Axiomatized Relationships Between Ontologies

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Agenda

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2. Ontology Decomposition: Verification of DOLCE
3. Ontology Composition: DOLCE & PSL
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Motivations

Primary Interests

- Provide better insight of axiomatized relationships between ontologies.
- Analyze how weak and strong ontologies can form relationships with one another.
  - *Weak ontology*: lack of expressible or characterizable semantics and the ability to express very simple meaning [4, 1].
  - *Strong ontology*: ability to characterize complex semantics to allow valid inferences and enforce sound semantic constraints through the use of theorem provers [4].

Ontologies of Interest

- Strong Ontologies: DOLCE, PSL, theories in COLORE.
- Weak Ontologies: CIMOSA, vendor API ontologies.

Ontology Relationships Examined

1. **Ontology Decomposition**: translation definitions are used in the verification and modularization of the *strong* DOLCE ontology.
2. **Ontology Composition**: combination of *strong* mathematical theories found in COLORE outlines the relationships between the *strong* DOLCE and PSL ontologies.
3. **Semantic Augmentation**: translation definitions are used to define relations in the *weak* CIMOSA ontology using terminology found in the *strong* PSL ontology.
4. **Ontology Mapping**: equivalent concepts between two *weak* vendor product ontologies are defined through the usage of mappings.

Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE)

What is DOLCE?

A *foundational ontology* developed by the Laboratory for Applied Ontology in Trento, Italy.

- Captures ontological categories that underlie natural language and common sense in *first-order logic*.
- Intended to clarify any implicit assumptions between existing ontologies or linguistic resources such as WordNet.

DOLCE's Relationships with Existing Theories in COLORE

- What kind of relationships exist between these different representations of concepts (e.g., participation, parthood)?
- Are these representations equivalent? If so, how?

DOLCE's Taxonomy

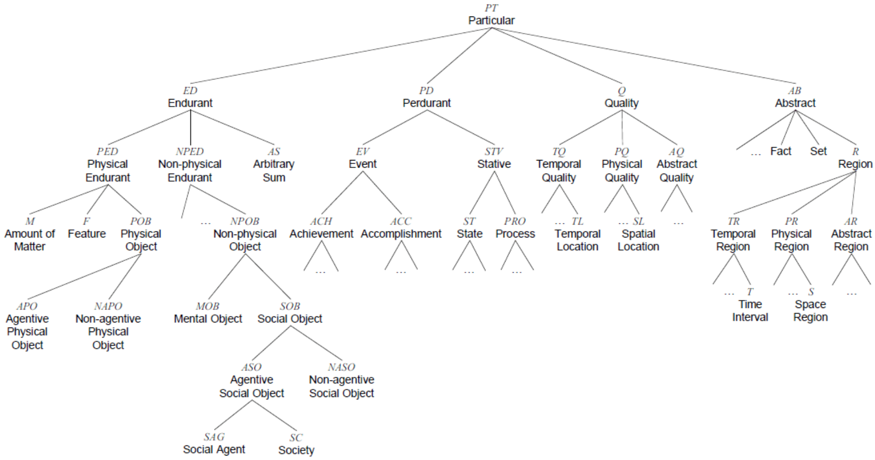
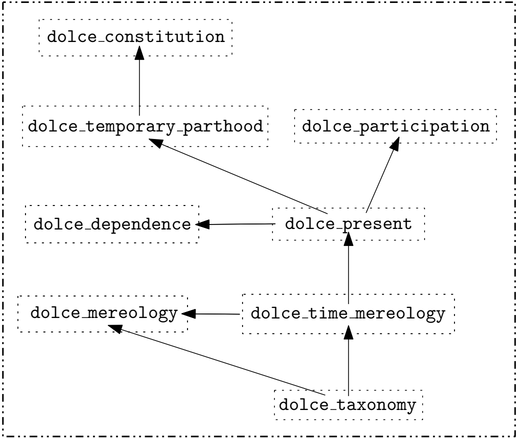
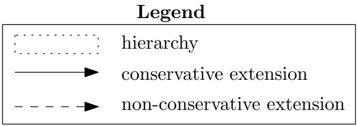


Figure : The DOLCE taxonomy (Figure 2 in [3]).

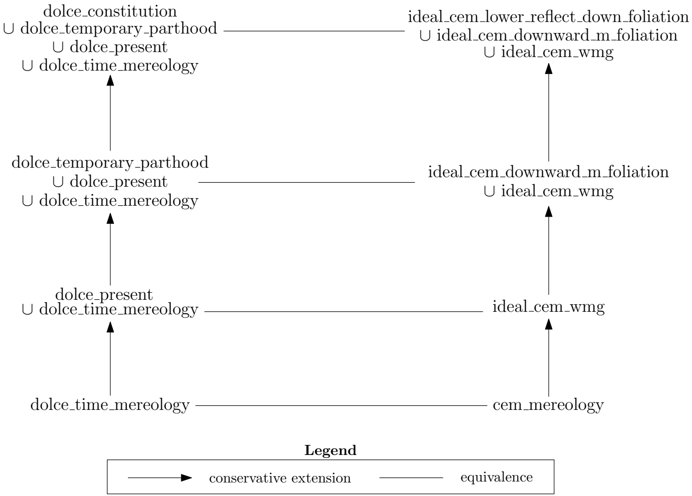
Modules of DOLCE



DOLCE Hierarchy



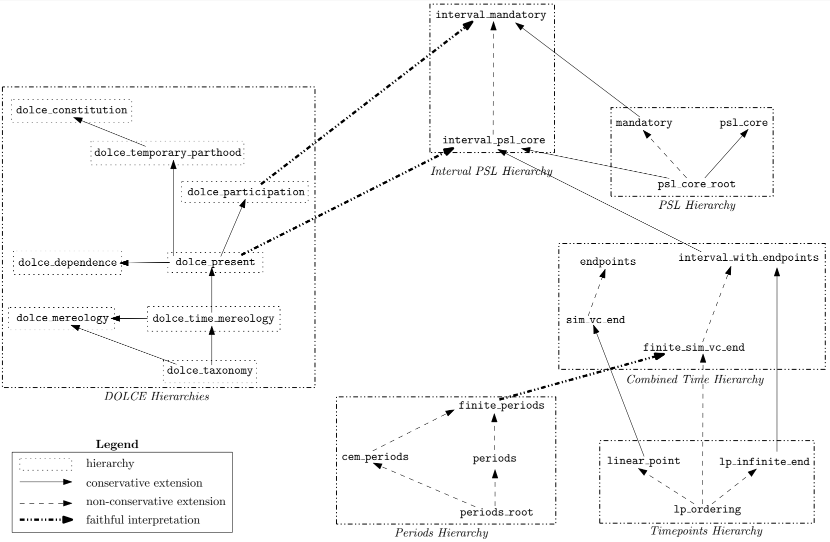
Relationships Between DOLCE Modules & COLORE Theories



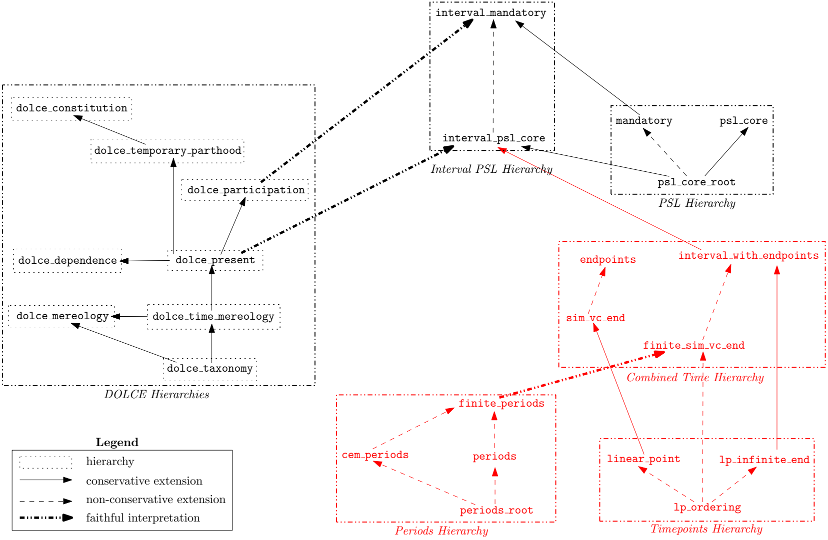
Key Insights

- This modularization of DOLCE is *coarser-grained* than the modules presented by Kutz and Mossakowski: every module in our modularization is a module of DOLCE, and every module in [2] is a module of the modules presented in this work.
- This modularization preserves the taxonomic structure found in the original DOLCE axioms.

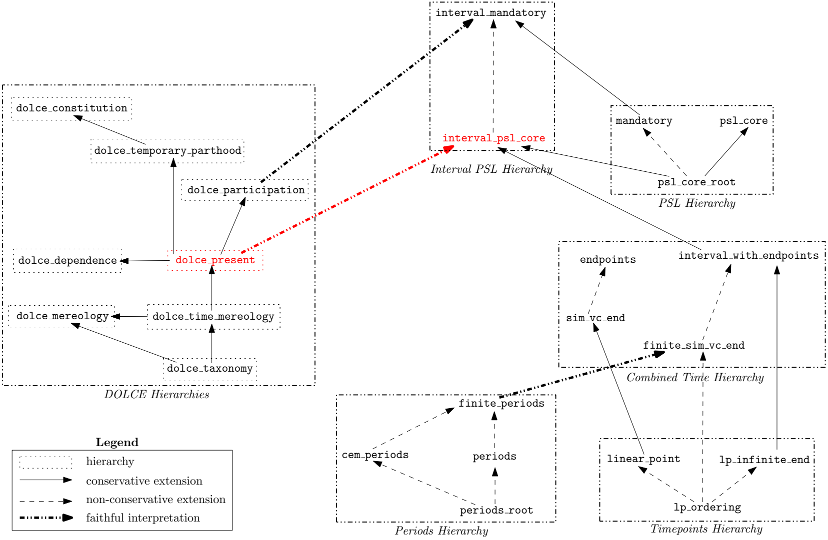
Ontology Composition: DOLCE & PSL



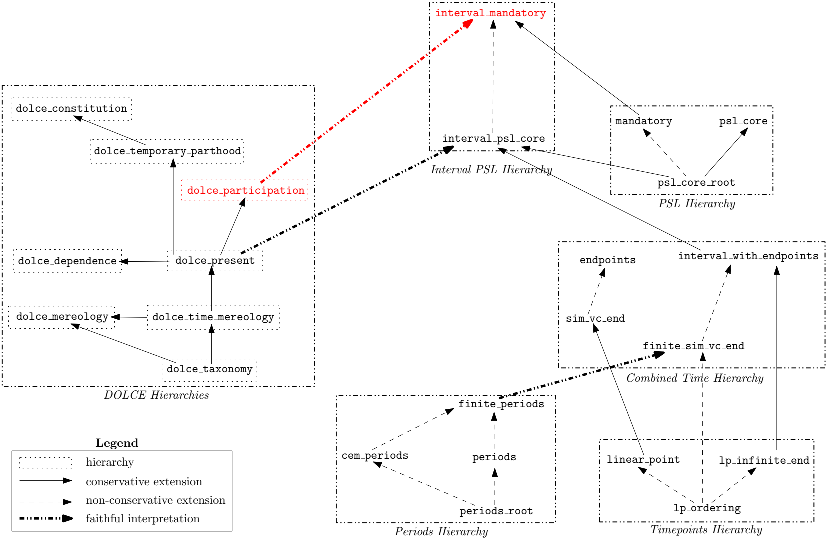
Ontology Composition: DOLCE & PSL



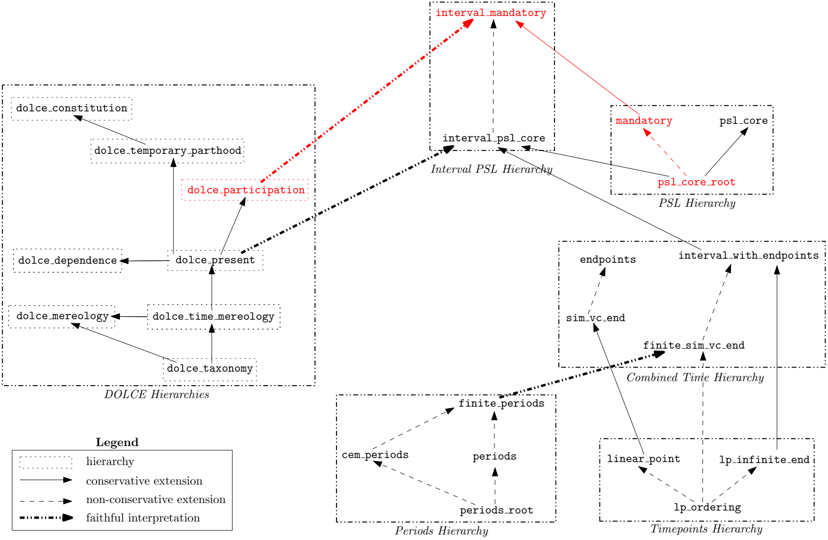
Ontology Composition: DOLCE & PSL



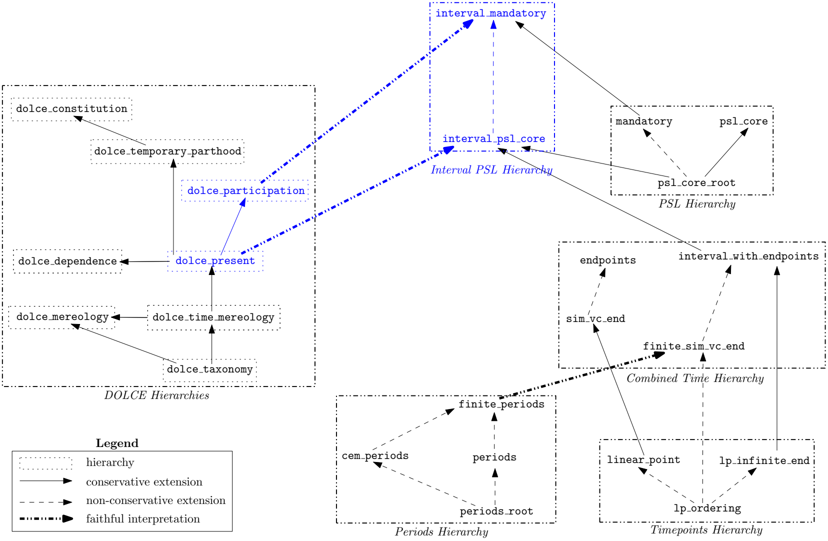
Ontology Composition: DOLCE & PSL



Ontology Composition: DOLCE & PSL



Ontology Composition: DOLCE & PSL



Key Insights

- Multiple 'bridges' were needed before any analyses with the $T_{dolce\_participation}$ and $T_{dolce\_present}$ theories could be carried out with theories in COLORE.
- Ontology composition outlines relationships between ontologies through the creation of intermediary theories.

Semantic Augmentation: CIMOSA

CIMOSA: Computer Integrated Manufacturing Open System Architecture

An enterprise modelling framework that supports integration of machines, computers, and people that was developed in the 1990s by AMICE Consortium. There currently do not exist ontologies that explicitly define the CIMOSA terms utilized in their syntactic constructs.

Goal

Develop a computer-interpretable process ontology for CIMOSA in first-order logic by *semantically augmenting* concepts using PSL terminology.

Behavioural Rules

Behavioural rules in CIMOSA are written in the form:

WHEN (*condition*) *DO action*

There are the following types of rules:

1. Process Triggering
2. Sequential
3. Forced Sequential
4. Conditional Sequential
5. Spawning
6. Rendezvous/Convergence
7. Looping
8. Process Completion

All of these rules have been axiomatized in the proposed CIMOSA process ontology, which can be found in COLORE: http://colore.oor.net/cimosa/cimosa.clif.

Key Insights

- The use of strong ontologies greatly assist in enriching weak ontologies with additional semantics through augmentation.
- Difficulties may arise when developing semantics for an area that lacks formalisms to describe enterprise modelling constructs.

Ontology Mapping: ServicedAtHome

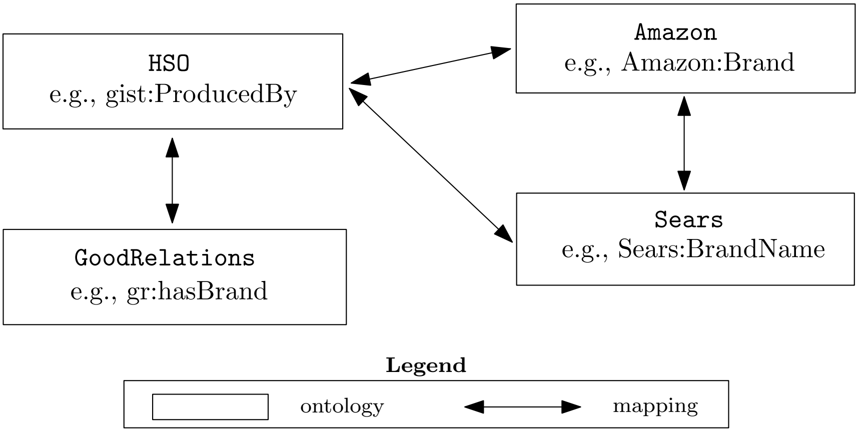


Figure : Relationship between the mappings across the different ontologies.

Ontology Mapping: ServicedAtHome

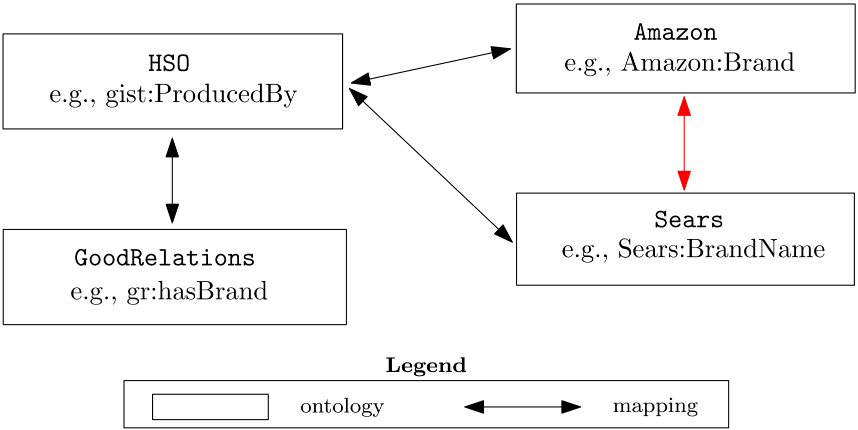
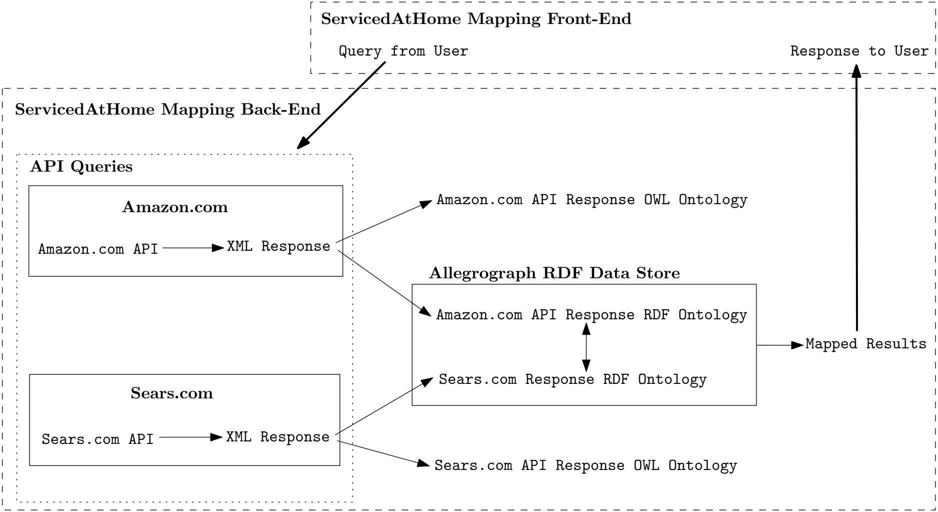
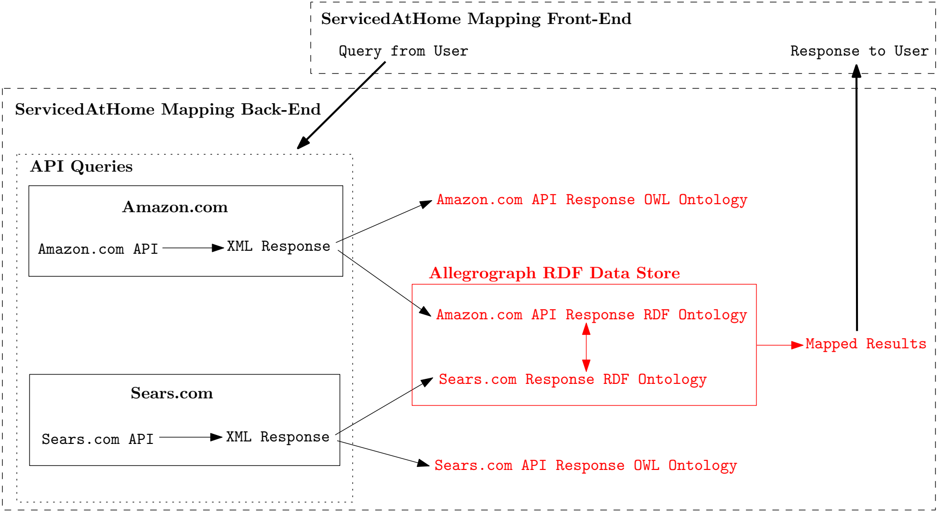


Figure : Relationship between the mappings across the different ontologies.

ServicedAtHome Architecture



ServicedAtHome Architecture



Key Insights

- There are difficulties in developing ontologies for vendor product specifications when there is a lack of semantic formalisms in e-commerce.
- There is a greater need for semantic technologies to be adopted in e-commerce.

Future Work I

Ontology Decomposition: Verification of DOLCE

- Complete the verification of the $T_{dolce\_dependence}$, $T_{dolce\_participation}$, $T_{dolce\_quality}$, and T_{dolce_quales} modules.

Ontology Composition: DOLCE & PSL

- Identify whether there are any additional similar notions of concepts found in $T_{dolce\_dependence}$, $T_{dolce\_quality}$, and T_{dolce_quales} with PSL and theories in COLORE.
- Verify the faithful interpretations between $\mathbb{H}^{dolce}$ and $\mathbb{H}^{periods}$, and $\mathbb{H}^{periods}$ and $\mathbb{H}^{combined\_time}$.

Semantic Augmentation: CIMOSA Process Ontology

- Verify the current axiomatization of CIMOSA.

Future Work II

Semantic Augmentation: Open Standards

- Develop a methodology that utilizes ontologies to remove ambiguity found in standards documents.
- Make clear distinctions between the various terminologies used to describe ontology relationships.

Ontology Mapping: Product Ontologies

- Develop a general product ontology that describes product features (e.g., a product is *electric*, requires *rechargeable AA batteries*).

Miscellaneous

- Use COLORE with automated reasoners to facilitate the reuse of theories, and the storage and organization of lemmas and theory subsets to improve theorem prover performance.

Overall Contributions

1. A *partial decomposition* (modularization) and verification of DOLCE that outlines the meta-theoretic interactions between the axioms found in these theories.
2. The identification of common intuitions between DOLCE and PSL through the *composition* of theories from DOLCE, PSL, and COLORE.
3. A proposed process ontology that describes the behavioural rules found in the CIMOSA modelling framework developed via *semantic augmentation* with PSL terminology.
4. The development of two vendor ontologies and an examination of an application of *ontology mappings* in the world of e-commerce.

References & Additional Links I

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