Formal Ontology at Work

ESSLLI 2005 introductory course on
Formal Ontology for Semanticists

Edinburgh – 10 August 2005

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At the end of the lecture, you should have

- a better grasp of the formalism,
- a hint on the need of (and relationships among) primitives, and
- an idea of the questions one should keep in mind in formalizing ontological notions.

Outline of the lecture

- Location

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- Qualities

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- Qualities
- Identity and Constitution

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- Location
- Qualities
- Identity and Constitution

- The “space” of ontological choices

On Location

Location

When modeling physical objects, one needs to talk about their relationship in space. Here is an axiomatization of *exact* location (or address) in mereotopological terms.
Note that we take mereology and topology as basic theories for modelling space.

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Source
R. Casati and A. Varzi "Parts and Places", MIT Press, 1999 (Chp. 7)

Location: why?

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- We already know that it allows us to better capture the relation “on” in the blocks world (Lecture 1).
- Different things can visit the same location (perhaps at different times).
- Motion and mereological change are different phenomena.
- Location and topological connection...

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Informally, we take $L(x, y)$ to mean “x is exactly located at y”

(we put no restriction on the ‘dimension’ of the entities...)

Location: axioms (1)

$L(x,y) \wedge L(x,z) \rightarrow y = z$ (functionality)

$L(x,y) \rightarrow L(y,y)$ (conditional reflexivity)

Consequences:

Location: axioms (1)

$$L(x,y) \land L(x,z) \rightarrow y = z \qquad \text{(functionality)}$$
$$L(x,y) \rightarrow L(y,y) \qquad \text{(conditional reflexivity)}$$

Consequences:

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- what about the domain of the theory? Think of $L(x,x)$...

Location: doubts

Do we want the followings?

$\forall x \exists y \, L(x,y)$ (everything is localized)

$\forall x \, (L(x,x) \rightarrow \exists y \, (x \neq y \wedge L(y,x)))$
(every region is the location of something)

Exact and Broad Locations (1)

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e.g. Italy is wholly located in (the location of) Europe

$GL(x,y) =_d \exists z,w\,(P(z,x) \wedge P(w,y) \wedge L(z,w))$ (generic location)
e.g. Museums are generically located in Berlin
(i.e. some museums, although perhaps not all, are located in Berlin)

Exact and Broad Locations (2)

...and other notions can be captured with the help of topology! Let $C(x,y)$ be the connection relation "x is connected to y" (reflexive and symmetric). Let $TP(x,y)$ be the tangential part relation "x is tangential part of y" (definable in terms of P and C).

Then, we can write

$$TWL(x,y) =_d \exists z\,(TP(z,y) \wedge L(x,z)) \qquad \text{(tangential WL)}$$

e.g. Italy is tangentially wholly located in Europe.

Exact/Broad Locations: axioms, consequences

Some new axioms:

A few consequences:

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(3) $P(x,y) \wedge L(z,y) \rightarrow PL(z,x)$

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(i) $PL(x,y) \wedge P(z,y) \rightarrow PL(x,z)$

(ii) $WL(x,y) \wedge P(z,x) \rightarrow WL(z,y)$

On Qualities

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Source

D. M. Armstrong “Four disputes about properties”, Synthese (2005) 144: 309-320

Qualities

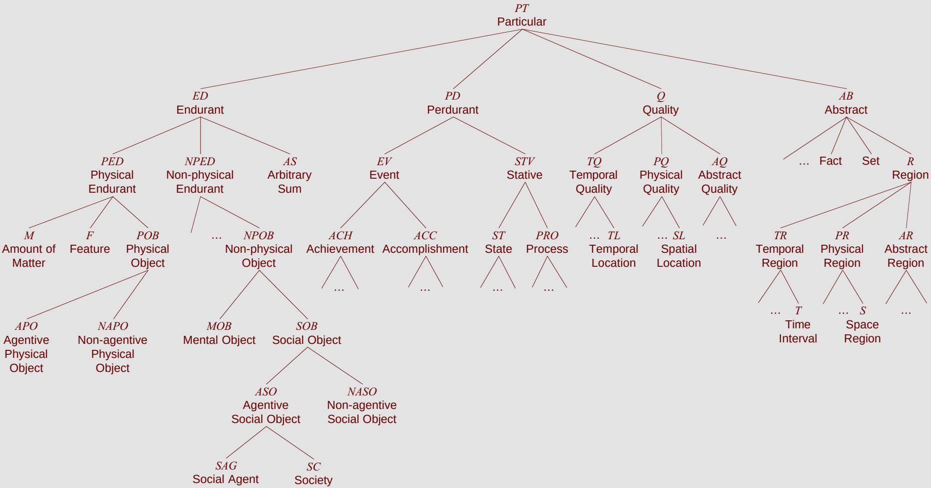
Let's concentrate on *qualities* !

On this topic we follow the DOLCE ontology.

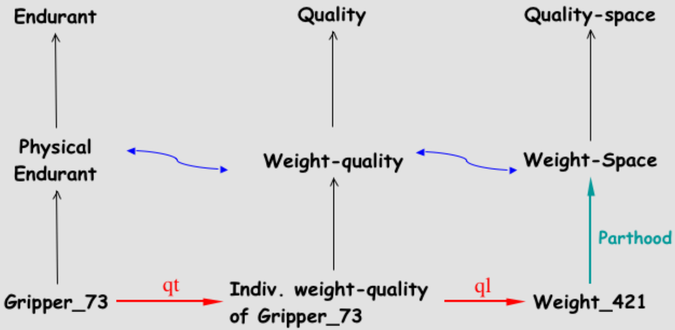
Source
http://www.loa-cnr.it/DOLCE.html

See also
C. Masolo and S. Borgo "Qualities in Formal Ontology" in Foundational Aspects of Ontologies (Ws Font 2005), to appear

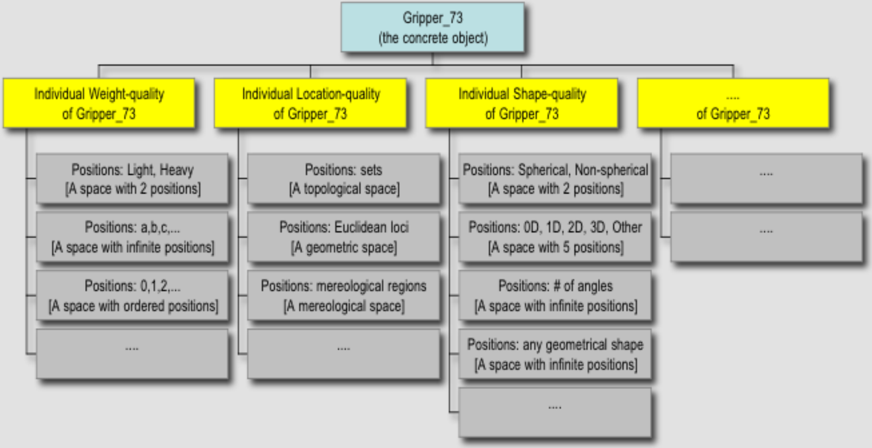
Qualities: DOLCE Taxonomy



Qualities, Qualia, and Hosts



Qualities and Qualia



Qualities: formalization (1)

$\mathrm{qt}(x, y)$ stands for "x is a quality of y"

Derived Relations

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Derived Relations

- $\mathrm{dqt}(x, y) =_d \mathrm{qt}(x, y) \wedge \neg\exists z(\mathrm{qt}(x, z) \wedge \mathrm{qt}(z, y))$ (*Direct Quality*)

  E.g. John is tall vs. John lived for 80 years.

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  (*Direct Quality*)

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- $\text{qt}(\phi, x, y) =_d \text{qt}(x, y) \wedge \phi(x) \wedge \text{SBL}_X(Q, \phi)$

  (*Quality of type* ϕ)

Qualities: formalization (2)

Argument Restrictions

Ground Axioms

Qualities: formalization (2)

Argument Restrictions

- $\mathrm{qt}(x, y) \rightarrow (Q(x) \wedge (Q(y) \vee ED(y) \vee PD(y)))$
- $\mathrm{qt}(x, y) \rightarrow (TQ(x) \leftrightarrow (TQ(y) \vee PD(y)))$
- $\mathrm{qt}(x, y) \rightarrow (PQ(x) \leftrightarrow (PQ(y) \vee PED(y)))$
- $\mathrm{qt}(x, y) \rightarrow (AQ(x) \leftrightarrow (AQ(y) \vee NPED(y)))$

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Ground Axioms

- $(\mathrm{qt}(x, y) \wedge \mathrm{qt}(y, z)) \rightarrow \mathrm{qt}(x, z)$
- $(\mathrm{dqt}(x, y) \wedge \mathrm{dqt}(x, y')) \rightarrow y = y'$
- $(\mathrm{qt}(\phi, x, y) \wedge \mathrm{qt}(\phi, x', y)) \rightarrow x = x'$
- $(\mathrm{qt}(\phi, x, y) \wedge \mathrm{qt}(\psi, y, z)) \rightarrow \mathrm{DJ}(\phi, \psi)$

Qualities: formalization (3)

Existential Axioms

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- $TQ(x) \rightarrow \exists! y(\mathrm{qt}(x, y) \wedge PD(y))$
- $PQ(x) \rightarrow \exists! y(\mathrm{qt}(x, y) \wedge PED(y))$
- $AQ(x) \rightarrow \exists! y(\mathrm{qt}(x, y) \wedge NPED(y))$
- $PD(x) \rightarrow \exists y(\mathrm{qt}(TL, y, x))$
- $PED(x) \rightarrow \exists y(\mathrm{qt}(SL, y, x))$

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qt(x, y) stands for “x is a quality of y”

ql(x, y) stands for “x is the quale of y”

ql(x, y, t) stands for “x is the quale of y during t”

PC(x, y, t) stands for “x participates in y during t”

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Derived Relations

- $\mathsf{ql}_{T,PD}(t, x) =_d PD(x) \wedge \exists z(\mathsf{qt}(TL, z, x) \wedge \mathsf{ql}(t, z))$

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- $\mathrm{ql}_{T,ED}(t, x) =_d ED(x) \wedge t = \sigma t'(\exists y(\mathrm{PC}(x, y, t'))$
- ...

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Argument restrictions

Ground Axiom

Existential and Structuring Axioms

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Existential and Structuring Axioms

- $TQ(x) \rightarrow \exists y(\mathsf{ql}(y,x))$
- $(\mathsf{L}_X(\phi) \wedge \phi(x) \wedge \phi(y) \wedge \mathsf{ql}(r,x) \wedge \mathsf{ql}(r',y)) \rightarrow$
  $\exists \psi(\mathsf{L}_X(\psi) \wedge \psi(r) \wedge \psi(r'))$

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- $(\mathsf{L}_X(\phi) \wedge \phi(x) \wedge \neg\phi(y) \wedge \mathsf{ql}(r, x) \wedge \mathsf{ql}(r', y)) \rightarrow \neg\exists\psi(\mathsf{L}_X(\psi) \wedge \psi(r) \wedge \psi(r'))$

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- After a while you accept my argument and leave.

Identity and Constitution

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1) how can this conclusion happen?
(The answer was given in words, if you missed class you can read the story in the paper cited below)

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Source

M. Rea "Introduction" in Material Constitution - A Reader, R. C. Rea (ed.), Rowman & Littlefield Publishers, Inc., 1997

Identity and Constitution: Assumptions (I-II)

Let F be a predicate like “being a man” (or “being a cat”).
Let $K(x, y, t)$ be the ternary relation “x compose y at t”.
Finally, let R be a binary relation (here *atemporal* constitution).

(I) Existence Assumption

$$\exists x, ps, t\,(F(x) \wedge K(ps, x, t))$$

(II) Essentialist Assumption

$$\forall x, ps, t\,[(F(x) \wedge K(ps, x, t)) \rightarrow \exists z\,[K(ps, z, t) \wedge \Box\, \forall qs, t\,(K(qs, z, t) \rightarrow R(qs, z))]]$$

Identity and Constitution: Assumptions (III-V)

(III) Principle of Alternative Compositional Possibilities

$$\forall x, ps, t\,[(F(x) \wedge K(ps, x, t)) \rightarrow$$
$$\exists w[K(ps, w, t) \wedge \Diamond\,(\exists qs, t\,(K(qs, w, t) \wedge \neg R(qs, w)))]]$$

(IV) Identity Assumption

$$\forall x, y, ps, t\,[(K(ps, x, t) \wedge K(ps, y, t)) \rightarrow x = y]$$

(V) Necessity Assumption

$$\forall x, y\,[x = y \rightarrow \Box\,((E(x) \vee E(y)) \rightarrow x = y)]$$

Dropping assumption (IV)

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Consequences of dropping the Identity Assumption

This solution commits us to the existence of entities $a \neq b$ such that, at some time t, both $K(ps, a, t)$ and $K(ps, b, t)$ hold,

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which is a way to say that:

there exist *distinct* entities which have all of the same parts at the same time, i.e. they are co-localized (D. Wiggins, F. Doepke, J. J. Thomson); this is sometimes weakened to entities of different 'kinds' or to identification of entities through essential properties.

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(i) identity is *contingent* (see A. Gibbard, G. Myro, and perhaps D. Lewis) and

(ii) there are no rigid designators (since rigidity is limited to sortals or relative to the counterpart relation).

Formal Ontology as a Space of Choices

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We have seen examples of formalizations and related problems.

Plenty of other issues need to be addressed when building a formal ontology.

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- Are space, time and space-time absolute OR are they relative (i.e. the result of relations holding between entities)?
- Are they atomic or atomless?

Space of Ontological Choices (1)

We have seen examples of formalizations and related problems.

Plenty of other issues need to be addressed when building a formal ontology.

For instance, beside talking about location, we haven't discussed much the fundamental notions of space and time.

- Are space, time and space-time absolute OR are they relative (i.e. the result of relations holding between entities)?
- Are they atomic or atomless?
- Which geometry do they satisfy?

Space of Ontological Choices (2)

What about the *persistence* of entities?

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What about the *persistence* of entities?

- How do entities persist?

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What about the *persistence* of entities?

- How do entities persist?
- What does it means for an entity to change maintaining its identity?

Space of Ontological Choices (2)

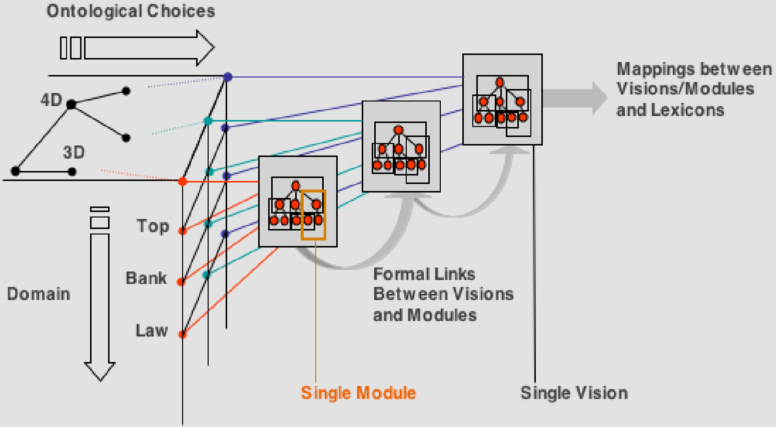
What about the *persistence* of entities?

- How do entities persist?
- What does it means for an entity to change maintaining its identity?
- Are entities spatio-temporal worms going through different phases? are they three-dimensional entities instantiating different properties at different times?

Space of Ontological Choices (3)

Two dimensions:

- *visions*, corresponding to basic ontological choices;
- *specificity*, corresponding to the domains



Minimal bibliography for today lecture

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