



How Formal Ontology can help Civil Engineers

Stefano Borgo

Laboratory for Applied Ontology, ISTC-CNR, Trento (IT)

borgo@loa-cnr.it

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Actual Title

How Formal Ontology can help those Civil Engineers that care about

- ▶ the foundations of their work,
- ▶ theoretical issues,
- ▶ stability over time,
- ▶ strong reusability,
- ▶ ...



Outline

- (1) Ontologies, Formal Ontologies, Foundational Ontologies
- (2) Qualities: a good tool for CE
- (3) Statics vs Dynamics
- (4) On the relationship between Ontology and Linguistic Resources
- (5) Dolce and implementations



Walking through ontology types...

On language

- ▶ **Linguistic/Terminological ontology** (weakest semantics)
 - ▶ Glossary
 - ▶ Controlled vocabulary
 - ▶ Taxonomy
 - ▶ Thesaurus
- ▶ **Implementation driven ontology**
 - ▶ Conceptual Schema
 - ▶ Knowledge Base
- ▶ **Formal ontology** (strongest semantics)
 - ▶ (depending on language expressivity)

On content

Domain / Core (reference) / Foundational ontology



Formal ontologies: the notion

An ontology is (first intuition [Gruber 93])

“a specification of a conceptualization of a knowledge domain”

Formal ontology deepens this intuition by requiring:

- ▶ clear semantics for the language (*formal semantics*)
- ▶ strict rules to specify terms and relations (*formal language*)
- ▶ explicit motivations for the adopted categories (*philosophical analysis*)

The complexity splits into two distinct aspects:

- 1) the organization of the knowledge structure
- 2) the information specific to application domains.

Formal ontologies look at the first issue only.



An example we are all familiar with: MATH

We all know that math is a language
terms, sentences, function symbols, quantifiers, constants ...

used to talk about entities

$\{a, b, c\}$, π , \mathbb{N}_0 , \log_e , \mathbb{Z}_R , $\begin{bmatrix} 0 & 2 \\ 3 & 3 \end{bmatrix}$, \oplus , ...

isolated by concepts (definitions)

sets, numbers, matrices, equations, integrals, spaces, morphisms ...

Q. : What is the ontology of math?

A. :



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Q. : What is the ontology of math?

A. : not the language, not the entities, not the definitions...

It is the complex of relationships between the concepts that we can express in the language



What is ontology then?

Leaving aside the variety of things people mean when using the term 'ontology' (a labeled graph, a set of terms, a knowledge base, a structure for knowledge, a science, etc.)

we must recognize that there is a clear-cut distinction between:
(knowledge) organization and *(knowledge) classification*

Let me insist on the crucial role of ontology in the first sense
(knowledge organization):

- ▶ *Foundational* aspects: organization of the basic entities
- ▶ *Formal* aspects: organization captured in formal language



What is a *foundational ontology* then?

Foundational ontologies are the most general formal ontologies.

They characterize general terms like entity, event, process, spatial and temporal location and basic relations like part-of, quality-of, participation, dependence

The purpose is:

- (1) to provide a formal description of entities and relationships that are common in all domains
- (2) to provide a consistent and unifying view



Static vs Dynamic - ontology vs data

General complain:

an ontology fixes a situation... and will be soon outdated

Question:

do you need to change your closet in order to change your clothes?

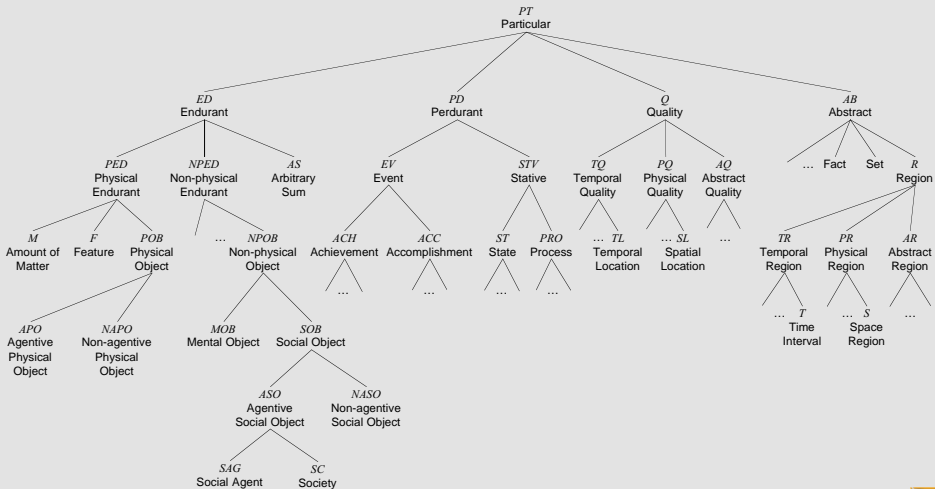
Question 2:

- do you need a process to describe a process?
(is a flowchart of a bank transaction a process?)

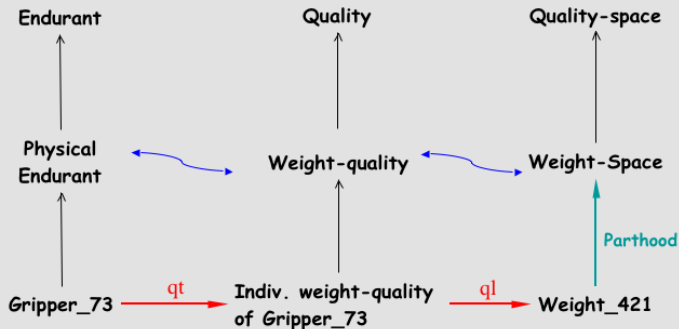
If we want to guarantee stability, we need to understand that an ontology can capture evolution being part of it.



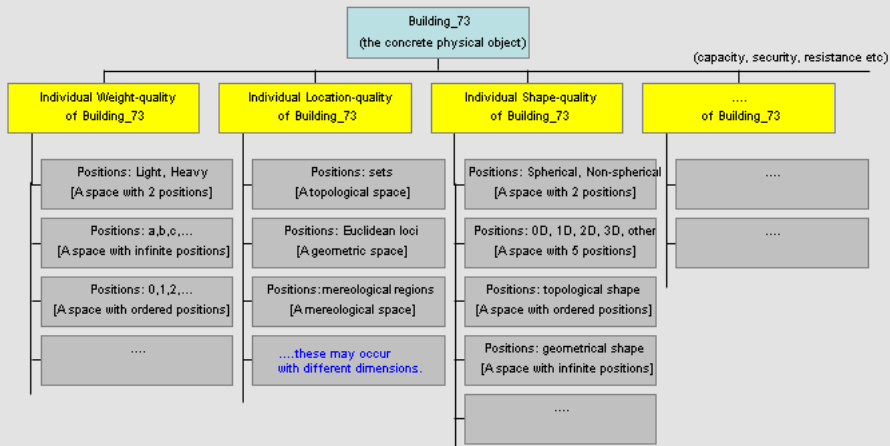
The DOLCE Taxonomy



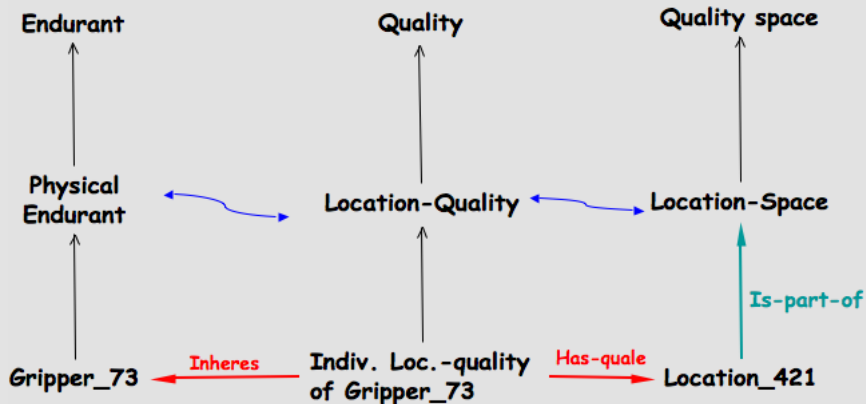
The good Qualities (good Qualia and their Hosts)



Qualities and Qualia



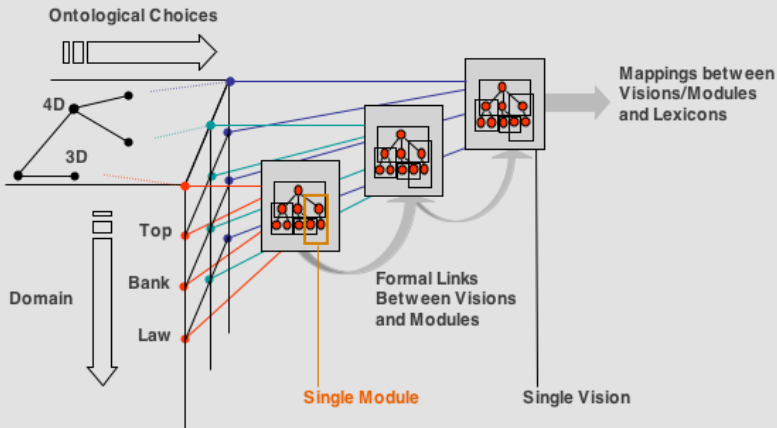
Location as Quality



Space of Ontological Choices

Two dimensions:

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



Ontology and Linguistic Resources

Merging ontologies and WordNet sounds like mixing apples and pears...

Three (and a half) main strategies:

- ▶ Re-structuring - (ontology at the meta-level, focus on L.R.)
Goal: improve the lexical resource [ex.: OntoClean]
- ▶ Populating - (systems treated as taxonomies, focus on mapping)
Goal: increase ontology coverage [ex.: OpenCyc, SUMO-WN]
- ▶ Aligning - (add info to the ontology, meta and obj. levels)
Goal: produce a system ontologically sound and linguistically motivated [ex.: OntoWordnet]
- Merging - (focus: remove redundancy)
Goal: produce a unified system



Can we actually use a rich ontology?

Formal ontologies *are* implemented.

DOLCE is a modal first order theory available in FOL, OWL-DL, KIF, etc.

For the full system we are using Casl (the *Common Algebraic Specification Language*) developed by the “Common Framework Initiative”.

Casl and its extensions can be used for different logics like

- Casl-DL (equivalent to SHOIN(D), an OWL-DL system)
- ModalCasl supports multi-modalities

and several other different logics



Thank you

