ONTOLOGIES AND CONCEPTUAL MODELING

Tatyana POLETAEVA

Ontology and Ontologies

Ontology is the philosophical discipline,

the study of what ***there*** (possibly) ***is***

the study of the nature and structure of reality

***An* ontology** is a theoretical or computational artifact;

a formal, explicit specification of a shared conceptualization;

a vocabulary of **terms** that refer to the things of interest in a given domain **+** some **specification of meaning** for the terms, grounded in some form of logic

using logical languages that allow specifying rigorously formalized logical theories

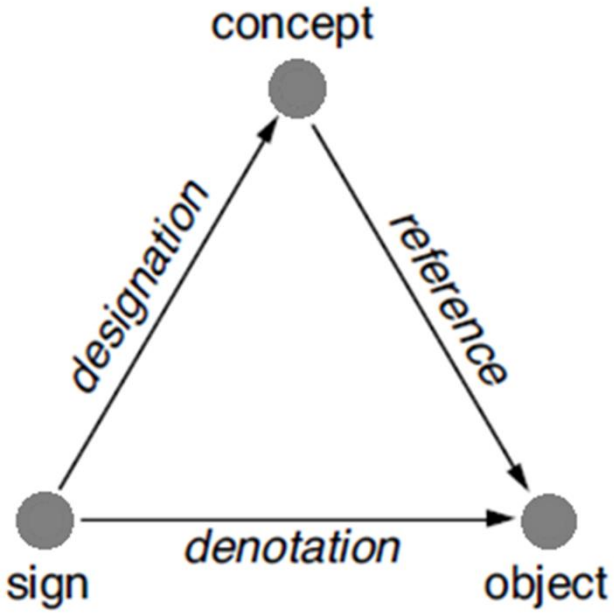
Ontological analysis is a study of content ***as such***

(independently of representation)

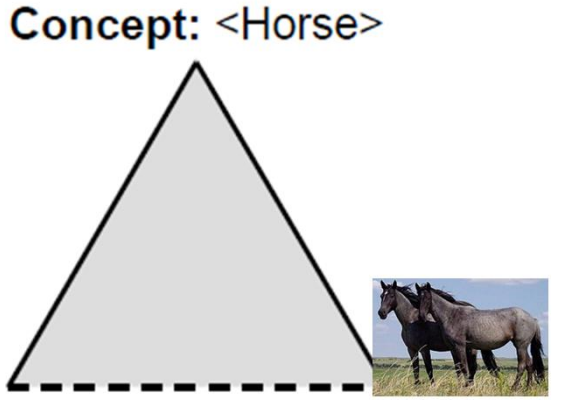
The portion of reality, a conceptualization and a language

Conceptual modeling is the activity of ***formally*** describing some aspects of the ***physical*** and ***social*** world around us for the purposes of ***understanding*** and ***communication***

(John Mylopoulos)



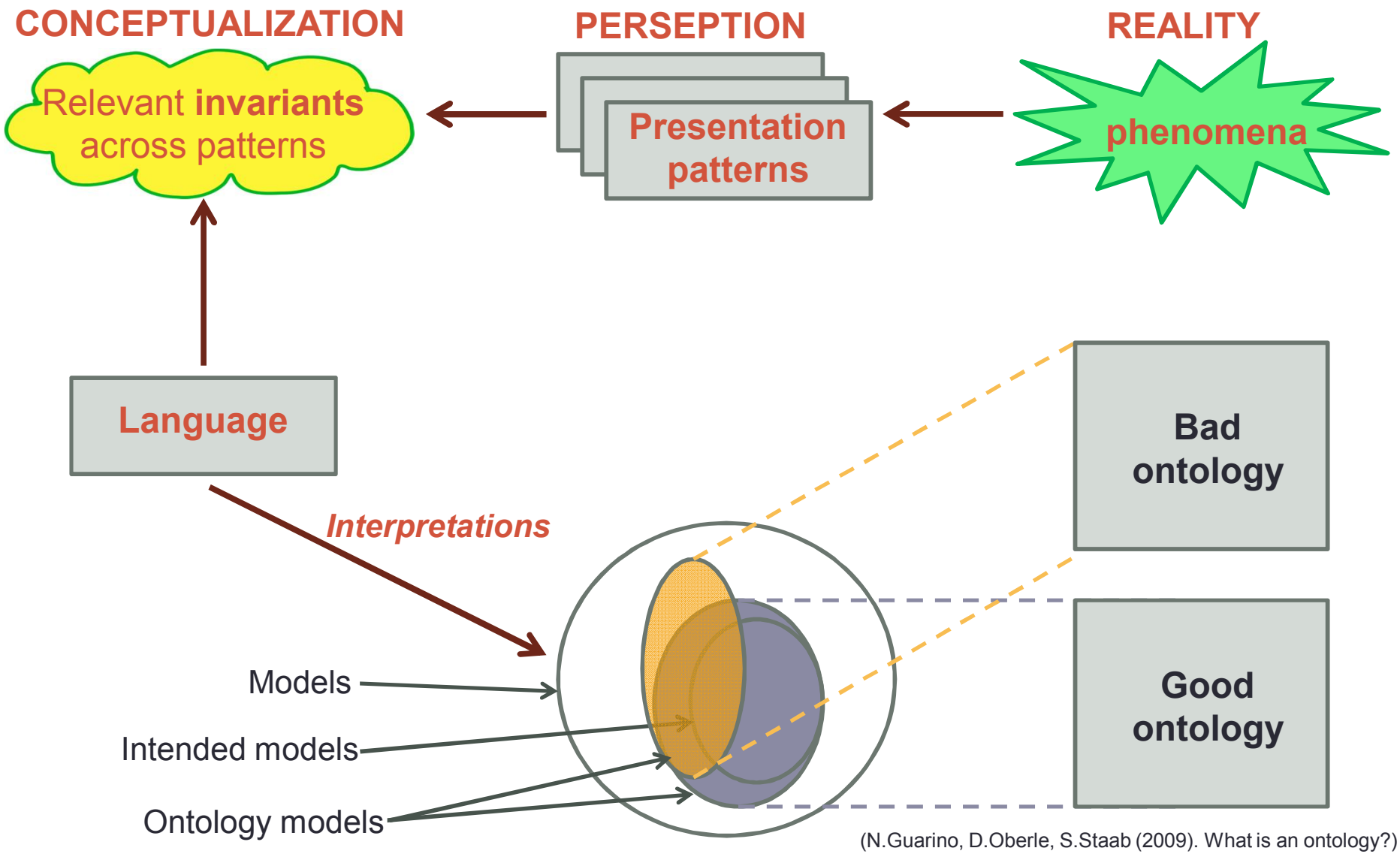
(after C.S.Peirce)



Word:
"Horse" (English)
"Hest" (Norwegian)
"Pferd" (German)

Referent:
A horse
in the real
world

From a Conceptualization to Ontologies



(N.Guarino, D.Oberle, S.Staab (2009). What is an ontology?)

Formal Ontologies

- The theory of ***formal distinctions and connections*** within
  - entities of the world, as we perceive it (particulars)
  - categories we use to talk about such entities (universals)

- Formal ontologies are **rigorous** and **general**
  - based on ***formal logic*** (connections between truths)
  - based on ***world-semantics*** (connections between things)
  - applied to ***all material domains*** in reality

Applied Ontologies

Applied Ontology is built on *philosophy, cognitive science, linguistics* and *logic* with the purpose of understanding, clarifying, making explicit and ***communicating people's assumptions*** about the nature and structure of the world.

The nature and structure of real world entities (**real-world semantics**) *define the meaning* of ontological concepts and relations between them.

Ontology is about ***what there is***, **semantics** is about ***referring*** to what there is

Foundational (Applied & Formal) Ontologies

- Foundational Ontologies are *theoretically well-founded domain independent* systems of categories that have been successfully used to improve the quality of conceptual modeling languages and models.

- Foundational ontologies form the basis for a *common ontology vocabulary*, because their ontological analysis provides for a rigorous methodology to characterize **intended meaning**

  - Useful when
    - *subtle distinctions* are important
    - *recognizing disagreements* is important
    - *rigorous referential semantics* is important
    - *general abstractions* is important
    - *careful explanation and justification of ontological commitment* is important
    - *mutual understanding* is more important than interoperability

- DOLCE, GFO, UFO, BORO, OCCHRE

Fundamental distinctions of formal ontological theory

are based on human cognition

- Abstraction / Identification

  - Capturing meaningful concepts

- Classification

  - Defining *universals* (abstract predicative terms that are repeatable across multiple instances)

- Partitioning (Independents and Relatives)

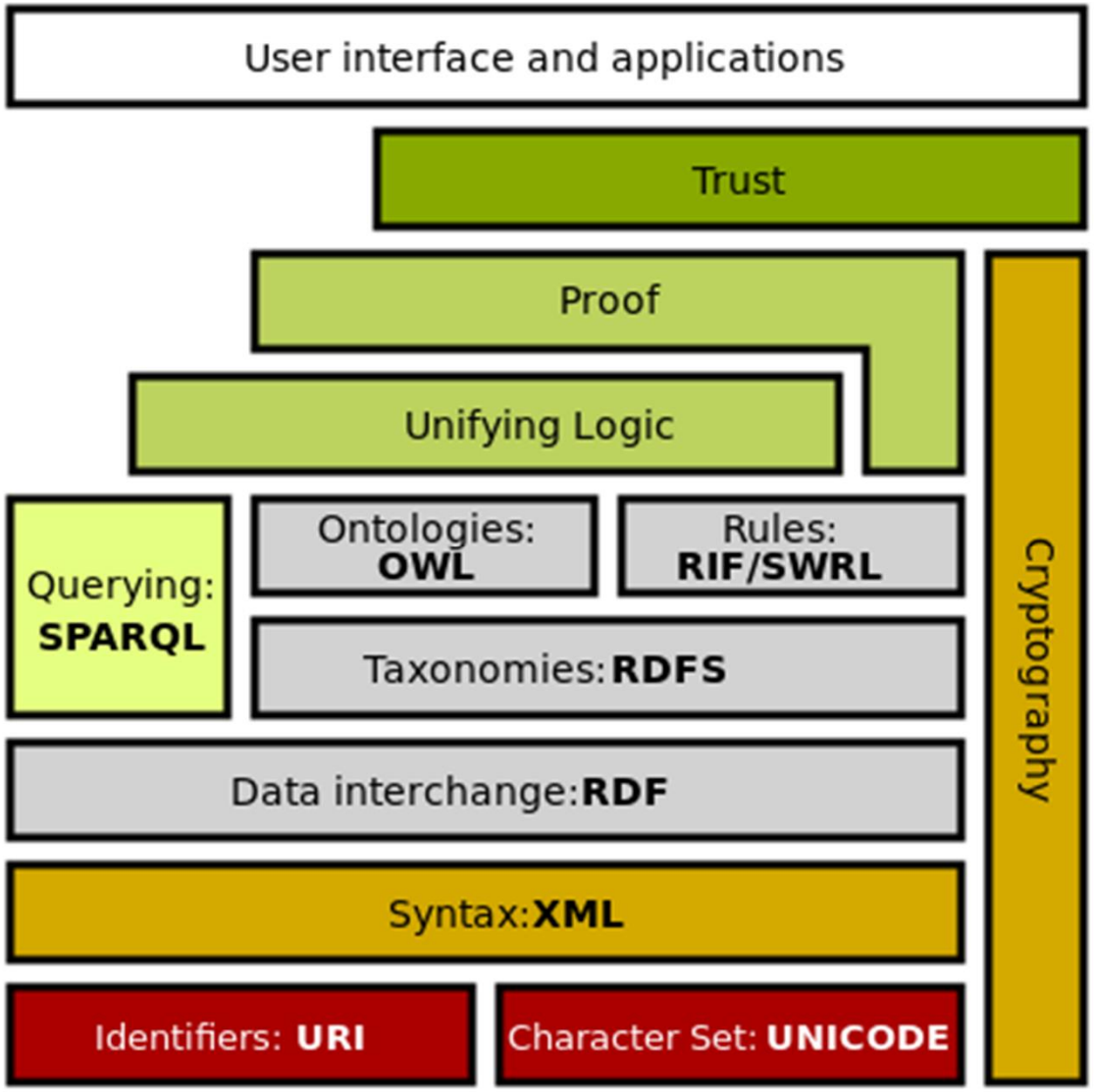
  - Defining parts

  - Defining universals in context of

  - Creation of taxonomies (hierarchical taxonomies are based on *sub class of* relation)

ONTOLOGY CODIFICATION

Semantic Web Stack



Web Ontology Language (OWL)

- Declarative statements about kinds of things and properties of those kinds of things
- Lets make logical statements about the relationships between kinds of things
- Framed in a sub set of First Order Logic (FOL)
- Is limited in its expressive power, but what we can express also depends on how we frame the semantics of the concepts (the kinds of things and the relationships between them)
- The syntax allows us to say things clearly and unambiguously in a way that is readable by machines
- It is computationally independent

Reasoning

- The logic lets us/machines infer truth values based on assertions in the model and in the available data (in UML/OWL);
- Logic (truth values) provides a means to an end – this is not the same as saying logic/truth is semantics

ONTOLOGICAL FOUNDATIONS OF MULTI-AGENT FRAMEWORK FOR OPERATIONAL DATA PROCESSING

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Background

- Support of the interactions between people or automated processes or both, by applying ICT
- Any interaction is related to a universe of discourse (or *subject domain*). The success of the interaction depends on the correct representation of this subject domain
- Abstractions of a given portion of reality can be articulated via *conceptual models*
- Conceptual models are composed by *conceptual modeling languages*
- In order for systems to interoperate, we must guarantee that they ascribe compatible meanings to real-world entities of their shared subject domain (*semantic interoperability)*
- The suitability of a conceptual modeling language to represent a set of real-world phenomena in a given domain is ensured by its coherence with the *reference ontology*

Motivation

- *Enterprise simulation* requires executable models
  - built upon sound theoretical foundations;
  - expressed in a modeling language with a machine-processable semantics;
- Support of *organizational dynamics* requires
  - comprising process and information views on the enterprise;
- Support of *business interactions* requires
  - proper information exchange;
  - information integration;

There is a lack of languages that have enough expressivity for enterprise knowledge while preserving a formal semantics.

Objectives

1. To construct a well-founded enterprise modeling language;
2. To propose a methodological approach for enterprise knowledge management;
3. To propose the design of a multi-agent platform for knowledge management;
4. To demonstrate the usefulness of the constructed language to address existing problems of enterprise conceptual modeling;
5. To demonstrate the adequacy of the enterprise modeling language (1), of the methodology proposed in (2), and of the design of a multi-agent platform (3) by extending enterprise simulation capabilities.

Scope

The *domain appropriateness* and the *comprehensibility appropriateness* of an enterprise conceptual modeling language is guaranteed by the metamodel of this language representing *full axiomatization of enterprise ontology.*

- Unified Foundational Ontology (UFO)

  G.Guizzardi (2005). *Ontological foundations for structural conceptual models.*

- DEMO enterprise ontology

  J.L.G.Dietz (2006). *Enterprise ontology. Theory and methodology.*

- Semantic Web technologies for knowledge management (OWL, SWRL)

Approach and Structure

Module 1. The enterprise modeling language with FEO meta-model;

Module 2. Codification of the enterprise modeling language in OWL & SWRL;

Module 3. The method for knowledge transformation;

Module 4. Software engineering methodology and cognitive agents;

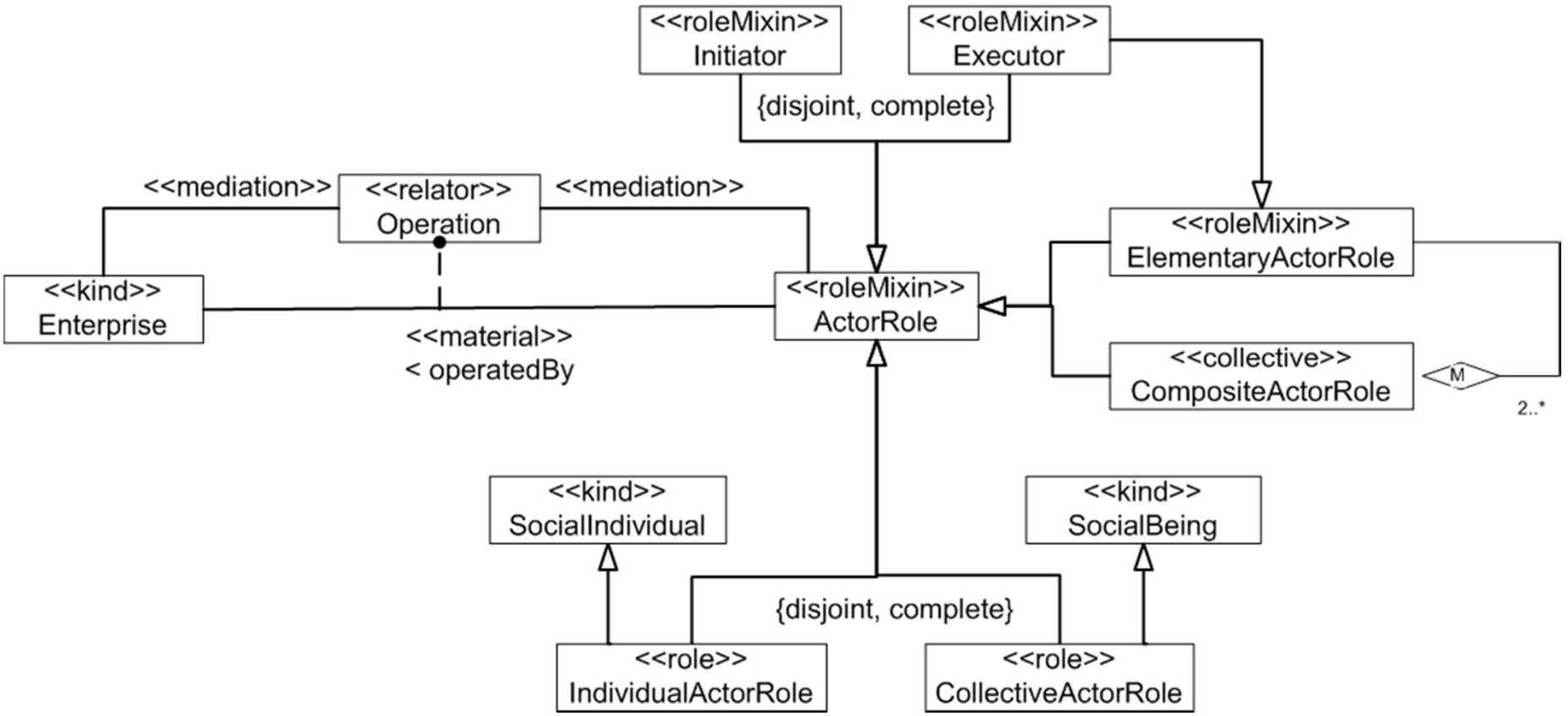
Module 5. Validation of created artifacts in case studies

Module 1. Enterprise Modeling language

- Formal Enterprise Ontology (FEO) based on the integration of UFO and DEMO;
- Verification of the logical consistency of the meta-model;
- Modeling language with FEO meta-model;

Module 1. Enterprise Modeling language

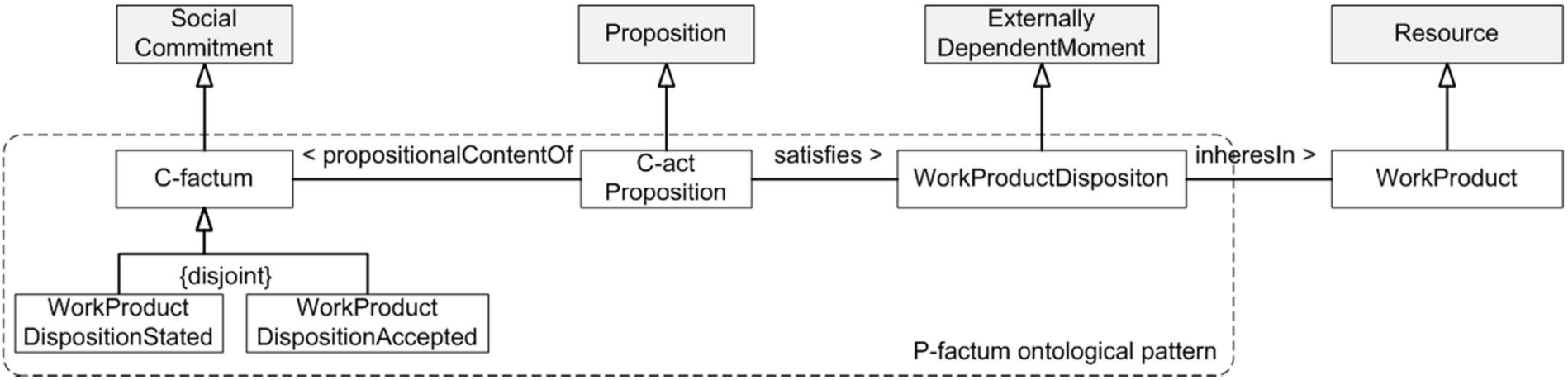
- Formal Enterprise Ontology (FEO) based on UFO & DEMO



Module 1. Enterprise Modeling language

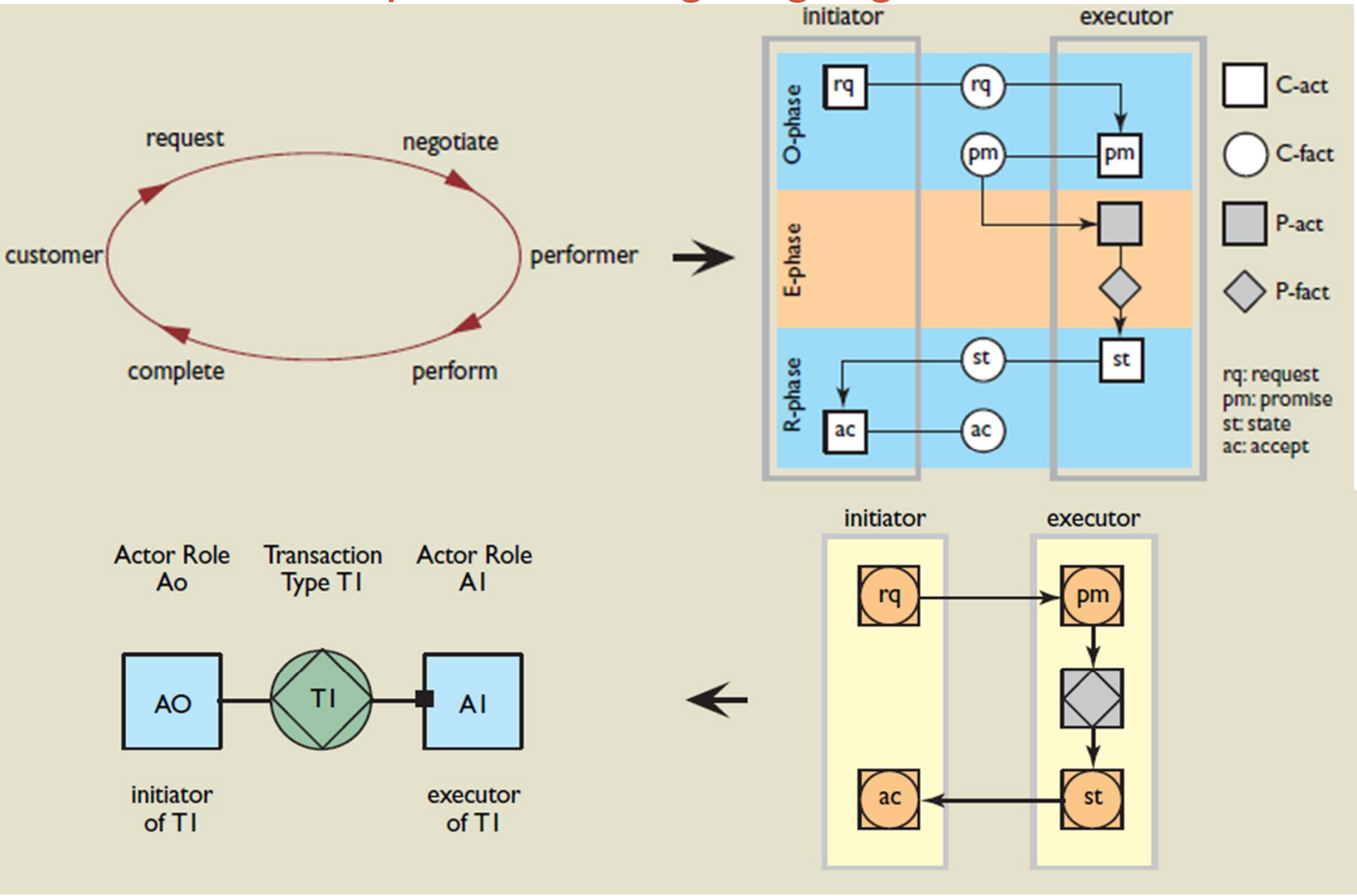
- Formal Enterprise Ontology (FEO) based on UFO & DEMO

Definition 1: An individual *p* is a P-factum iff there is a work product disposition *p* which satisfies both the propositional content of the statement of this disposition, and the propositional content of the acceptance of this disposition. Formally,

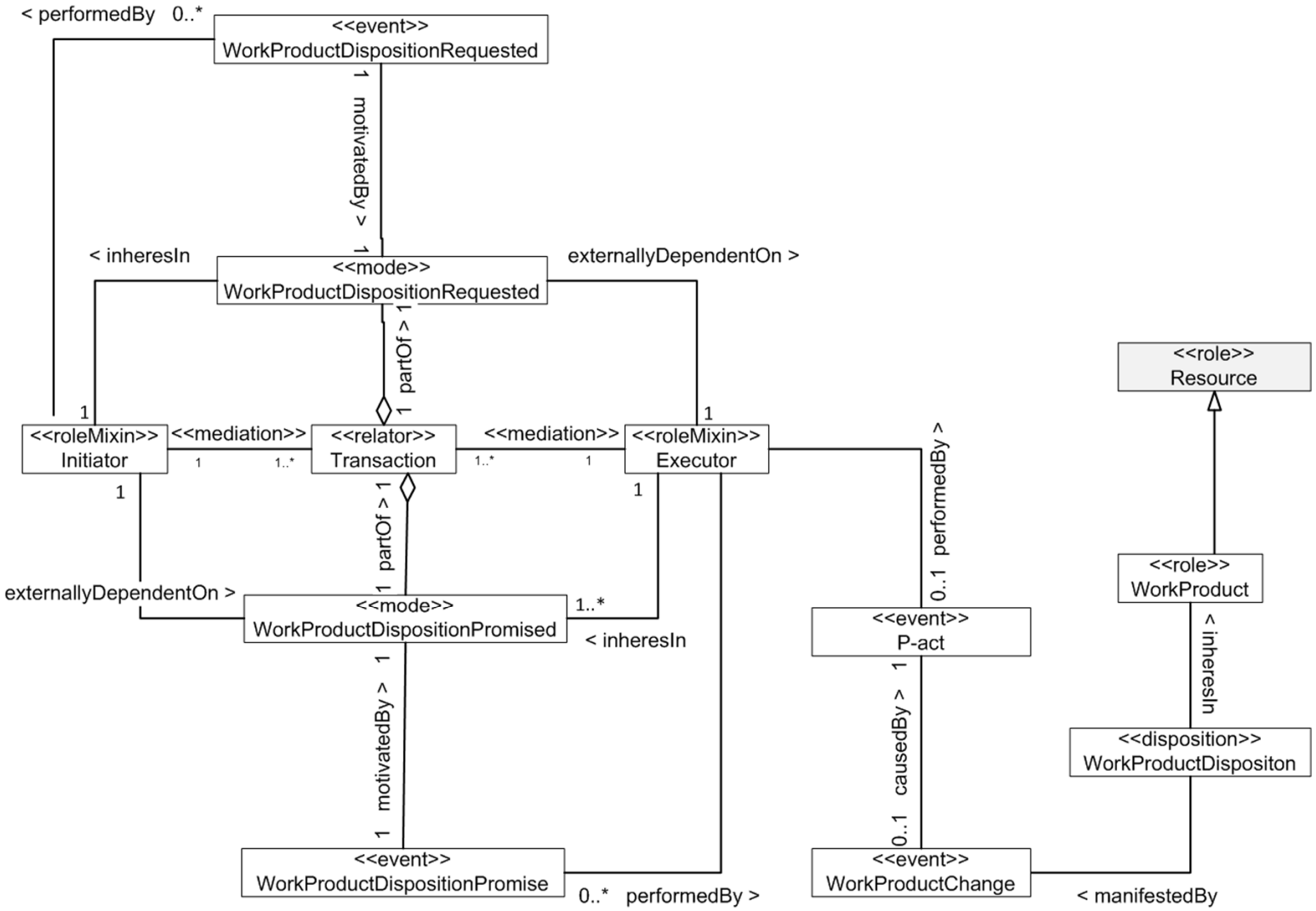


$$P\text{-}factum(p) =_{def} WorkProductDisposition(p) \wedge \exists x\,(satisfies(x,p) \wedge x::C\text{-}actProposition) \wedge \exists!y\,(propositionContentOf(x,y) \wedge y::WorkProductDispositionStated) \wedge \exists!z\,(propositionContentOf\,(x,z) \wedge z::\,WorkProductDispositionAccepted)$$

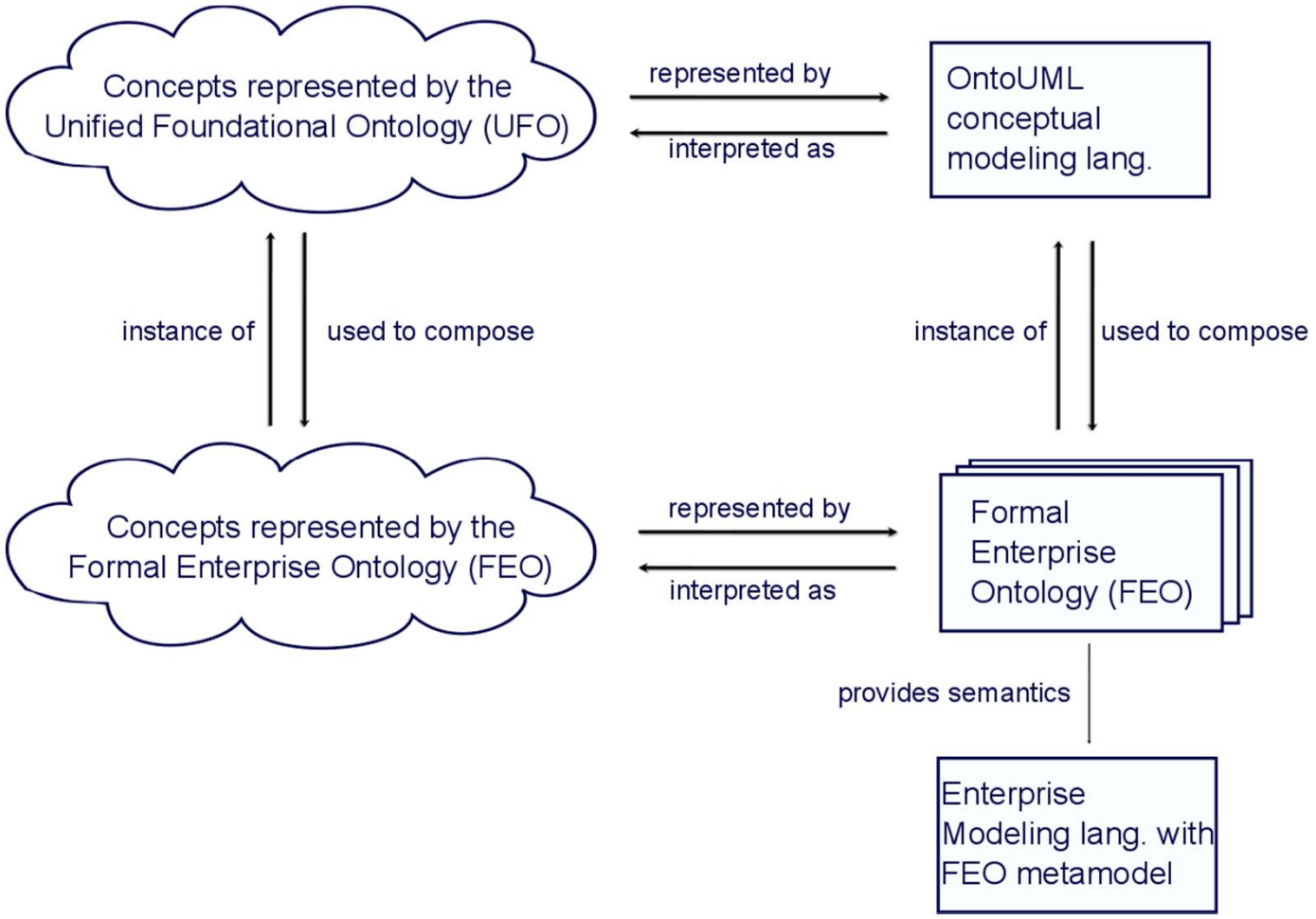
Module 1. Enterprise Modeling language



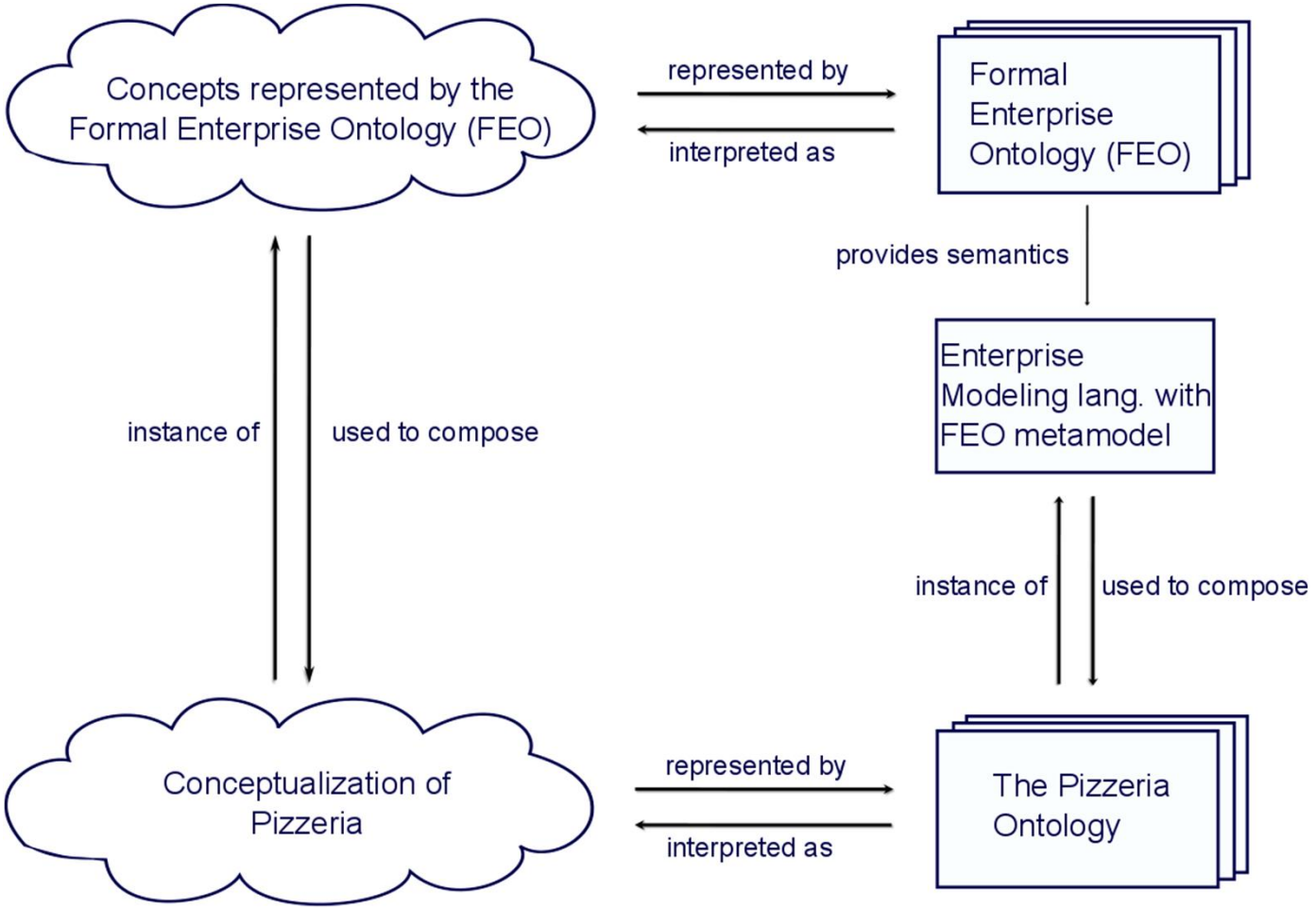
Module 1. Enterprise Modeling language



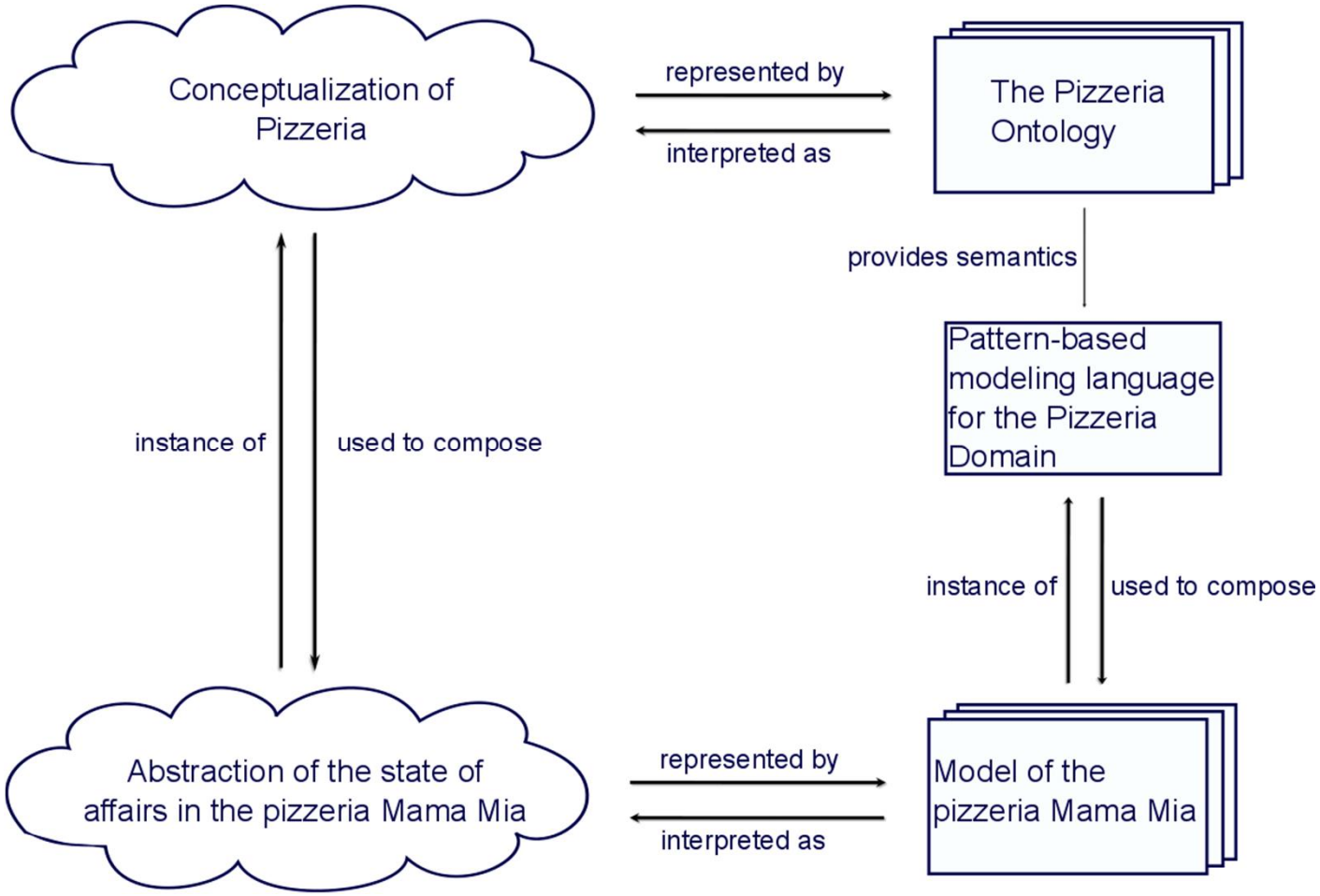
Module 1. Enterprise Modeling language



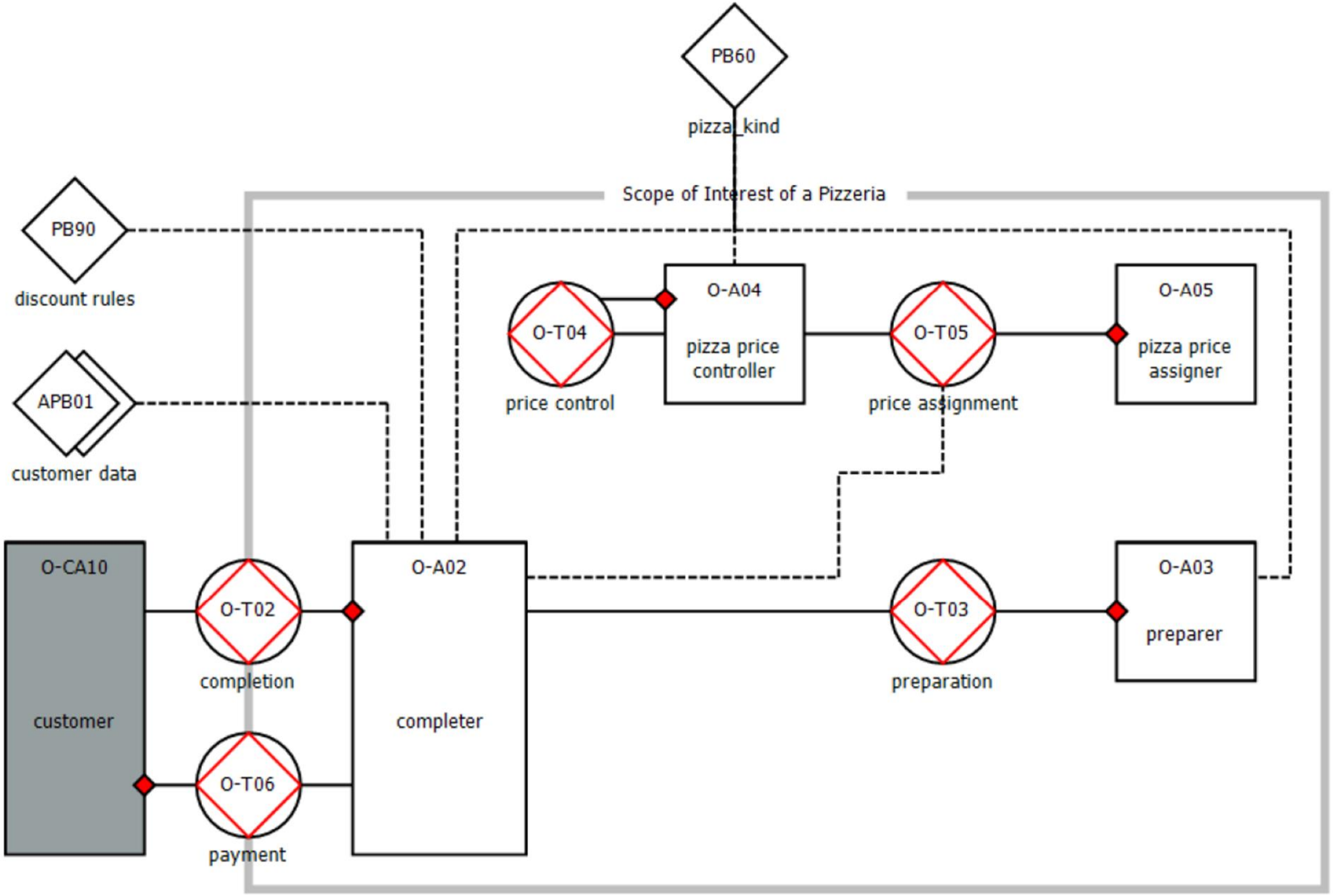
Module 1. Enterprise modeling language validation in case studies (1)



Module 1. Enterprise modeling language validation in case studies (2)



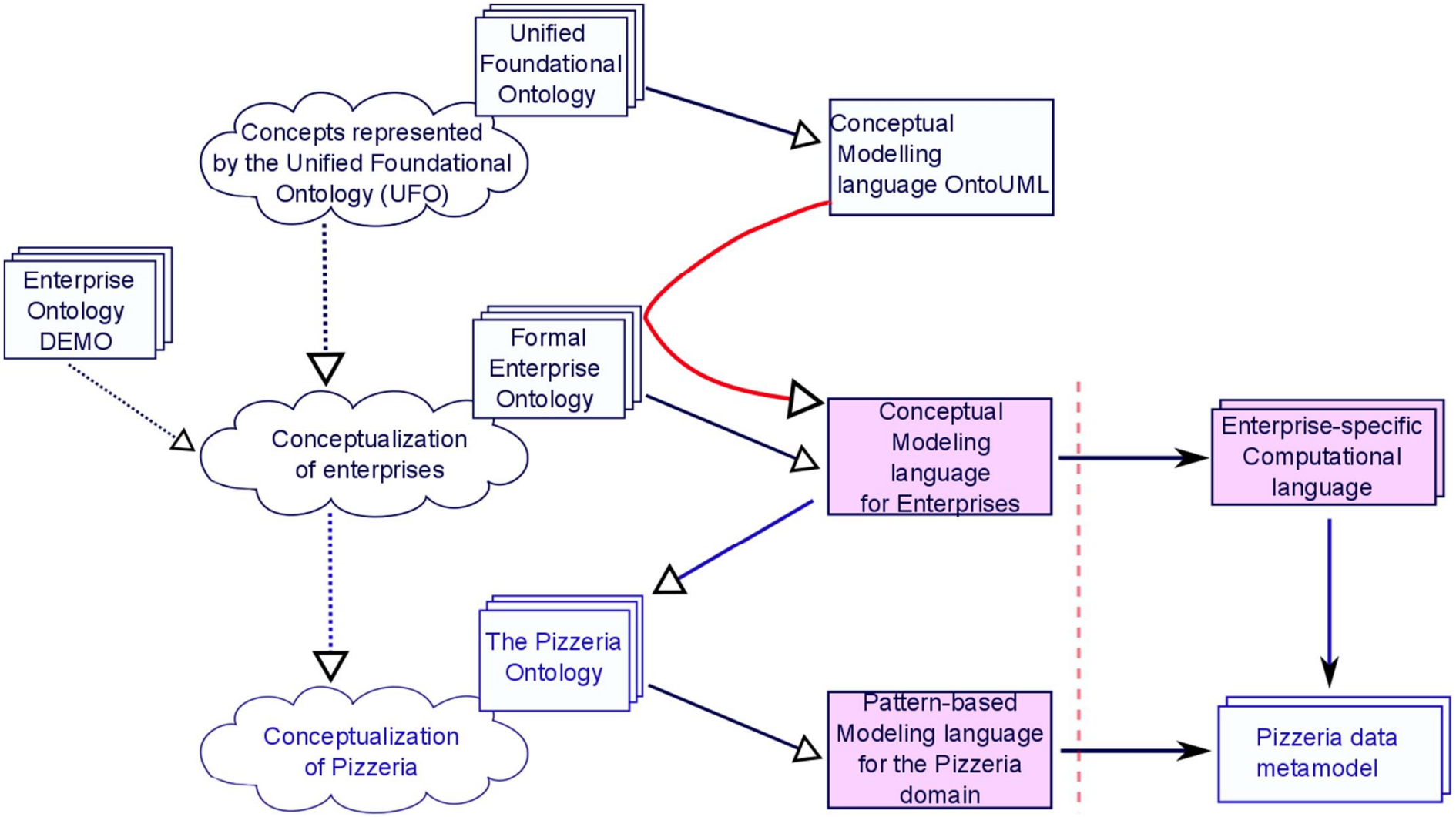
Module 1. Enterprise modeling language validation in case studies (2)



Module 1. Enterprise modeling language validation in case studies (2)

when	completion **for** new Order is requested **with** **the** pizza_kind **of** Order **is** a Pizza_kind **the** #ordered_pizzas **of** Order **is** a #Ordered_pizzas **the** customer **of** Order **is** a Customer	O-T02/rq
assess	*justice:* **the** Performer **of the** request **is the** customer **of** Order *sincerity:* <no specific condition> *truth:* <existence of Pizza_kind> <Price of Pizza_kind is available>	
if **then** **else**	*complying with request is considered justifiable* promise completion **for** Order decline completion **for** Order	

Module 2. Codification of the enterprise modeling language

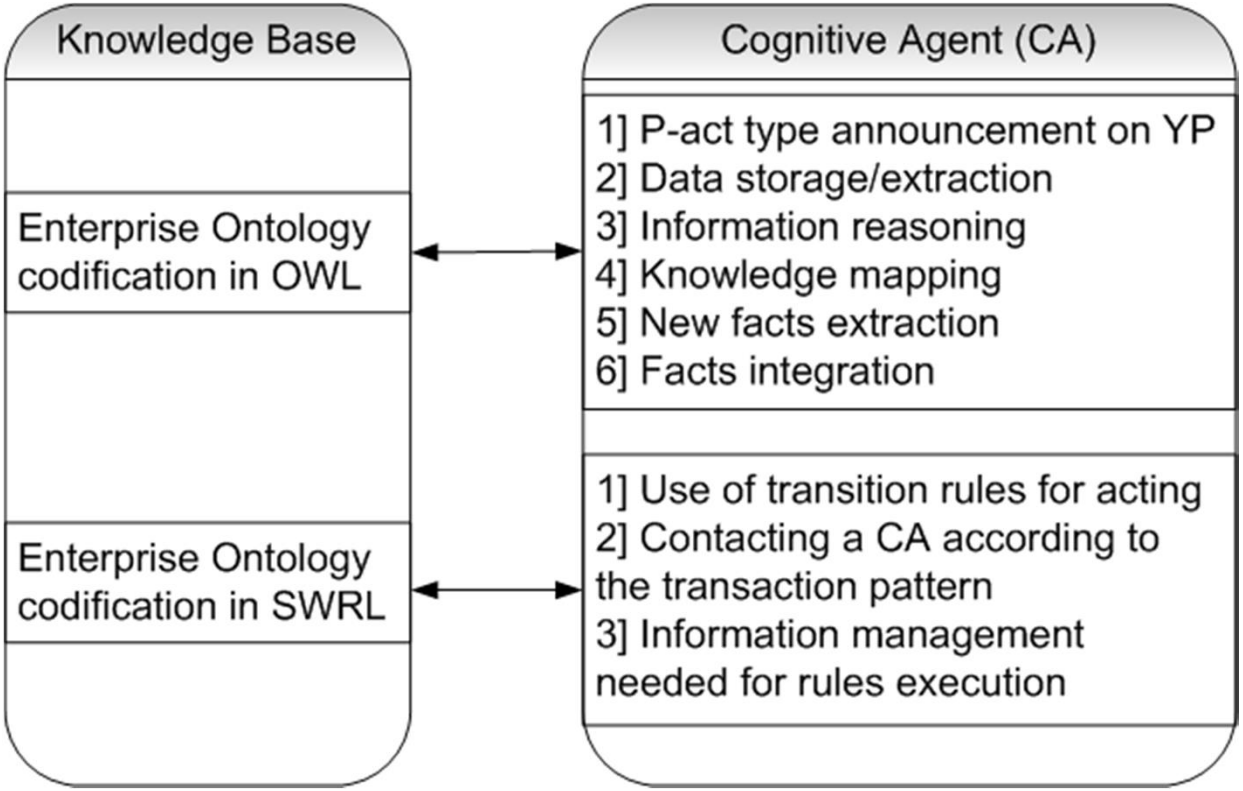


Module 3. The method for knowledge transformation

- Domain-specific extension of the meta-model the modeling methodology

- Automated knowledge transformation:
  - ✓ Comparison
    - ASMOV algorithm for ontologies mapping;
    - Consistency validation and integration of business rules;
  - ✓ Understanding
    - Discovery of meaning in reasoning and negotiations;
  - ✓ Extension / replacement
    - Localization of changes related to new concepts via pattern-based approach to transformation;

Module 4. Principle design of Cognitive Agents



THANK YOU FOR YOUR ATTENTION

AND FOR YOUR QUESTIONS !

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