

Dolce: motivating its ontological distinctions

DOLCE a Descriptive Ontology for Linguistic and Cognitive Engineering

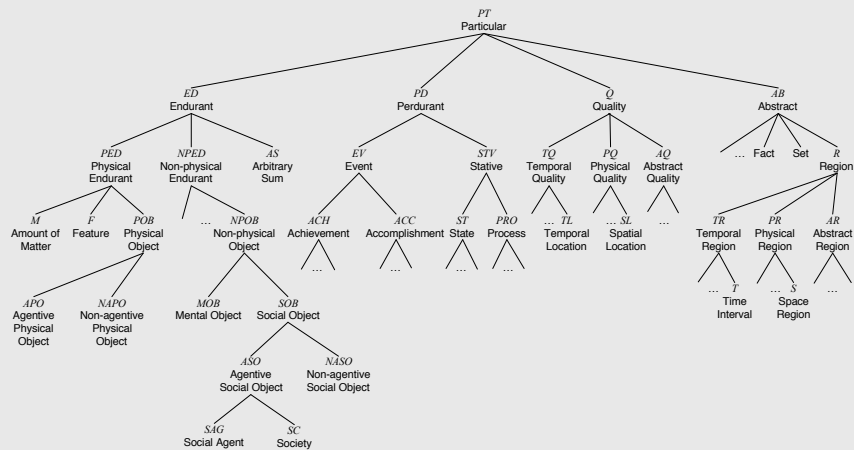
- Strong cognitive/linguistic bias:
 - **descriptive** (as opposite to *prescriptive*) attitude
 - Categories mirror cognition, common sense, and the lexical structure of natural language.
- Emphasis on **cognitive invariants**
- Categories as **conceptual containers**: no “deep” metaphysical implications
- Focus on **design rationale** to allow easy comparison with different ontological options
- Rigorous, systematic, interdisciplinary approach
- **Rich axiomatization**
 - 37 basic categories
 - 7 basic relations
 - 80 axioms, 100 definitions, 20 theorems
- Rigorous quality criteria
- Documentation

DOLCE's basic taxonomy



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DOLCE taxonomy



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DOLCE's Basic Ontological Choices

- **Objects** (aka *continuants* or *endurants*) and **Events** (aka *occurrences* or *perdurants*)
 - distinct categories connected by the relation of *participation*.
- **Qualities**
 - Individual entities *inhering in* Objects or Events
 - can live/change with the objects they inhere in
 - Instance of *quality kinds*, each associated to a **Quality Space** representing the "*values*" (*qualia*) that qualities (of that kind) can assume. Quality Spaces are neither in time nor in space.
- **Multiplicative approach**
 - Different Objects/Events can be spatio-temporally co-localized: the relation of *constitution* is considered.

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Objects and Events

- **Objects (3D *continuants*)**
 - Need a time-indexed parthood relation
 - Exist in time
 - Can genuinely change in time
 - May have non-essential parts
 - All proper parts are present whenever they are present (wholly presence, no temporal parts)
- **Events (4D *occurrences*)**
 - Do not need a time-indexed parthood relation
 - Happen in time
 - Do not change in time (*as a whole...*)
 - All parts are essential
 - Only some proper parts are present whenever they are present (partial presence, temporal parts)
- Objects *participate to* Events

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Qualities and qualia

- 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*
 - *Red is opposite to green and close to brown*
 - *The patient's temperature is increasing*
 - *The doctor measured the patient's temperature*
- Each object or event comes with certain qualities that permanently **inhere** to it and are **unique** of it
- Qualities are perceptually mapped into **qualia**, which are regions of **quality spaces**.
- Properties hold because qualities have certain locations in their quality spaces.
- Each quality type has its own quality space

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Qualities



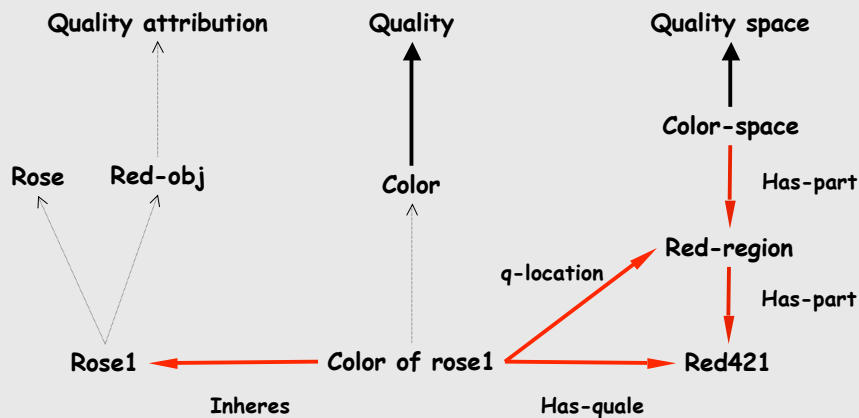
The rose and the chair have *the same color*:

- different color qualities inhere to the two objects
- they are located in the same quality region

Therefore, the same color attribute (red) is ascribed to the two objects

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Qualities



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What's special with qualities?

- A simple attribute-value structure is not enough as a representation formalism: you need to put **individual qualities** in the domain of discourse
- Differently from instances of other attributes, individual qualities are existentially dependent on their bearers
- The so-called **determinable/determinate issue** is not actually an issue:
 - **redness** (a quality type) is very different from **red** (a color region) and has a quality space very different from that of colors...

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Qualities vs. Features



- **Features:** “parasitic” physical entities.
- **relevant parts** of their host...
... or **places**
- Features have qualities, qualities have no features.



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Abstract vs. Concrete Entities

- Concrete:
 - located (at least) in time
- Abstract - two meanings:
 - Result of an abstraction process (something common to multiple exemplifications)
 - ☛ **Not located in space-time** (no inherent spatial or temporal location)
- Examples: *propositions, sets, symbols, regions*, etc.
 - **Quality regions** and **quality spaces** are abstract entities
 - Mereological sums (of concrete entities) are concrete, the corresponding sets are abstract...

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Physical vs. Non-physical Objects

- Physical objects
 - Inherent spatial localization
 - Not necessarily dependent on other objects



- Non-physical objects
 - No inherent spatial localization
 - Dependent on agents
 - mental (depending on singular agents)
 - social (depending on communities of agents)
 - Agentive: a company, an institution
 - Non-agentive: a law, the Divine Comedy, a linguistic system...
 - Descriptions, an extension of DOLCE

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DOLCE Extensions and Applications

DOLCE Extensions

(mainly by Aldo Gangemi @LOA-RM)

- Allen-based ontology of time for events
- Ontology of common-sense locations
- Descriptions and Situations (D&S) ontology (reified relations and relationships)
- Ontology of Functional Participation (cf. *thematic roles*)
- Ontology of Plans and Tasks (DDPO) (Metokis project)
- Ontology of Information Objects (DDIO (Metokis project)
- Ontology of Knowledge Content Objects (KCO), from Metokis, for multimedia description and negotiation
- Ontology of Services, based on DDPO (with UKA, VUA)
- Ontology of Semantic Middleware (by Daniel Oberle at UKA)
- Core Legal Ontology (CLO, with ITTIG-CNR)
- Metaontology of ontology as semiotic object (O2)
- Ontology of ontology evaluation and quality (oQual)
- Ontology of design patterns
- Ontology of social entities and organizations (MOSTRO project @LOA-TN)

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Mapping with lexicons: the OntoWordNet project

(Aldo Gangemi, Alessandro Oltramari, Massimiliano Ciaramita)

- 809 synsets from WordNet1.6 directly subsumed by a DOLCE+ class
 - Whole WordNet linked to DOLCE+
 - Lower WordNet levels still need revision
- Glosses being transformed into DOLCE+ axioms
 - Machine learning applied jointly with foundational ontology
- WordNet “domains” being used to create a modular, general purpose domain ontology
- Ongoing work on ontological analysis of specific WordNet domains (cognition, emotion, psychological feature)
- Ongoing cooperation with Princeton University.

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The OntoWordNet methodology

1. **Populate** a general ontology (DOLCE) by adding single synsets (or whole taxonomy branches) from a c. lexicon (upon suitable classification)
2. **Restructure** a c. lexicon by checking ontological constraints (e.g. *OntoClean* meta-properties) throughout the branches
3. **Merge** an ontology and a c. lexicon (includes 1. and 2.)
4. **Enrich** the resulting structure by extracting relationships from the glosses.

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Formalizing DOLCE

Basic Relations

- Parthood
 - Between quality regions (immediate)
 - Between arbitrary objects (temporary)
- Dependence
 - Specific/generic constant dependence
- Constitution
- Inherence (between a quality and its host)
- Quale
 - Between a quality and its region (immediate, for unchanging entities)
 - Between a quality and its region (temporary, for changing entities)
- Participation
- Representation

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Axiomatizing basic relations

- Domain restrictions
- Ground axioms (mainly algebraic)
- Links to other relations
- Dependence on time

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Domain restrictions on basic relations

Parthood: “ <i>x is part of y</i> ” $P(x, y) \rightarrow (AB(x) \vee PD(x)) \wedge (AB(y) \vee PD(y))$
Temporary Parthood: “ <i>x is part of y during t</i> ” $P(x, y, t) \rightarrow (ED(x) \wedge ED(y) \wedge T(t))$
Constitution: “ <i>x constitutes y during t</i> ” $K(x, y, t) \rightarrow ((ED(x) \vee PD(x)) \wedge (ED(y) \vee PD(y)) \wedge T(t))$
Participation: “ <i>x participates in y during t</i> ” $PC(x, y, t) \rightarrow (ED(x) \vee PD(y) \wedge T(t))$
Quality: “ <i>x is a quality of y</i> ” $qt(x, y) \rightarrow (Q(x) \wedge (Q(y) \vee ED(y) \vee PD(y)))$
Quale: “ <i>x is the quale of y (during t)</i> ” $ql(x, y) \rightarrow (TR(x) \wedge TQ(y))$ $ql(x, y, t) \rightarrow ((PR(x) \vee AR(x)) \wedge (PQ(y) \vee AQ(y)) \wedge T(t))$

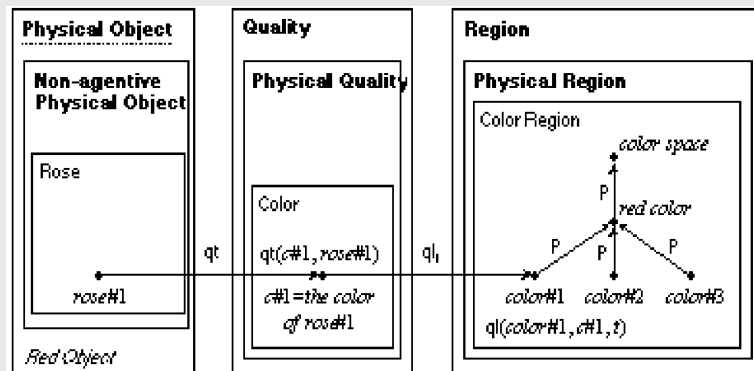
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Kinds of dependence

- (D1) $SD(x, y) =_{df} o(\exists t(PR(x, t)) \wedge \forall t(PR(x, t) \rightarrow PR(y, t)))$ (Specific Const. Dep.)
(D2) $SD(\phi, \psi) =_{df} DJ(\phi, \psi) \wedge o(\forall x(\phi(x) \rightarrow \exists y(\psi(y) \wedge SD(x, y)))$ (Specific Const. Dep.)
(D3) $GD(\phi, \psi) =_{df} DJ(\phi, \psi) \wedge o(\forall x(\phi(x) \rightarrow \exists t(PR(x, t)) \wedge \forall x, t((\phi(x) \wedge At(t) \wedge PR(x, t)) \rightarrow \exists y(\psi(y) \wedge PR(y, t))))$ (Generic Const. Dep.)
(D4) $D(\phi, \psi) =_{df} SD(\phi, \psi) \vee GD(\phi, \psi)$ (Constant Dependence)
(D5) $OD(\phi, \psi) =_{df} D(\phi, \psi) \wedge \neg D(\psi, \phi)$ (One-sided Constant Dependence)
(D6) $OSD(\phi, \psi) =_{df} SD(\phi, \psi) \wedge \neg D(\psi, \phi)$ (One-sided Specific Constant Dependence)
(D7) $OGD(\phi, \psi) =_{df} GD(\phi, \psi) \wedge \neg D(\psi, \phi)$ (One-sided Generic Constant Dependence)
(D8) $MSD(\phi, \psi) =_{df} SD(\phi, \psi) \wedge SD(\psi, \phi)$ (Mutual Specific Constant Dependence)
(D9) $MGD(\phi, \psi) =_{df} GD(\phi, \psi) \wedge GD(\psi, \phi)$ (Mutual Generic Constant Dependence)

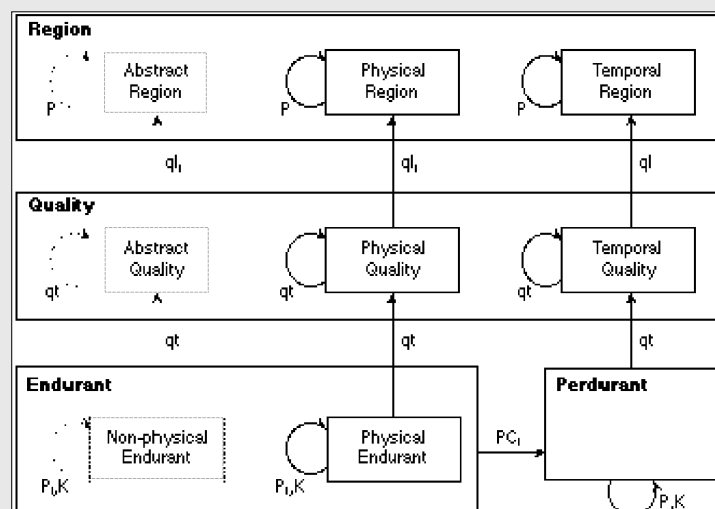
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Quality relations



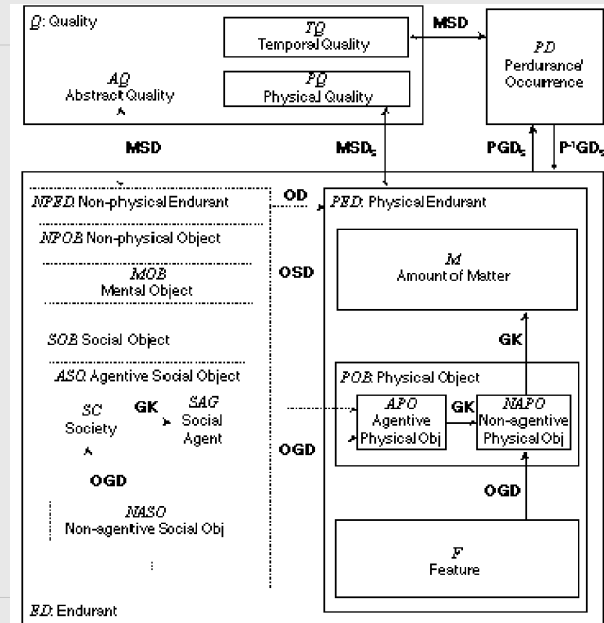
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Primitive relations and basic categories



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Dependence relations



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Participation relations

- Hold between a perdurant and its involved endurants
- Extremely relevant for domain modelling
- Current axiomatization covers:
 - constant vs. temporary
 - complete vs. partial
- Further distinctions are currently primitive (thematic roles)
 - *Agent, Theme, Substrate, Instrument, Product*
 - More is needed on event structure, intentionality, and artifacts to produce analytic definitions

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Towards an ontology of organizations

Organizations belong to *social reality*

- They are brought into existence by the performance of (social) **speech acts** (acts involving promises, obligations, duties...) [Searle]

What is the physical basis for this extended existence?

- In small societies: the memories of those involved
- In large societies: **documents** [De Soto]
- Indeed, documents are often the main (the only) communication channel among complex organizations (take the **e-government** example)

Beyond documents: what is missing?

- the various entities documents and services are about: *events, people, locations, organizations, goods...*
- the social and institutional (deontic, quasi-legal) entities created by documents
- the *social interactions* in which documents play an essential role (how documents bind people together)
- the sorts of things which we can *do* with documents
- the different types of *institutional systems* to which documents belong

No e-government interoperability without this rich ontology!

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Important aspects of organizations

- Organizations are
 - **Structured** and **multilayered**: not necessarily reducible to basic roles and their interrelations;
 - **Designed**: created with specific functions;
 - **Realized** by autonomous agents playing specific roles;
 - **Agentive** mental attitudes (e.g., goals and intentions) can be ascribed to (actual realizations of) organizations
 - **Situated**: immersed in an environment;
 - **Dynamic**: structure and realization can vary in time.

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Structured organizations

- An organization is a set of *interacting roles* [van den Broek]
- An organization is a structured entity where agents playing roles interact to achieve organization-wide goals [De Loach and Matson]
 - [relations between individual and organizational goals have a special relevance]
- An organization has a *social structure* (basically a role structure) and an *interaction structure* (interaction relations between roles) [Dignum]

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Levels of description of an organization

- *Abstract level*: no reference to real agents – only organization roles, their links and groups, global plans, and permissions/obligations [Sichman]
- *Concrete level*: an organization is *realized* (i.e., its goals are achieved) by real agents that play the organizational roles.

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Social roles

- Basic components of an organization, characterized by
 - the **functions/objectives** they have
 - the **interactions** with other roles – normally regulated by *norms*
 - the **requirements** agents need to satisfy in order to play the role
- collectively, all the aspects above contribute to the **competences** assigned to a role

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Agents play roles

- The **glue** between concrete and abstract aspects of an organization is **social commitment**:
 - Agents are committed in various ways to other agents to do what is specified by the roles they play
 - An emblematic case of social commitment is the **promise** [Castelfranchi, Tuomela, Searle...]
 - Promises strongly depend on **trust** and **delegation** considerations
 - Promises are made public and precise by means of **contracts**
 - Contracts have **deontic** implications (**obligations, rights, permissions...**)

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Agents vs. Roles

- When an agent plays a role it acquires a certain *property*:
 - John plays the 'student' role -> John is a student
- These properties are very different from other properties like 'person' or 'red' (formal ontological distinctions can be established)
- The same agent can play different roles simultaneously
- The same role can be played by different agents
- Agents can change role
- Some social roles have *institutional persons* associated with them
- In general, we have to distinguish:
 - The role
 - The individual playing the role
 - The institutional person associated to the role
 - The individual *qua* playing the role

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The Artifact Metaphor

- Organizations can be seen as **artifacts** whose function is to constrain some collective behavior to obtain a specific objective [Tummolini and Castelfranchi 2006]
 - For a chair, each part contributes to the main function
 - Similarly, competences are assigned to every part of an organization, and they contribute to its general objective
- The specification of an organization can be *refined during the process of design*
- In short, organizations seem to represent a clear case of **social intelligence design**

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The social dimension of semantic integration: the e-government case

- Subtle differences in meaning contribute to create the (digital) divide between citizens and the Public Administration
- **The citizen is ONE!**
- ...while Public Administration presents itself as a multitude of different services and organizations.
- E-government solutions need to be *designed* at multiple integration levels:
 - Among different **services**
 - Among different **organizations**
 - Among **services** and **organizations**
 - Among **organizations and the context** they operate in
- Integration of services goes hand in hand with the integration of organizations. *Ontologies of services are not enough.*

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What is a service? A business-level analysis

- An action?
- An action *type*?
- An organization?
- What do you *pay for*, when you invest in a service?
 - public services: firemen, road cleaning, child care..
- What are the identity conditions of a service?
- Has a service spatial and temporal qualities?
- Literature analysis: no convincing definition...
 - (Certainly W3C definition of *web services* doesn't help...)

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Services as events: the basic idea

A service is an agent's availability to guarantee some action useful for somebody, in correspondence of certain situations

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Services as *complex* events

- Provider's perspective:
 - Service offering (legal responsibility)
 - Service coordination/support
- User's perspective:
 - Service delivery, customization and support
 - Service intervention
 - Basic service actions

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Conclusion

- Subtle meaning distinctions do matter
- Formal ontological analysis provides a rigorous methodology to obtain robust and coherent theories
- A humble interdisciplinary approach is essential

...Is this hard?

Of course yes!

(Why should it be easy??)