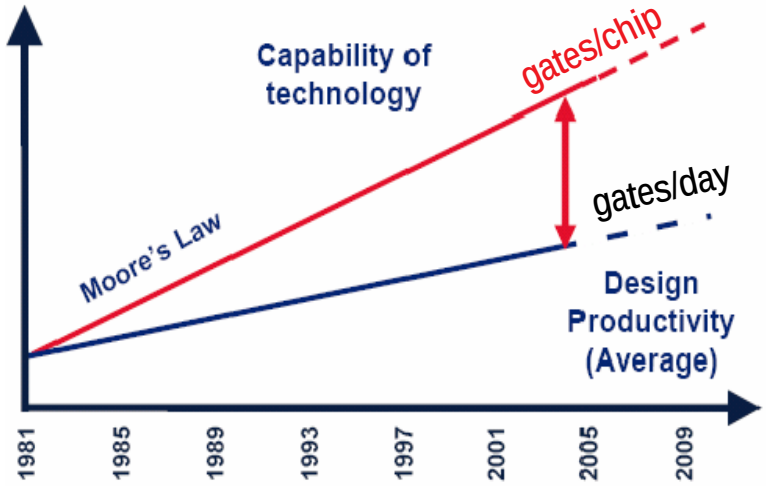
- Why do we need an Upper-Level model?
- Ontological choices and the relationship to the rest
  - PSI Core, …
- Some topical modeling decisions
  - Events and Actions, Actions and Patterns, Agents, Stateful Processes, Environments
  - Relationships to PSI Core
  - The deeper we go – the more formal semantics is elaborated
    - PSI Upper-Level ← PSI E2H ← PSI Time Full
- Implementation, methodology, and evaluation
- Conclusions and outlook

Performance Simulation Initiative (PSI)

- Performance Gap
- R&D project of Cadence Design Systems GmbH
  - 2004 - ongoing
  - Goal: Assess and Manage Performance in Engineering Design
  - Domain: Microelectronics and Integrated Circuits
  - Method: knowledge-intensive, agent-based simulation of:
    - A Design System and
    - A Dynamic Engineering Design Process
- A “horizontal” framework:
  - Plugged-in focused activities
  - Deepening and broadening the Domain in other projects
    - PRODUKTIV+ (BMBF, http://www.edacentrum.de/produktivplus/)
      - Performance metrics
    - ACTIVE IP (EC FP7, http://active-project.eu/)
      - Knowledge process model

Peter van Staa, Inv. talk at HoloMAS’2007





(Source: International Technology Roadmap for Semiconductors)

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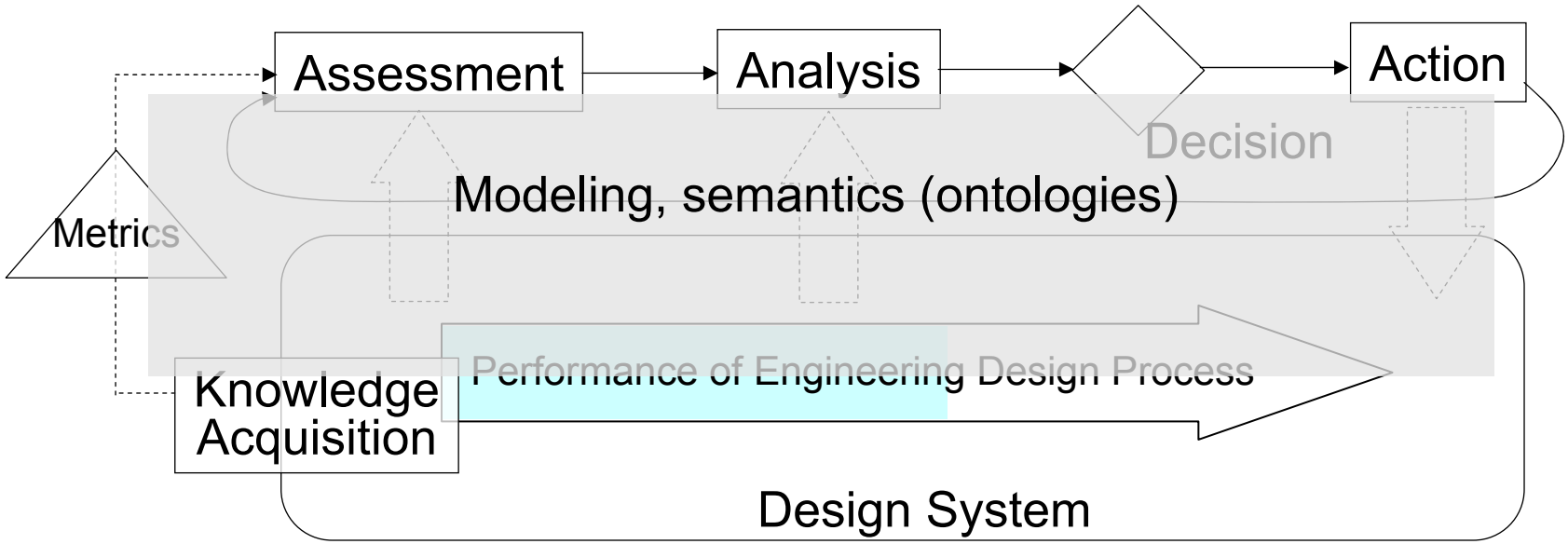
Performance Assessment and Management

Engineering Design Processes, Microelectronics and IC



"Design productivity breakthroughs [are] mandatory to win the design race!"

Peter van Staa, Bosch Automotive Electronics

Inv. talk at HoloMAS'2007

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Why Developing the Upper-Level?

- A Hobby Horse?
  - Fellow partners, peer reviewers …
  - An (ugly) combination of (intended) academic rigor and solid industrial basics?
- Consensual Domain theory for Engineering Design
  - Foundational theories do NOT always FIT PERFECTLY – to be corrected
  - Semantic bridge for alignments
    - E.g. PSI Core to PRODUKTIV+ Extensions
- A broader view of Knowledge Processes
  - ACTIVE:
    - Semantic bridge to the case study Domain representation
    - An “umbrella” theory for the emerging Knowledge Process model
- Methodological reasons
  - Important step in Domain Ontology refinement process
  - E.g. checking by commonsense theories …
  - Making ontological commitment easier

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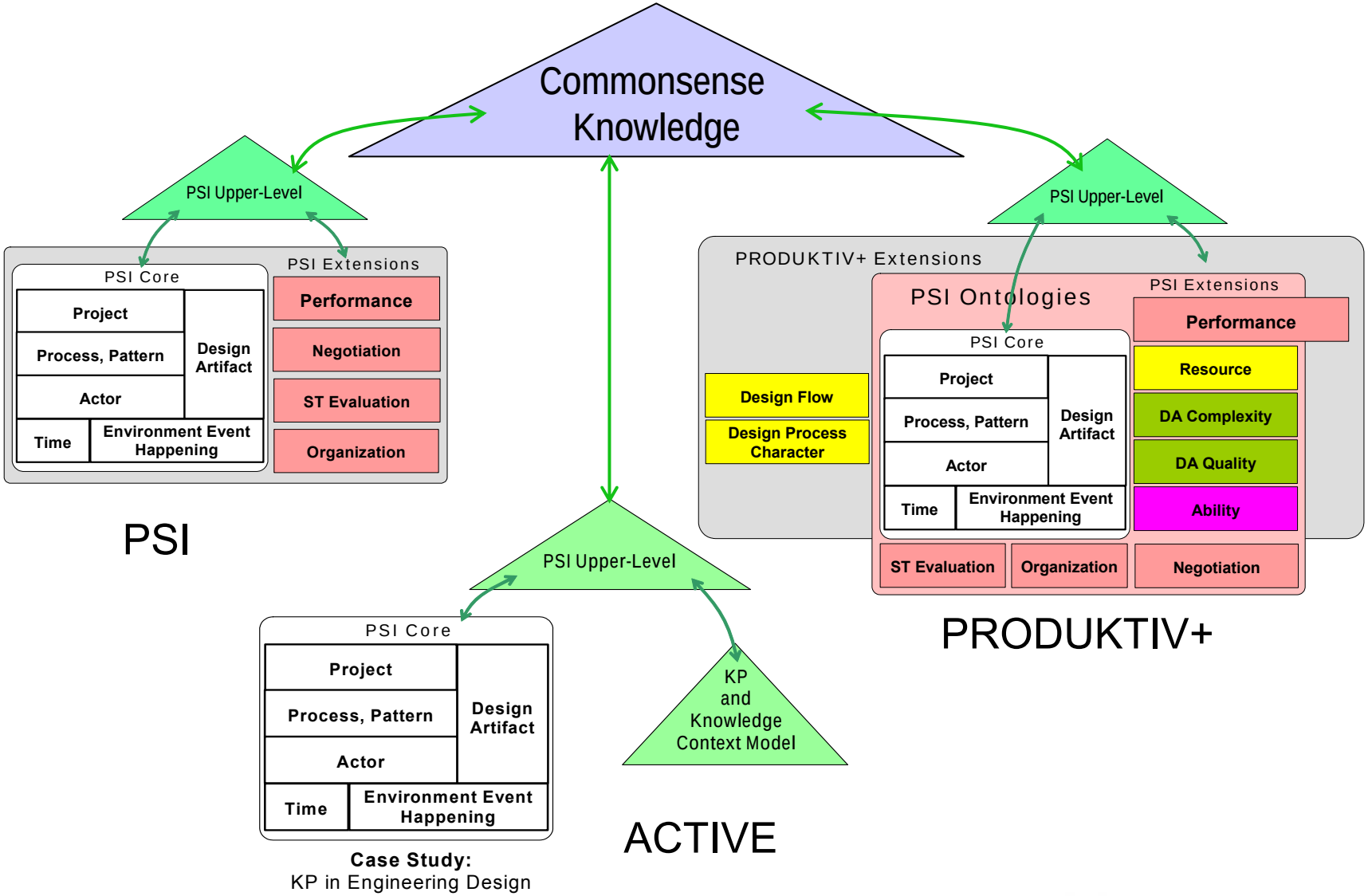
Why Developing the Upper-Level?



Case Study:
KP in Engineering Design

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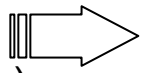
Ontological Choices …

- Descriptive (no revisionary metaphysics)
  - Describing ontological assumptions based on the surface structure of Domain knowledge and human common sense
  - A “referential” theory
    - More elaborated formal semantics in lower-level Domain theories (PSI Core)



- Multiplicative (no reductionism)
  - Allowing different entities to be co-localized in the same space-time
    - An Agent may be an individual or a team of individuals
- Possibilistic
  - Possible alternative entities correspond to different modalities in different possible worlds
    - Alternative follow-up Actions in a Process are different Possibilia
- Perdurantistic (still allowing Endurants)
  - Environments, Phenomena, Events are Perdurants …

- SUMO+WordNet
- The most upper part of DOLCE taxonomy

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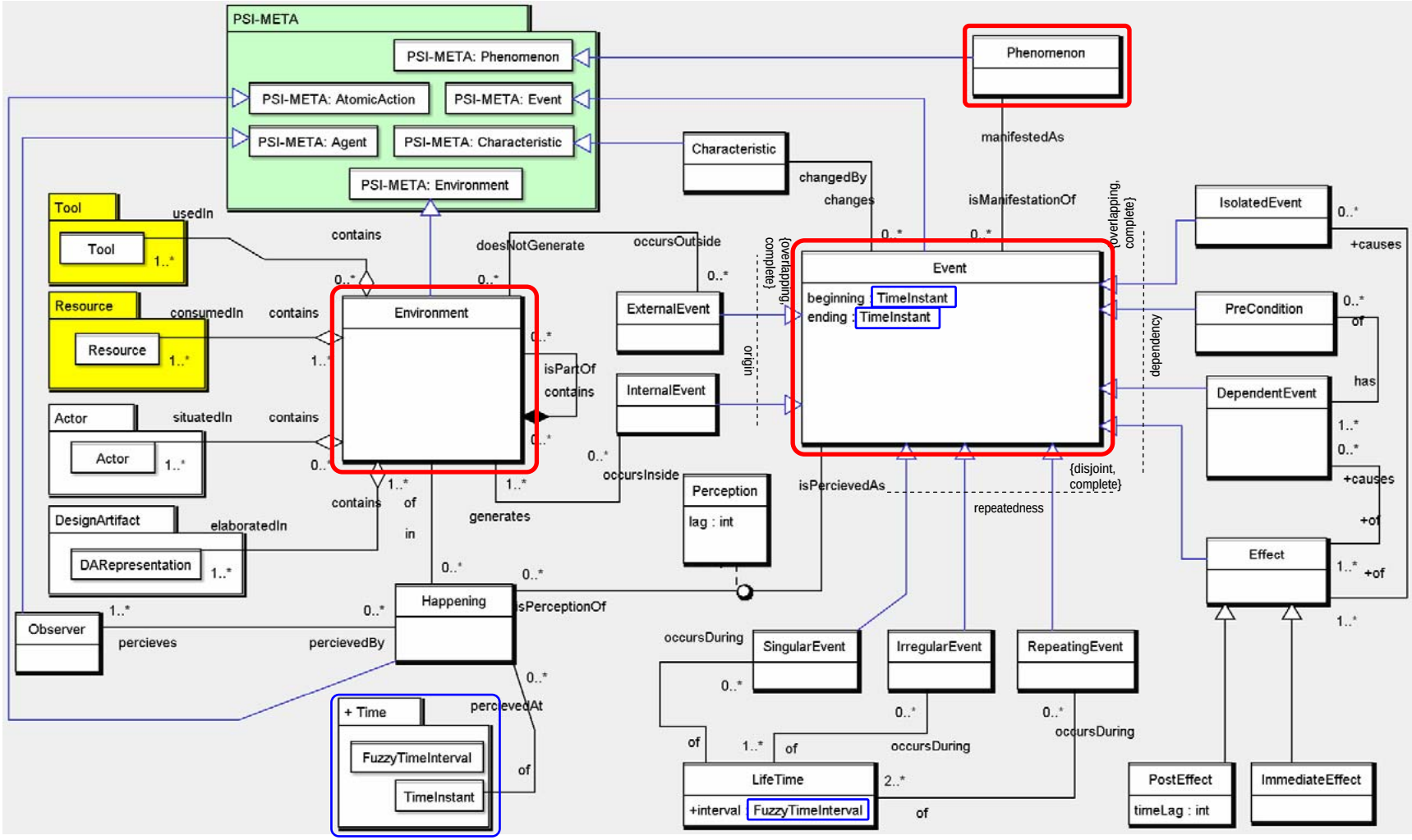
More Semantics Downwards: E2H←Time Full



Ermolayev, V., Keberle, N., Matzke, W.-E.: An Ontology of Environments, Events, and Happenings. In: Proc 31st IEEE COMPSAC 2008, Turku, Finland, Jul. 28 - Aug. 1, 2008, 539-546

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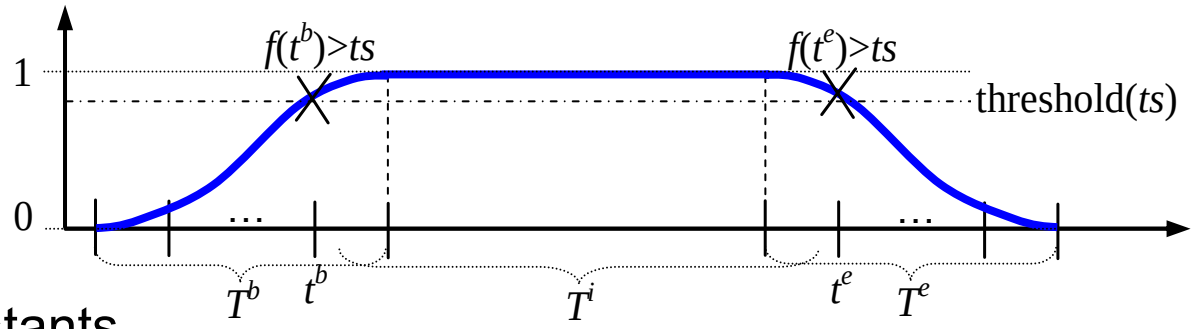
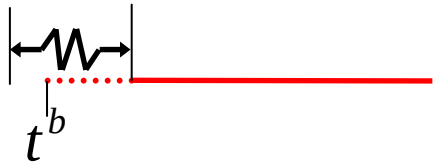
Time Full: Fuzzy Extension of Time Crisp (Allen)



- Fuzzy time interval:
  $I = \{T^b, T^i, T^e, f\}$
- T^i - the Core – inner instants
- Beginning and Ending sets:
  - Beginning ($T^b = \{t_j^b\}$): $\forall t_j^b : t_j^b > t^b \rightarrow t_j^b \in T^i$
  - Ending ($T^e = \{t_j^e\}$): $\forall t_j^e : t_j^e < t^e \rightarrow t_j^e \in T^i$



- Discrete membership function: $f : Z \rightarrow [0,1]$ - individual for Agents
- Thresholds: reputation and confidence
- Rich set of axioms extending (fuzzyfying) Allen's time interval logic

Ermolayev, V., Keberle, N., Matzke, W.-E., Sohnius, R.: Fuzzy Time Intervals for Simulating Actions. In: Kaschek, R., Kop, C., Steinberger, C. and Fliedl, G. (Eds.) Proc. UNISCON 2008, Apr. 22–25, 2008, Klagenfurt, Austria, LNBIP Vol. 5, 429-444

Some Topical Ontological Decisions

- Events vs Actions
- Actions vs Action Patterns
- Atomic and Compound Actions
- Objects and Agents

- Environments

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Event vs Action

- Occasionality vs pro-activity
- Event:
  - An objective manifestation of a tangible change in an Environment
- Action:
  - A kind of an Event
  - Performed by Agent
  - Who has a goal to be reached
  - Decision

Falling
(unintentional)

Acting
(pro-active)

Event vs Action

- Occasionality vs pro-activity
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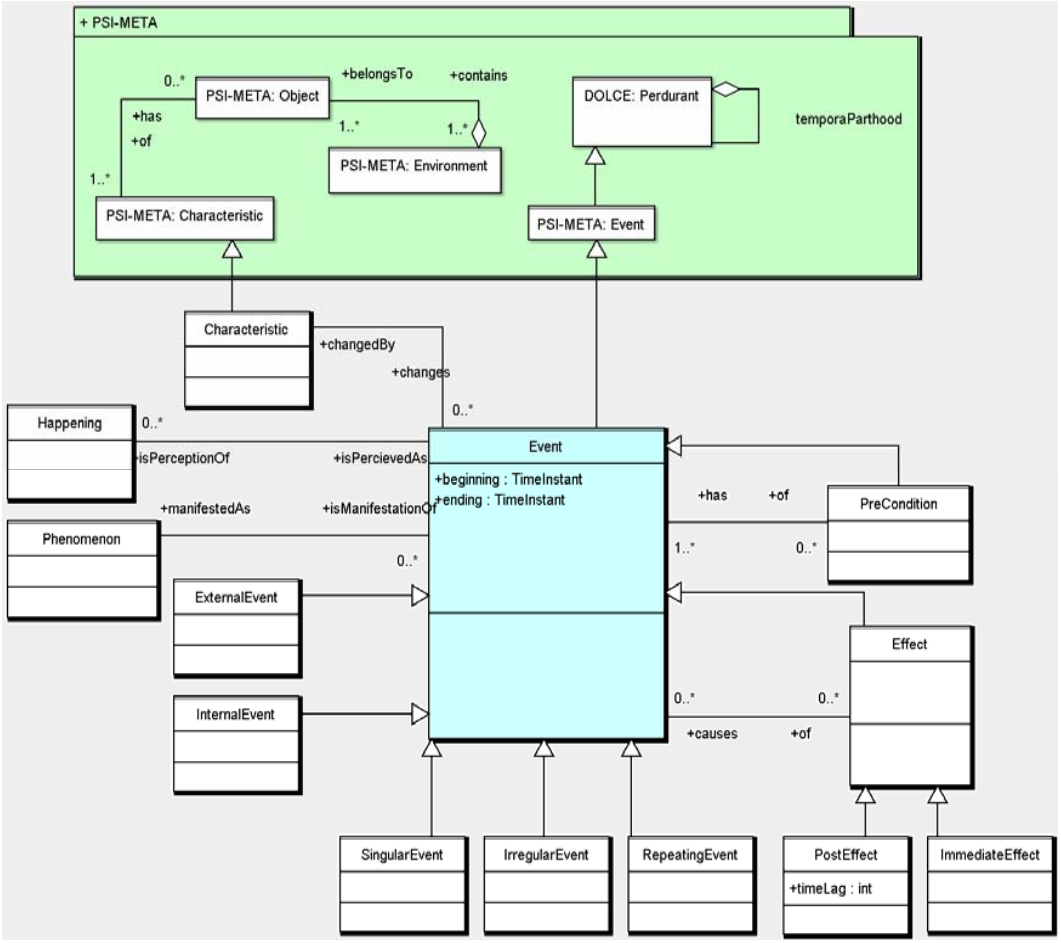
- Action:
  - A kind of an Event
  - Performed by Agent
  - Who has a goal to be reached

- **D**iscrete **E**vent **C**alculus



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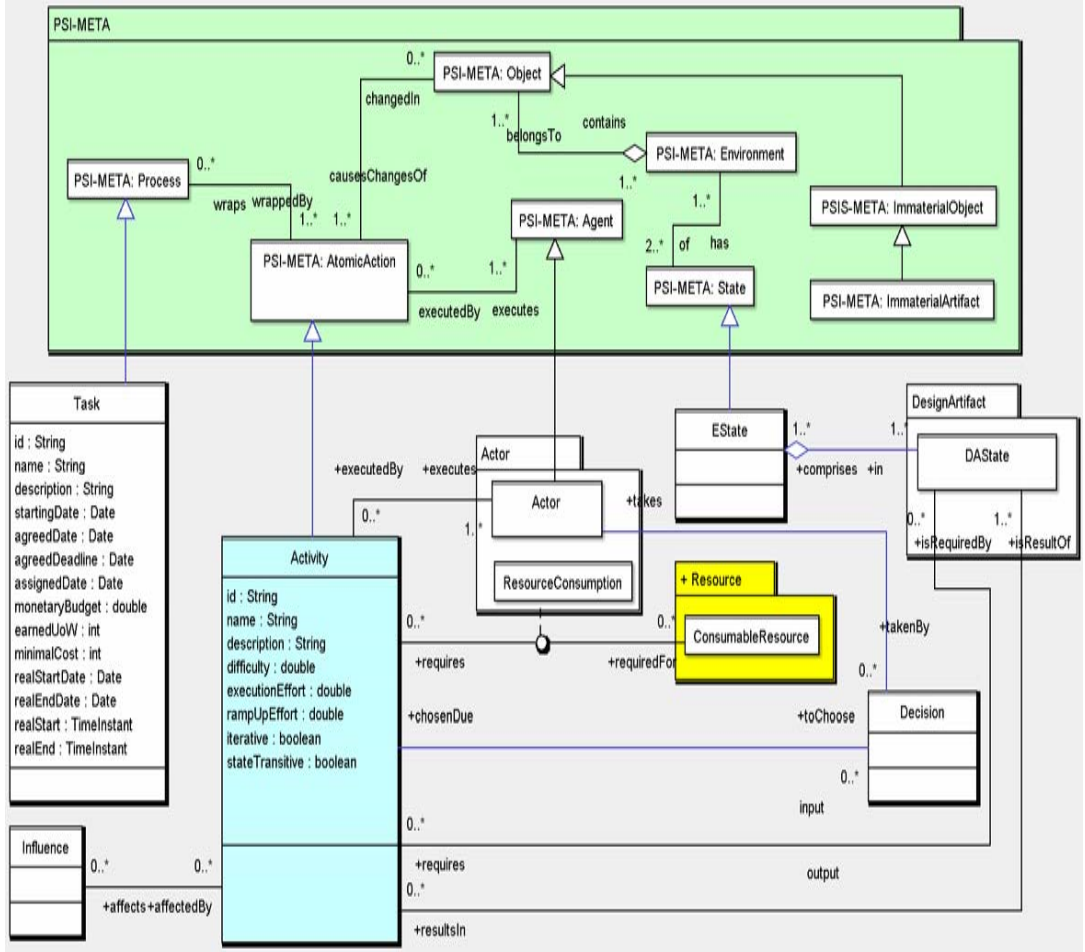
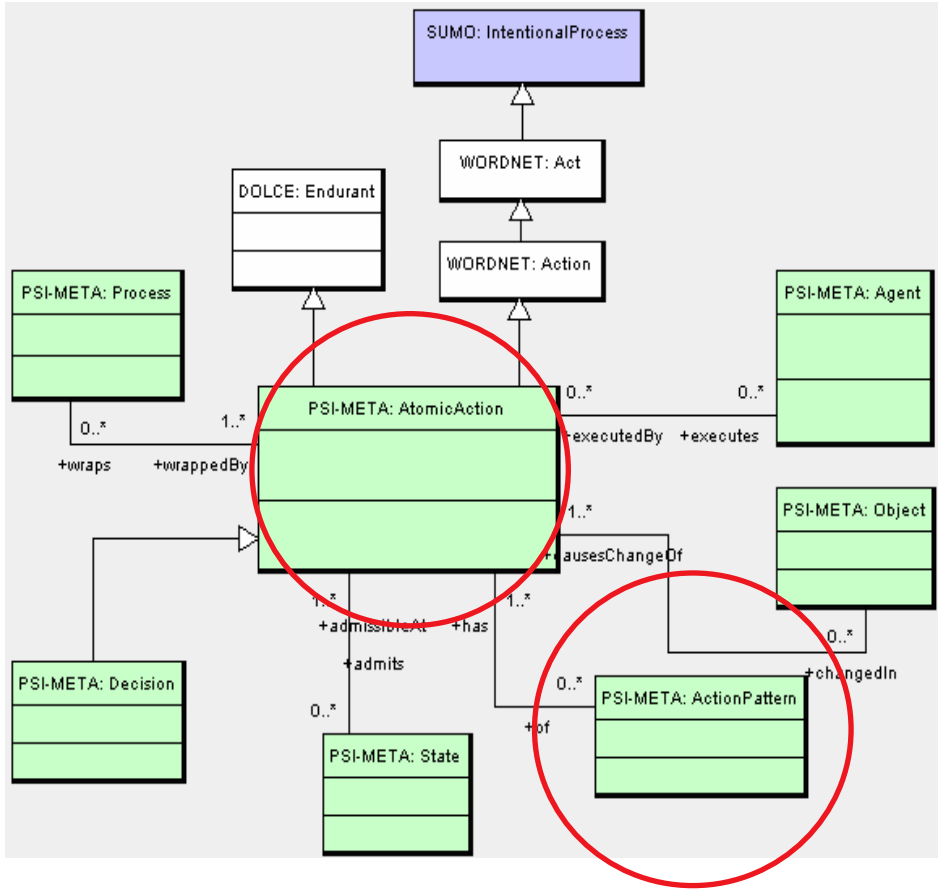


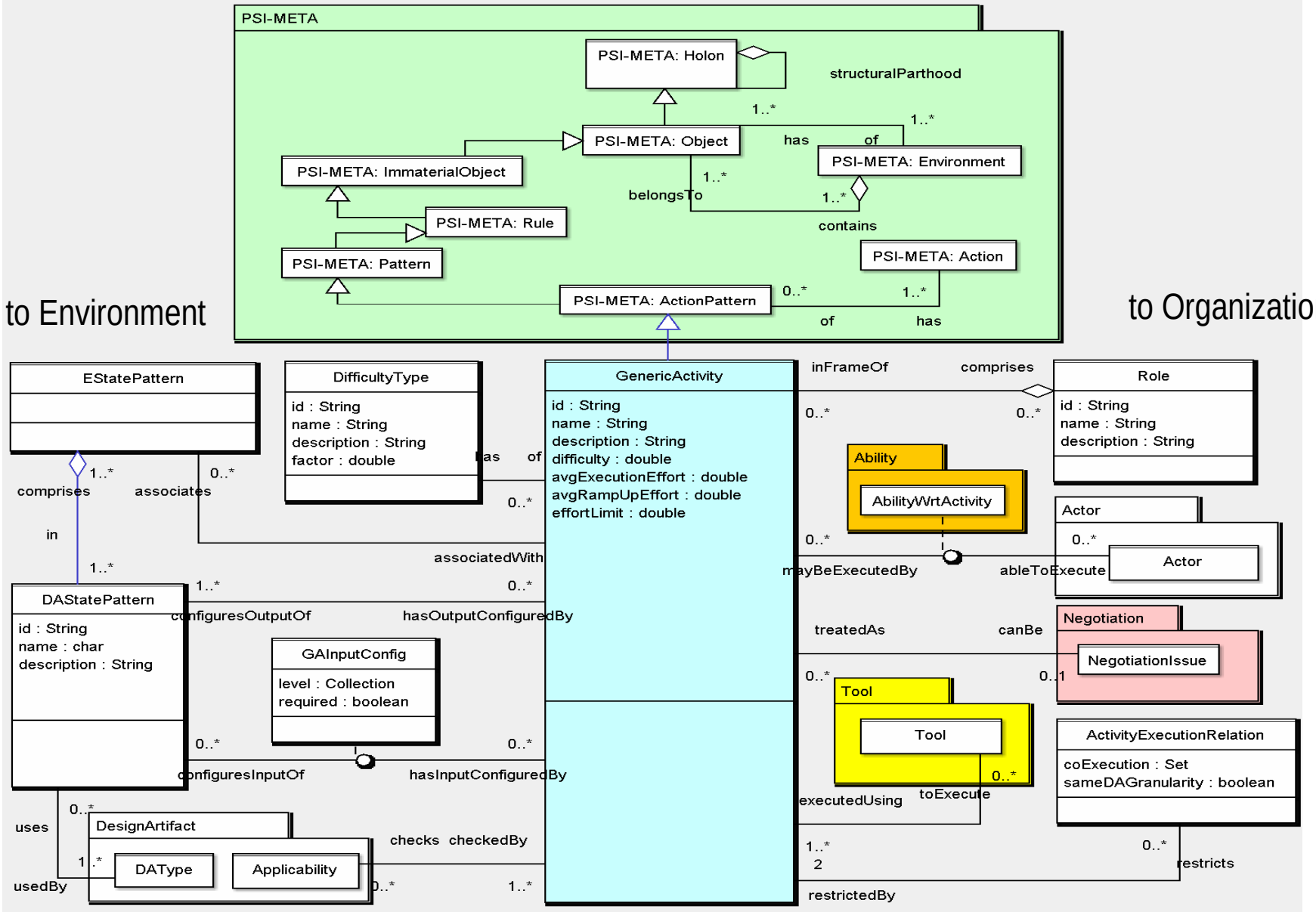
An Action vs an Action Pattern

- Patterns are possible (allowed, suggested) ways to execute
- Actions are executions (pattern enactments)
- To make an Action of a Pattern:
  - Assign the Agent
  - Provide Resources
  - Provide Pre-conditions
  - Check by Policies
  - Initiate …
  - …Enjoy*
- We also have:
  - Process Patterns
  - Behavior Patterns – for Agents
  - State Patterns – for the States of Environments
- More – in PSI Core …



* Not yet in the model …

Activity (Atomic Action) **Pattern**



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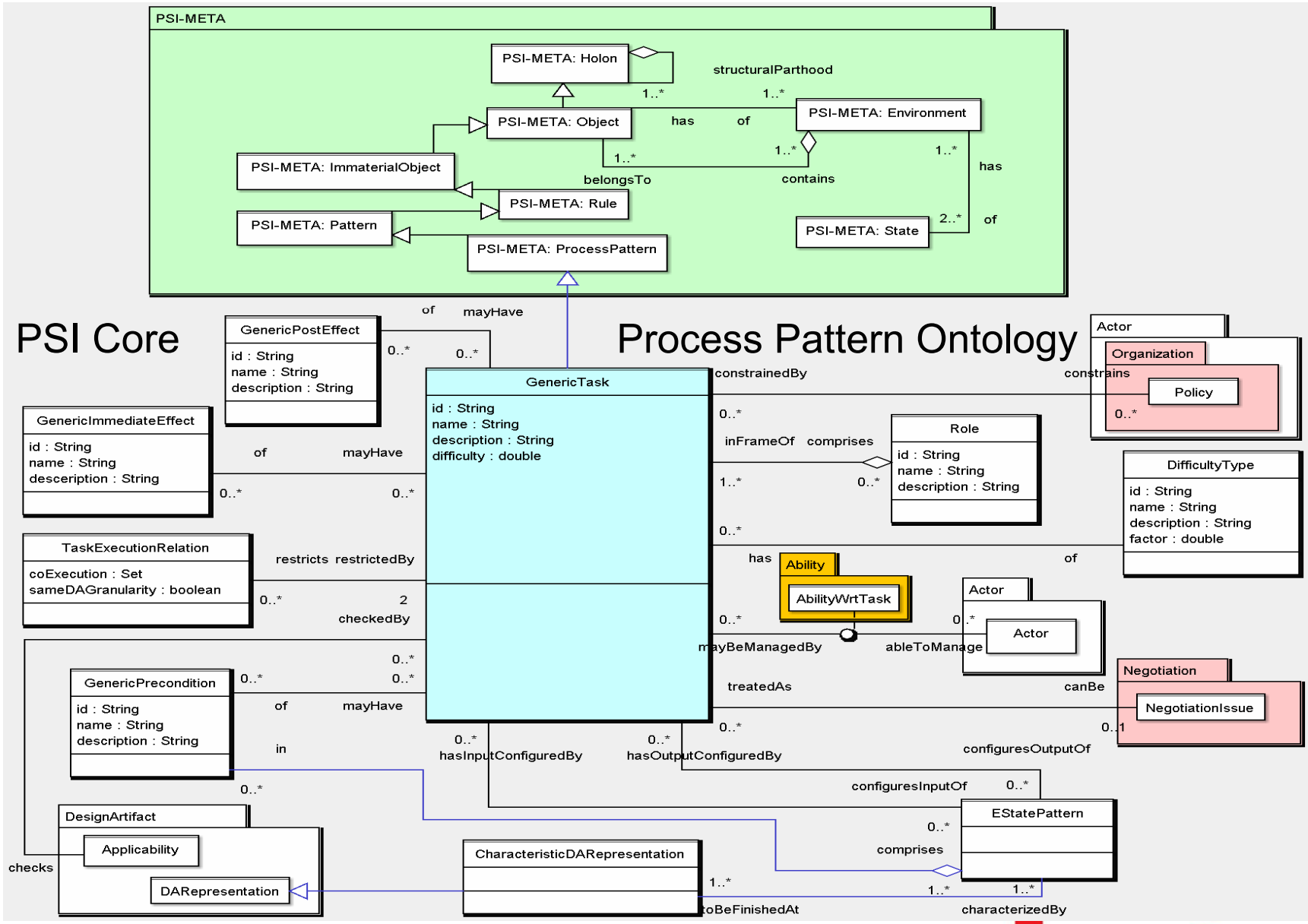
Task (Compound Action - Process) **Pattern**



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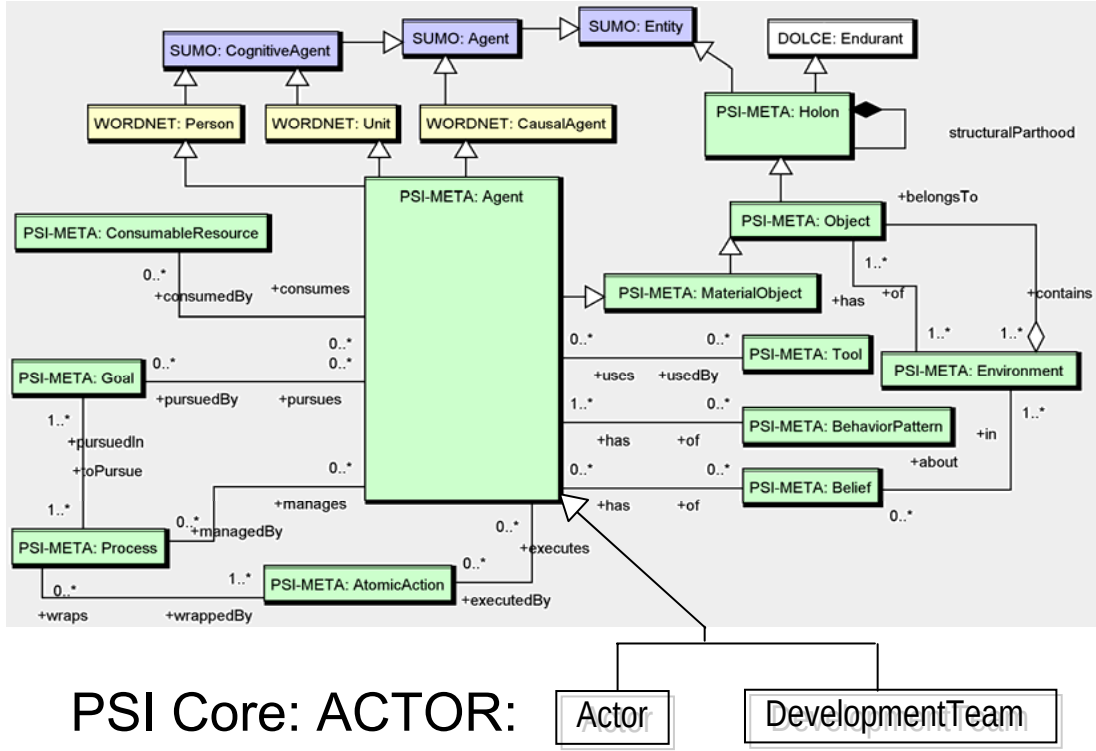
Objects and Agents

- Object:
  - A Holon
  - Belongs to Environment
  - Has Environment
- Agent:
  - **Team and Individual**
  - Pro-active
  - Changes Environment
  - By executing ATOMIC Actions
- Environments and Beliefs of Agents

the Upper-Level view …

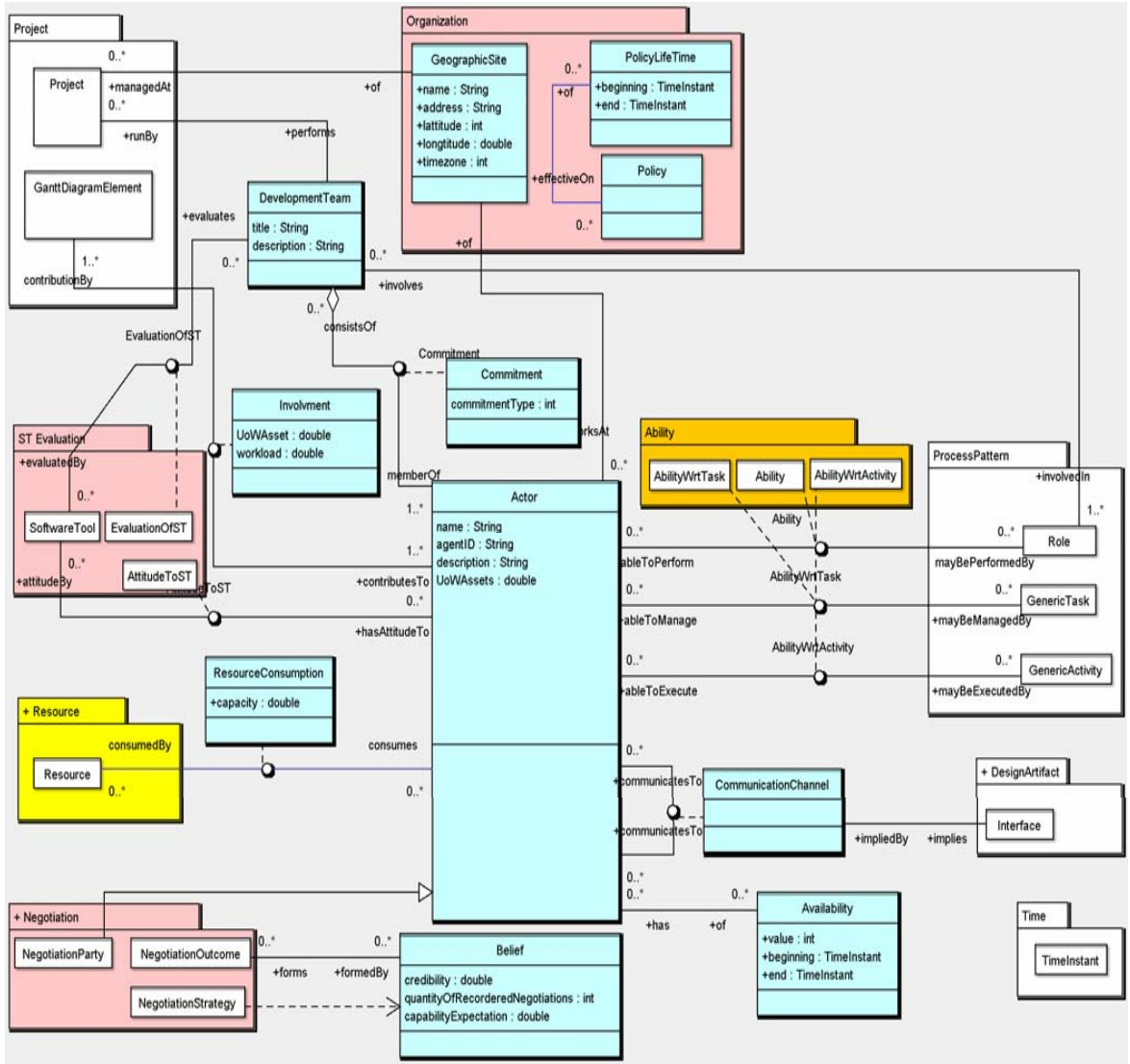


. . . . . .

Actors, Teams → Agents

- Actor
  - Subsumes to PSI-UPPER:Agent
  - Is the member of a Team
  - Communicates to other Actors
  - Has Abilities
  - Consumes resources
  - Contributes to projects
  - May be Available
  - Is related to an Organization at a particular Site
  - …

the Core view



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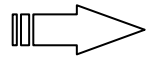
Implementation and User Evaluation

- OWL-DL ontology
- Method: goal-driven evaluation
- Goal: Check if the Ontology fit the requirements of software development
  - Appropriateness, completeness (competency questions)
  - Upward compatibility
- Object: PSI Core v.2.2
  - Developed using PSI Upper-Level
  - Used in the development of Cadence Project Planning Expert System 
- Technique:
  - TBox: automatic conversion of OWL-DL statements to Java classes
  - ABox: automated ontology instance migration from v.2.1 to v.2.2
- Tool: Groovy script using OWLAPI (WonderWeb)
  - Uses Groovy template mechanism
- Result:
  - Minor problems which have been immediately resolved
  - Version fix

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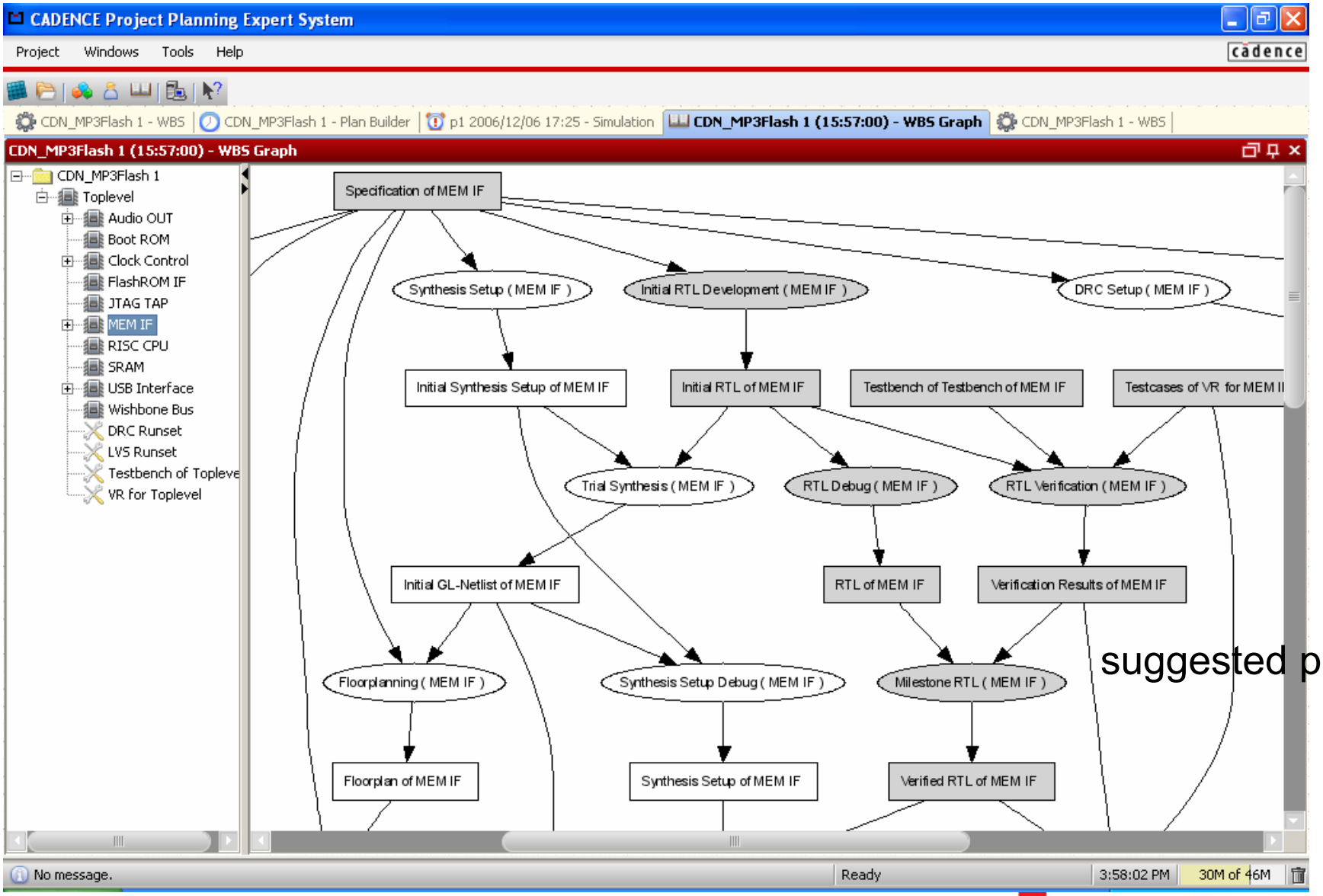
Simulation Tool: WBS generation



suggested path

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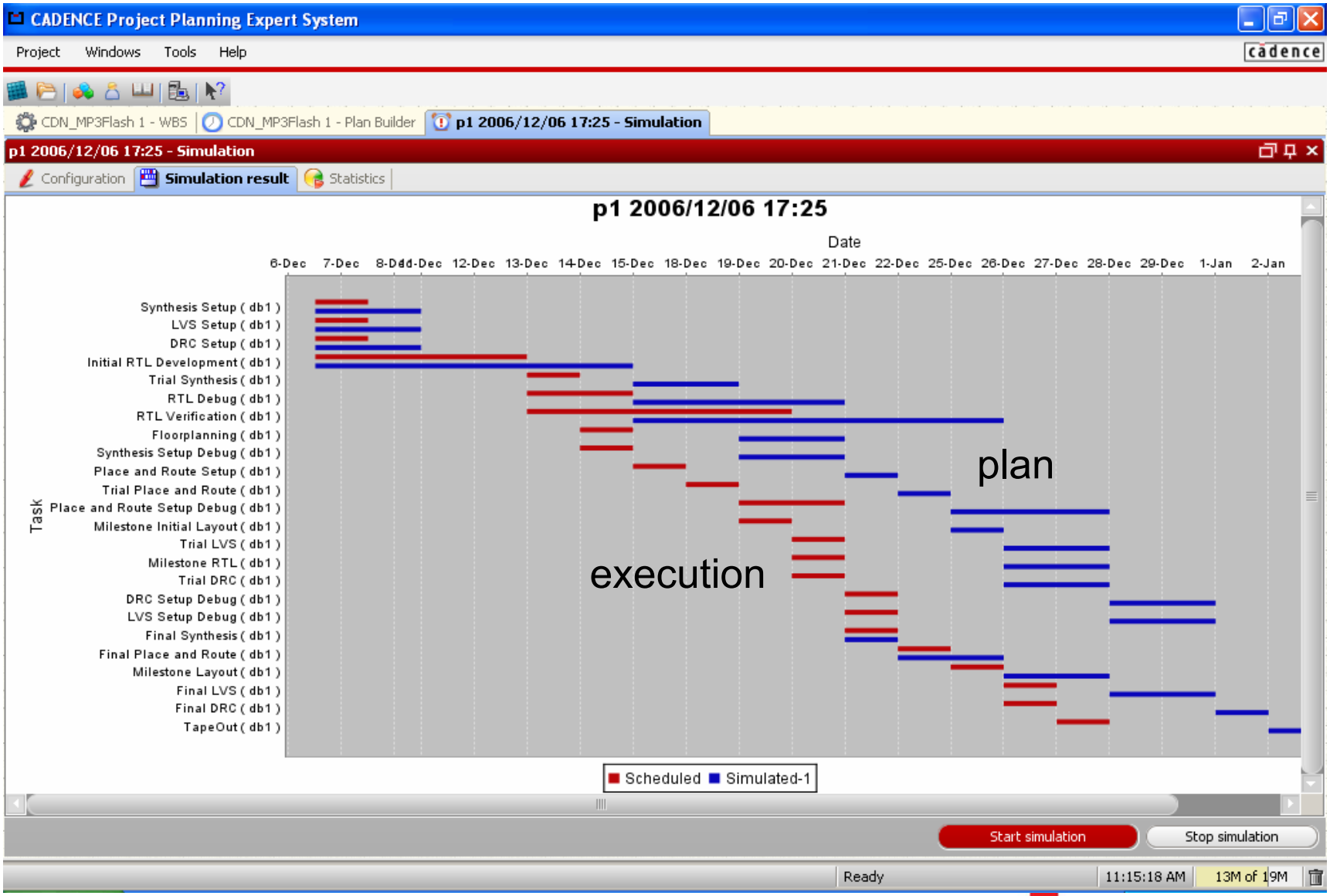
Simulation Tool: Design Process Simulation



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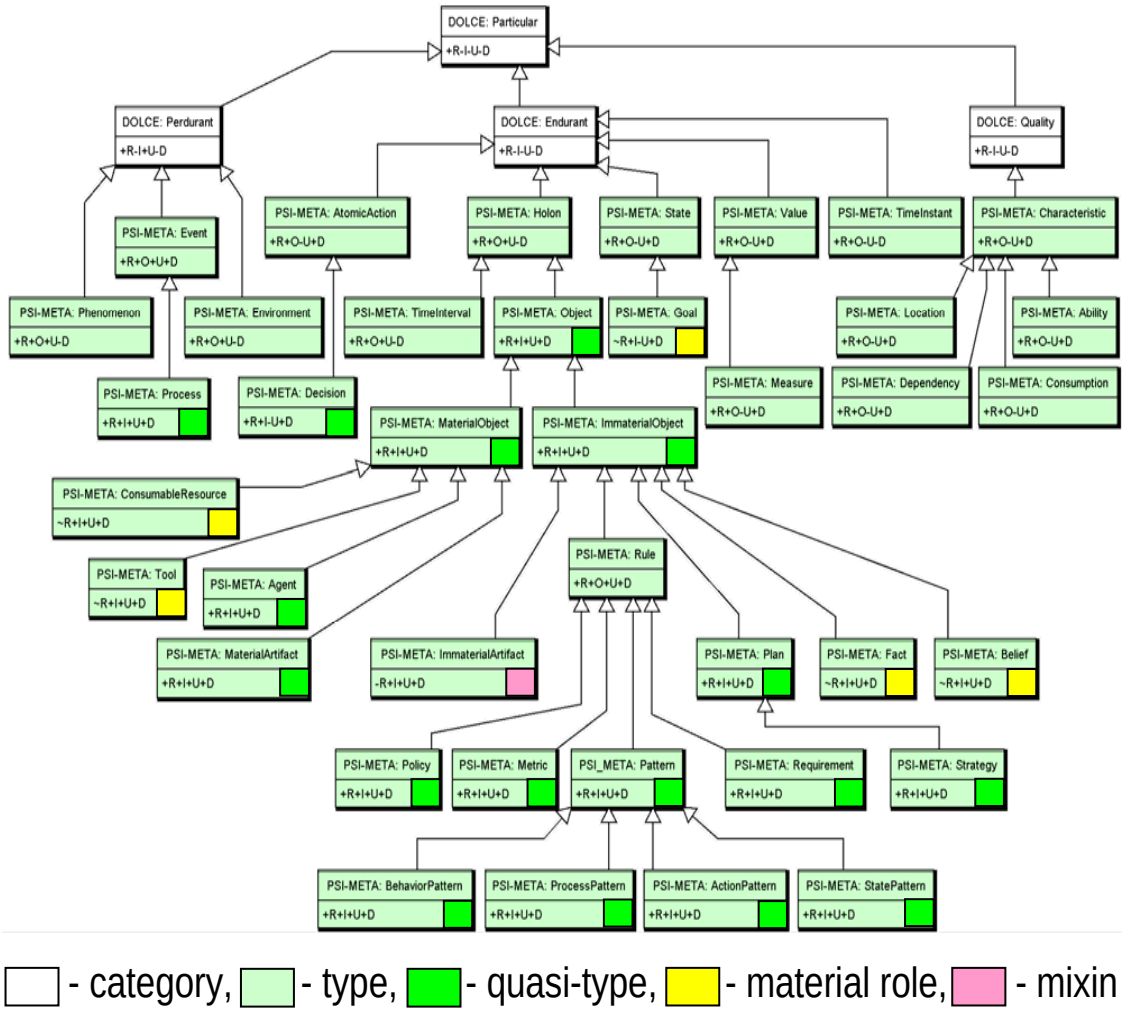
Formal Evaluation

- Taxonomy structure
- Formal correctness
- OntoClean
- No formal constraint violations found
- Formal Property types:
  - All own concepts are sortals
    - 16 types
    - 17 quasi-types
    - 5 material roles
    - 1 mixin
  - No phased sortals, formal roles, attributions



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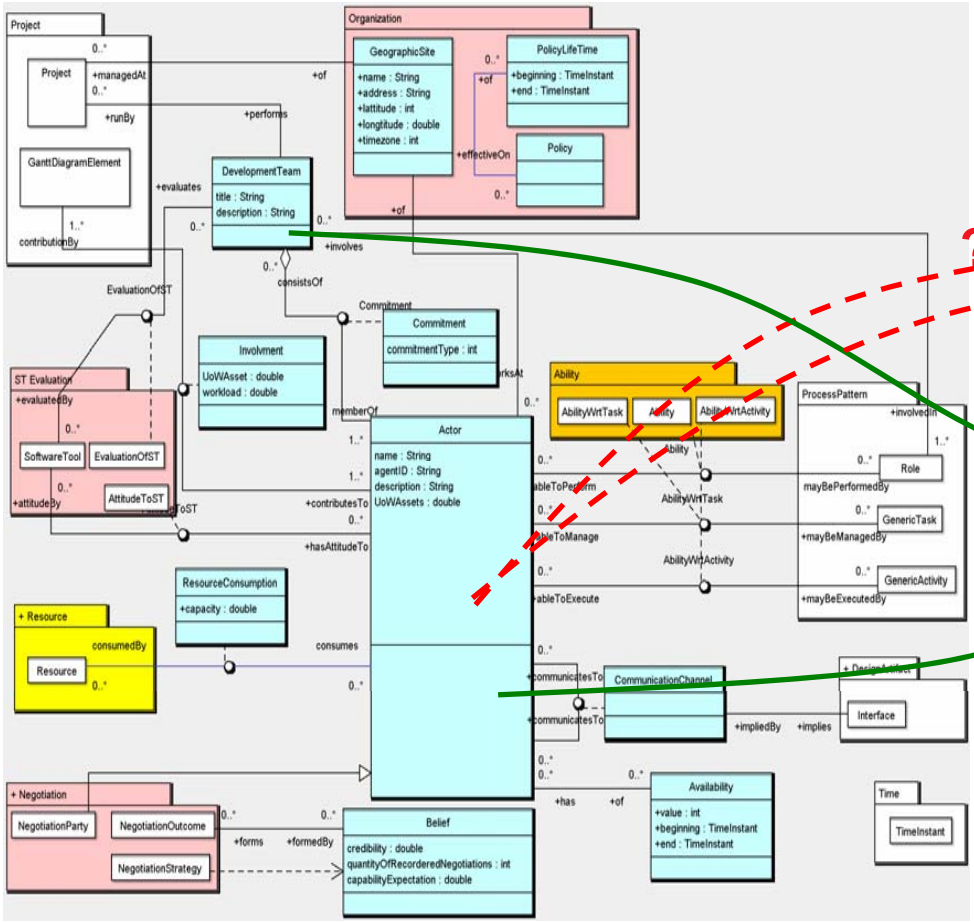
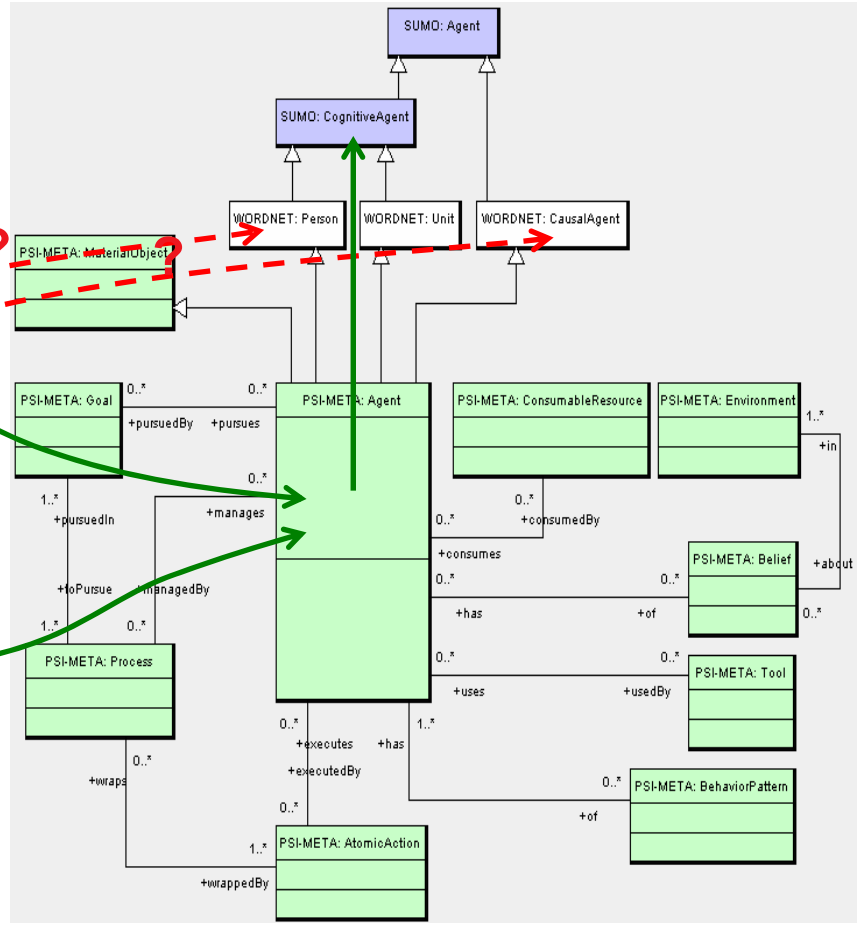
Commonsense Evaluation

- Commonsense disambiguation
- Facilitating to easier and broader ontological commitment
- Facilitating mappings to a “Golden Standard” (if any)



PSI Core: Actor Ontology



Agent-related context of PSI Upper-Level

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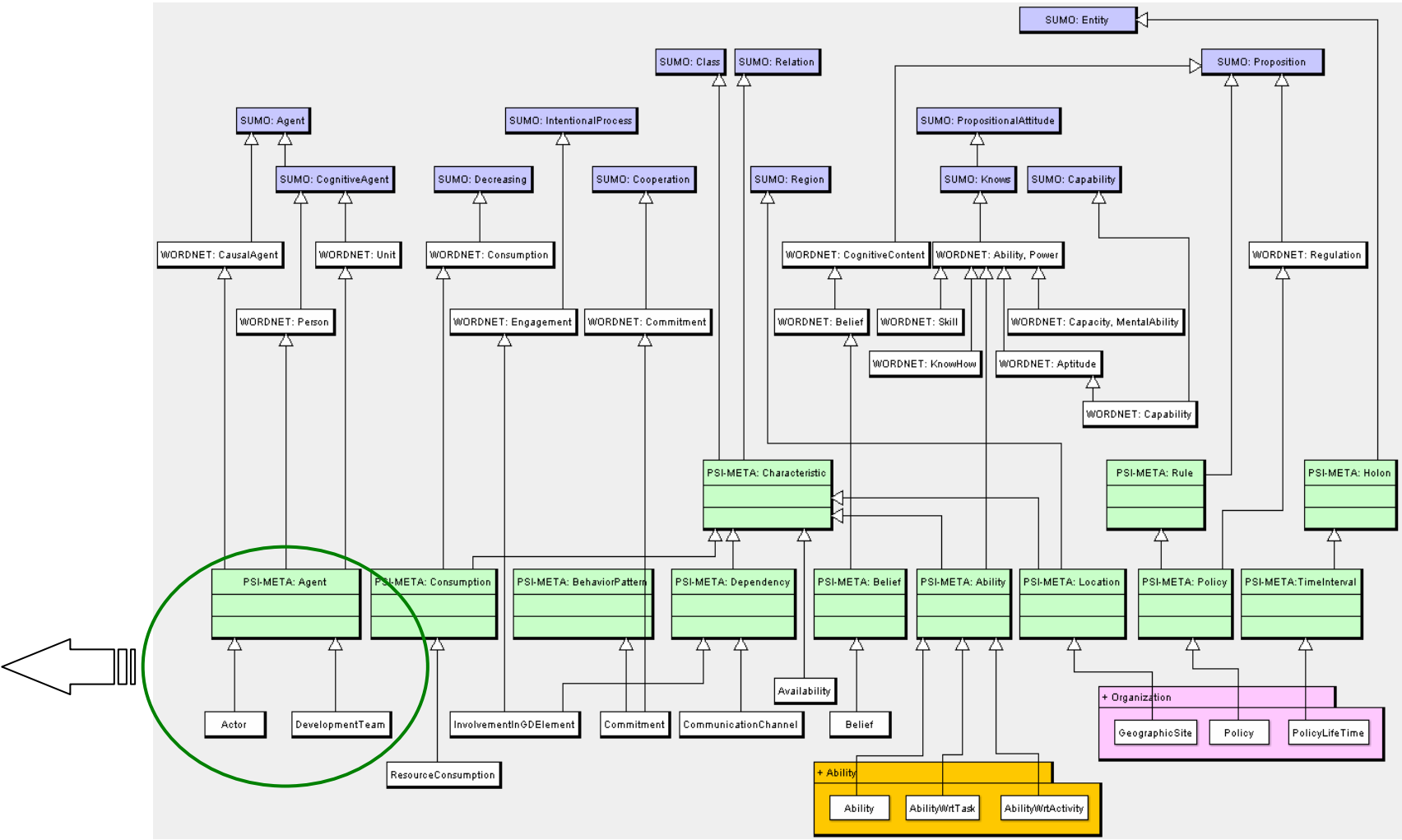
Commonsense Evaluation

- PSI Core Actor Ontology: (disambiguated) subsumptions to the common sense



Conclusions and Outlook

- PSI Upper-Level ontology:
  - A referential descriptive theory – formal semantics is further elaborated in lower-level Domain theories
  - A semantic bridge to human common sense
  - Knowledge-intensive, structurally and dynamically ramified, stateful, goal-directed processes
  - Not-deterministic, discrete, nested, dynamic environments
- Cross-Domain orientation
  - Engineering Design in Microelectronics and Integrated Circuits
  - Knowledge Processes in business environments
- Is implemented (OWL-DL) and is in use (Cadence PPES, …)
  - Shaker methodology for ontology refinement in PSI
  - An umbrella theory for PRODUKTIV+ and ACTIVE
- Future work:
  - Contexts as consciously perceived bounded parts of Environments
  - “Golden Standard” evaluation (no appropriate GS)
    - Looking at meta-theories like ISO/IEC 24744
    - Alternatively – cross-evaluation with a theory pursuing a similar approach but in a different domain
  - More facets of commonsense knowledge
    - Looking again at OpenCYC and its micro-theories

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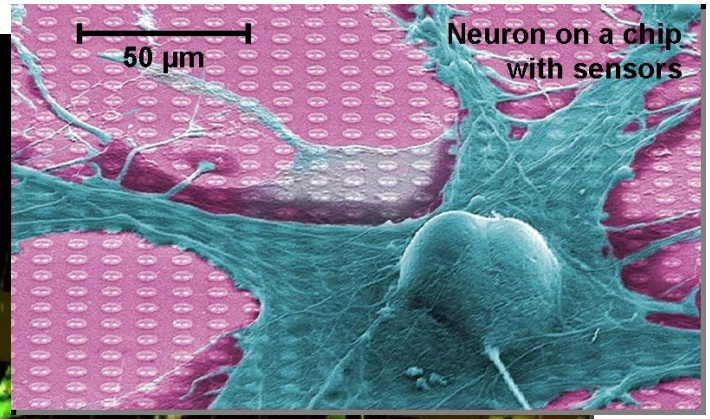
Questions Please



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