Foundational Ontologies for the Semantic Web

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Summary

- Different uses of ontologies for the semantic web
- Good and bad ontologies
- The ontology sharing problem
- The WonderWeb project: towards a library of foundational ontologies
- A glimpse to the OntoClean Top ontology
- Some conclusions…
Different uses of ontologies for the semantic web

- **Application ontologies** (*run time*)
  - offer *terminological services*, checking constraints between terms
  - limited expressivity (stringent computational reqs.)

- **Reference ontologies** (*develop. time*)
  - *establish consensus* about meaning of terms (in general)
  - higher expressivity (less stringent computational reqs)

- *Mutual understanding* more important than mass interoperability
  - understanding disagreements
  - establish trustable mappings among application ontologies

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Bad and good (reference) ontologies

- **Bad ontology**
- **Good ontology**
A simple example

Talking about the "on" relationship in the blocks world

Only one predicate in the language: on/2

Simplified domain: just two blocks a, b

Just one axiom:
~on(x, x)

Further axiom for a bigger domain:
on(x, y) & on(y, z) \rightarrow \neg on(x, z)

Non-intended models are excluded, but the intended meaning of "on" for describing situations in the blocks world is not captured.

Ontology Completeness and Accuracy

• In general, a single intended model may not discriminate among relevant alternative states of affairs
  - Lack of primitives
  - Lack of entities
• Capturing all intended models is not sufficient for a "perfect" ontology
• Completeness: all non-intended models are excluded
• Accuracy: all non-intended states of affairs are excluded
• Accurate ontologies may need an extension of language and domain which is not necessary for run-time purposes
Ontology quality

- Completeness
- Accuracy
- Cognitive adequacy

Foundational (well-founded) ontologies

- Based on formal relations
- Minimal general categories
- Explicit commitment on major ontological choices
- Clear branching points
- Pointers to established literature
- Link to natural language
Towards a library of foundational ontologies

- The Monolithic View vs. the Modular View
- Two senses of “library”
  - Different views of the world (*choose vision*)
  - Different “clusters” of relevant concepts and relations (*choose subject*)

The WonderWeb Foundational Ontologies Library

- List the *basic options*
- Explore most relevant mutual *dependencies*
- Propose one preliminary upper level which is carefully *justified* and *positioned* with respect to the space of possible choices
- Add some *minimal ontologies* specifically relevant for the *semantic web*
- For the final release, a few *alternative* upper levels will be considered
WonderWeb Foundational Ontologies Library

The Foundational Ontologies Library

Menu
3D vs. 4D
4D: object/event
....
Extensionality
....
Formal Ontological Analysis

- Theory of Parts
- Theory of Wholes
- Theory of Essence and Identity
- Theory of Dependence
- Theory of Qualities
- Theory of Composition and Constitution

The WonderWeb approach

- Not a candidate for a “universal” ontology
- Strong cognitive bias: descriptive (as opposite to revisionary) attitude, influenced by
  - Perception
  - Culture
  - Social conventions
- Categories as conceptual containers: no “deep” metaphysical implications
- Clear branching points to allow easy comparison with different ontological options
The WonderWeb Reference Ontology

- **Quality**: temporal/spatial location, color, mass...
- **Quality region**: time, space, color space...
- **Aggregate**
  - **Amount of Matter**: mass, fluid, mixture, chemical element...
  - **Aggregation**: arbitrary aggregation
- **Object**
  - **Physical object**
    - **Body**: universe, electron, physical body
    - **Ordinary Object**: piece of wood, body of water, artifact, animal...
  - **Mental object**: belief, goal, ...
  - **Social object**: legal person, social group, law...
- **Occurrence**
  - **State**: existence, condition
  - **Process**: increment, activity...
  - **Accomplishment**: conference, game, performance...
- **Feature**
  - **Relevant Part**: bump, edge, skin, mountain...
  - **Place**: hole, corner, opening, gulf...
  - **Abstract**: set, proposition, symbol...

The WonderWeb reference ontology

- **Entity**
- **Aggregate**
- **Object**
- **Quality**
- **Quality Region**
- **Feature**
- **Occurrence**
- **Amount of Matter**
- **Aggregation**
- **Physical object**
- **Abstract object**
- **Relevant Part**
- **Place**
- **Object**
- **Physical object**
- **Mental object**
- **Social object**
- **State**
- **Feature**
- **Occurrence**
General notions

- Rigidity
- Unity
- Constant dependence
- Endurance vs. perdurance

Endurance vs. Perdurance

- Endurants:
  - All proper parts are present whenever they are present (wholly presence, no temporal parts)
  - Exist in time
  - Can genuinely change in time
- Perdurants:
  - Only some proper parts are present whenever they are present (partial presence, temporal parts)
  - Happen in time
  - Do not change in time
Qualities, qualia, and quality spaces

- Linguistic evidence
  - This rose is red
  - Red is a color
  - This rose has a color
  - The color of this rose turned to brown in one week
  - The room’s temperature is increasing
  - Red is opposite to green and close to brown
- Qualities are different from properties
- Every entity comes with certain qualities that permanently inhere to it and are unique of it
- Different quality types
- Qualities are perceptually mapped into qualia, which are regions (points) of quality spaces.[Gardenfors]
(1) Aggregate vs. Object

Objects and aggregates are enduring entities: they are in time and are wholly present at a time. What distinguishes an object from an aggregate is that the former is an essential whole, namely it has a unity criterion, while the latter is not. For example, John can "make-up" a snowman (object) starting from the scattered snow (amount of matter) covering his courtyard, adding a hat, a carrot, two deadwoods, etc. In general, amounts of matter are mass-nouns (you can't say a snow, a water, ...), while objects are count-nouns (such as a snowman, five glasses of water).
(2) Aggregate vs. Object

- *Arbitrary collections* are just mere sum of wholes which are not themselves essential wholes (as the collection of goods in a bazar). In this sense, they are kinds of *aggregate*. On the other hand, there are collections which are themselves essential wholes, as a *library*. In our top-level these *unitary collections* are to be conceived as a specialization of the *object* category.

(3) Physical vs. Mental Object

- Objects can have an *inherent spatial localization* and be *not dependent from other objects* (physical objects, like cars) or no inherent localization and be dependent on *persons* (mental objects, like laws). Mental objects are also *mereologically variable*, while only some physical objects are.
- Mental objects can also be divided into *subjective* (depending on singular persons) and *inter-subjective* (depending on communities).
(4) Aggregate vs. Physical Object

- A physical object can change some parts, keeping or not its identity. In the first case (mereologically variable), we call it Ordinary Object, in the second case (mereologically invariant), Extensional Object, or Body. Bodies are equivalent to the objects of physics. My car will continue to be the same even if I replace one of its wheels. On the contrary, if I consider the universe, removing a single elementary particle I won’t have the universe any more, but a different entity.

- Regarding aggregates, we say that amounts of matter are mereologically invariant, while arbitrary collections can be considered as pseudo-constant: changes in the parts of a member of a collection may be allowed.

Occurrences

- Occurrences are perduring entities: they happen in time and are only partly present at a time. They are assumed to have only occurrences as temporal or spatial parts, while objects participate to occurrences.
  - The penalty that Roberto Baggio had not to kick

- Parts of occurrences can be:
  - temporal (the first movement of a symphony)
  - spatial (the strings playing within a symphony)

- Occurrences are distinguished into homeomeric (states) heteromeric (accomplishments), or weakly homeomeric (processes): into relational or non-relational according to the number of participants, and into intentional (activities, generically dependent on a mental object) or non-intentional (phenomena, specifically dependent on an object)
Features

- Features are "parasitic" entities, that exist insofar their host exists.
- Features may be relevant parts of their host, like a bump in a road, or dependent places, such as a hole in a piece of cheese, the underneath of a table, or the shadow of a tree (which are not parts of their hosts).
- All features are essential wholes, but no common unity criterion may exist for all of them (*U).
- Moreover, relevant parts are part of their host, while places are not.

Abstracts

- Abstracts are entities that have no inherent spatial nor temporal localization. Examples of Abstract are propositions, sets, symbols, etc.
## Figure Conventions

- Given an entity $x$ to be characterised as $D(x)$, its properties are written with the following compact syntax (in the 'attribute' slot of the next UML class diagrams):

<table>
<thead>
<tr>
<th>Property</th>
<th>Syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C$</td>
<td>$\forall x , D(x) \rightarrow C(x)$</td>
</tr>
<tr>
<td>NOT($C$)</td>
<td>$\forall x , D(x) \rightarrow \neg C(x)$</td>
</tr>
<tr>
<td>$R:C$</td>
<td>$\forall x , D(x) \rightarrow \exists y , R(x,y) \land C(y)$</td>
</tr>
<tr>
<td>$[EXn]$</td>
<td>$\forall x , D(x) \rightarrow \exists n(y) , R(x,y) \land C(y)$</td>
</tr>
<tr>
<td>$[ALL]R:C$</td>
<td>$\forall x,y , D(x) \rightarrow R(x,y) \rightarrow C(y)$</td>
</tr>
<tr>
<td>NOT($R:C$)</td>
<td>$\forall x , D(x) \rightarrow \neg \exists y , R(x,y) \land C(y)$</td>
</tr>
</tbody>
</table>

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## OCT: the OntoClean Top-level

![OCT Diagram](image-url)
Aggregate, Quality, and Quality Region

Object
Basic Relations

- Parthood
  - Between quality regions (immediate)
  - Between arbitrary objects (temporary)
- Dependence
  - Specific/generic constant dependence
- Inherence
- Quality extension
- Participation
- Constitution
- Membership
Axiomatizing basic relations

- Ground axioms (mainly algebraic)
- Links with other relations
- Dependence on time