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Part 3:
Descriptive ontology for linguistic and cognitive engineering (DOLCE)

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Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 32, *Data management and interchange*.

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Introduction

The descriptive ontology for linguistic and cognitive engineering (DOLCE) (see References [1] and [3]) is a top-level ontology (TLO) conforming to ISO/IEC 21838-1:2021. It contains definitions of its terms and relational expressions and formal representations in OWL 2 and in Common Logic (CL).

DOLCE is a top-level ontology aimed at making people's assumptions about the nature and structure of the world explicit, as reflected by natural language, cognition and human common sense (see its backbone taxonomy in Figure 1). DOLCE is widely used by a diverse array of domain ontologies in areas like enterprise and process modeling, engineering, robotics, geographical information systems, socio-technical systems and digital humanities.

The natural language specification of the DOLCE signature supports human maintenance and use of the ontology, including use in development of conformant domain ontologies.

The adoption of the Web Ontology Language (OWL) as a W3C standard was motivated by the need to have a decidable ontology representation language as the basis for the Semantic Web. The OWL 2 formalization of DOLCE supports use of the ontology in computing, including enabling DOLCE to be used in tandem with other ontologies expressed in OWL and in related languages, and in allowing ontology quality control through use of OWL reasoners.

The CL formalization of DOLCE provides the expressivity needed to provide an axiomatization whose models are the intended models of DOLCE. This axiomatization has a modular structure (see Figure 2 where the arrows represent the relation of extension of theories).

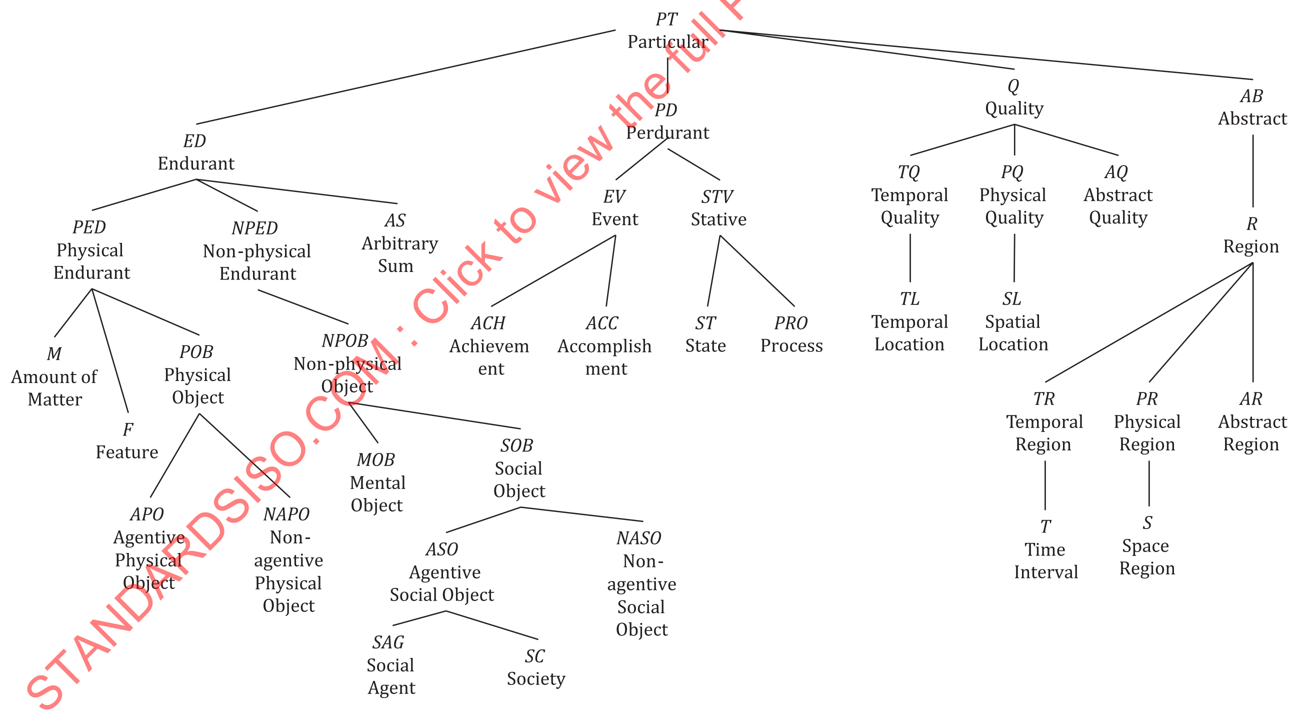

Figure 1 — DOLCE taxonomy

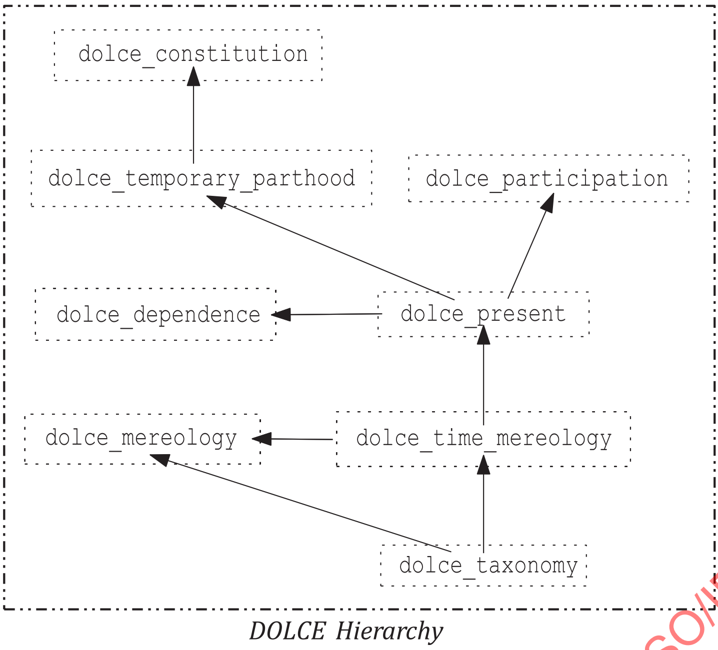

Figure 2 — DOLCE modules

Information technology — Top-level ontologies (TLO) —

Part 3:
Descriptive ontology for linguistic and cognitive engineering (DOLCE)

1 Scope

This document describes descriptive ontology for finguistic and cognitive engineering (DOLCE) as an ontology that is conformant to the requirements specified for top-level ontologies in ISO/IEC 21838-1.

This document describes DOLCE as a resource designed to support ontology design, ontology integration, and semantic integration of heterogeneous information systems.

The following are within the scope of this document:

— definitions of classes and relations in the signature of DOLCE;

— axiomatizations of DOLCE in OWL 2 and CL;

— documentation of the conformity of DOLCE to the requirements specified for top-level ontologies in ISO/IEC 21838-1;

— documentation of the methodology for specifying domain ontologies that conform to DOLCE.

The following are outside the scope of this document:

— specification of ontology languages, including the languages RDF, OWL, and CL standardly used in ontology development;

— specification of methods for reasoning with ontologies;

— specification of translators between the notations of ontologies developed in different ontology languages.

2 Normative references

The following documents are referred to in the text in such a way that their content constitutes requirements of this document. The latest edition of the referenced documents (including any amendments) applies.

ISO/IEC 21838-1:2021, *Information technology — Top-level ontologies (TLO) — Part 1: Requirements*

ISO/IEC 24707, *Information technology — Common Logic (CL) — A framework for a family of logic-based languages*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO/IEC 21838-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
conservative extension
superset of axioms from which no new theorems in the signature of the original logical theory are provable

3.2
consistent extension
supserset of axioms which is a consistent logical theory

3.3
logically synonymous
theories whose sets of models are in a one-to-one correspondence

3.4
module
subset of the axioms in a formal theory that is a *conservative extension* (3.1) of the subset

4 Conformance of DOLCE to ISO/IEC 21838-1

4.1 Overview

DOLCE has three elements, the documentation of which is provided at https://standards.iso.org/iso-iec/21838/-3/ed-1/en/:

— natural language representation of its terms, relational expressions and definitions;

— formalization in OWL 2 (Web Ontology Language);

— formalization in CL (Common Logic).

4.2 Natural language representation of DOLCE

The natural language representation of DOLCE, provided at https://standards.iso.org/iso-iec/21838/-3/ed-1/en/ DOLCE-Terms.docx, establishes conformance of DOLCE to ISO/IEC 21838-1:2021, 4.1.

4.3 OWL 2 formalization of DOLCE

The OWL 2 formalization of DOLCE, provided at https://standards.iso.org/iso-iec/21838/-3/ed-1/en/ DOLCE-OWL, establishes conformance of DOLCE ISO/IEC 21838-1:2021, 4.2.

4.4 Common Logic axiomatization of DOLCE

4.4.1 General

Conformance of DOLCE to ISO/IEC 21838-1:2021, 4.3 is established by DOLCE-CL, which is an axiomatization in Common Logic Interchange Format (CLIF) in accordance with ISO/IEC 24707.

4.4.2 Modularity

The axioms in DOLCE-CL are divided into the following modules in conformance to the requirement of explicit modularization at ISO/IEC 21838-1:2021, 4.1.

— DOLCE Taxonomy;

— DOLCE Mereology;

— DOLCE Present;

— DOLCE Dependence;

— DOLCE Participation;

— DOLCE Temporary Parthood;

— DOLCE Contitution;

— DOLCE Qualities.

NOTE Relationships between the modules of DOLCE are illustrated in Figure 2.

4.5 Specification of the purpose of DOLCE (in conformance to ISO/IEC 21838-1:2021, 4.4.2)

DOLCE is an upper ontology that is designed to capture the ontological categories found in natural language and human common sense. DOLCE is intended to be used to design domain ontologies through the extension of the DOLCE taxonomy.

4.6 Description of how conformance of a domain ontology to DOLCE is established (in conformance to ISO/IEC 21838-1:2021, 4.4.3)

A domain ontology in Common Logic conforms to DOLCE if and only if the axioms are specified in a CL dialect and the set of axioms is a consistent extension of the axiomatization of DOLCE as specified in the same CL dialect.

A domain ontology in OWL conforms to DOLCE if and only if the axioms are specified in OWL-2 and the set of axioms is a consistent extension of the axiomatization of DOLCE as specified in OWL-2.

4.7 Demonstration of the consistency of the CL axiomatization of DOLCE (in conformance to ISO/IEC 21838-1:2021, 4.4.4)

The demonstration of the logical consistency of the DOLCE Ontology, following the methodology of Reference [2] is available at:

https://standards.iso.org/iso-iec/21838/-3/ed-1/en/consistency

4.8 Interpretability of the OWL 2 axiomatization of DOLCE in CL (in conformance to ISO/IEC 21838-1:2021, 4.4.5)

Interpretability of the OWL 2 axiomatization described in DOLCE-OWL in the CL axiomatization (provided at https://standards.iso.org/iso-iec/21838/-3/ed-1/en/owl-interpret/) was established by incorporating a CL counterpart of the OWL axiomatization into the CL axiomatization

4.9 Demonstration of breadth of coverage of DOLCE (in conformance to ISO/IEC 21838-1:2021, 4.4.6)

4.9.1 General

This subclause provides a set of answers to the questions listed in ISO/IEC 21838-1:2021, 4.4.6 demonstrating the breadth of coverage of DOLCE.

4.9.2 Space and time

Within DOLCE is the distinction between enduring and perduring entities, where the fundamental difference between the two is related to their behaviour in time. Endurants are wholly present at any time: they are observed and perceived as a complete concept, regardless of a given snapshot of time. Perdurants, on the other hand, extend in time by accumulating different temporal parts, so they are only partially present at any given point in time. In this way, DOLCE recognizes both entities that persist in time and entities that occur in time.

DOLCE also recognizes entities that are extended in both space and time. Spatial locations form a subclass of physical qualities. Temporal locations form a subclass of temporal qualities. Regions (further specialized as physical and temporal regions) form a subclass of abstract entities. The only explicit axiomatization for these classes is the mereology on time intervals and space regions.

4.9.3 Actuality and possibility

Possible objects can be incorporated into DOLCE through the use of reified concepts which supports the classification of objects but does not commit to the temporal existence of an object at a point in time.

4.9.4 Classes and types

Classes of classes do not appear within the ontology, although they are allowed within the language of Common Logic.

4.9.5 Change over time

Temporal existence of endurants is represented via the PRE relation, which has the intended interpretation of endurant is present, or exists in, a time region.

DOLCE also axiomatizes the notion of temporary parthood for endurants. The temporary parthood relation only holds for endurants, thereby allowing the parts of an endurant to change over time. On the other hand, perdurants do not have temporary parts, but simply have temporal parts, and hence do not change over time.

Although DOLCE does represent how objects and processes exist in time, it does not appear to be the case that DOLCE makes a distinction between past, present and future entities. In particular, there seems to be no way of representing objects that hypothetically exist in the future.

4.9.6 Parts, wholes, unity and boundaries

The axiomatization of the parthood relation in DOLCE is logically synonymous with the classical extensional mereology. Consequently, it entails axioms of transitivity (if one entity is part of a second entity, and this entity is part of a third entity, then the first entity is also part of the third entity), as well as the existence of wholes formed through the summation of parts. DOLCE's axiomatization of mereology also entails the property of strong supplementation (if one entity is part of but not identical to a second entity, there must be a third entity which makes up the difference). In extensions of DOLCE, one can define physical boundaries as physical endurants whose regions are based on the abstract boundaries.

DOLCE allows a domain ontology designer to specify her own unity criteria, whereby a whole is such that all its parts are related to each other, and only to each other, by a single distinguished relation. For example, spatial location is typically used for the unity criteria for material objects.

4.9.7 Space and place

DOLCE deals with places and locations primarily through the class of Quality, that is, space and time locations are themselves individual qualities. The qualia (see 4.9.9) for spatial locations is a region in geometric space, while the qualia for time locations is a region in temporal space.

Physical endurants have a unique spatial location, while perdurants are indirectly located in space through the spatial location of the physical endurant that participate in them.

DOLCE makes no commitment about whether more than one object can occupy exactly the same spatial location at the same time. On the other hand, material objects that are simultaneously located at different places shall be different and events that have different temporal locations are different as well.

Similarly, shape is a quality in DOLCE, whose quality space contains the set of all possible shapes. Although DOLCE itself does not explicitly include holes, conduits, and cavities, extensions of DOLCE have represented these as subclasses of Feature and dependent features (e.g. surfaces, boundaries, edges or voids).

4.9.8 Scale and granularity

DOLCE itself does not deal with scale, granularity and levels of reality, although an extension of DOLCE can treat the material world as being made up of entities at distinguished levels. To compare the granularity levels of physical endurants — including both material endurants and voids — a partial ordering relation is introduced, with the intended interpretation that one physical endurant is of the same or a finer granularity than another

4.9.9 Qualities and other attributes

Besides endurants and perdurants, one of the other top-level classes in DOLCE is that of Quality. This is one of the most distinctive aspects of the DOLCE ontology. Qualities (such as shape, colour, size, weight) are individuals that inhere to entities. A distinction is made between a quality (e.g. the length of a specific object) and the value associated with the quality (e.g. the value of the length). Such values (known as qualia) belong to a quality space that is characteristic of each quality kind. Two objects do not have the same quality (e.g. same length), but rather their qualities have the same position in the corresponding quality space.

4.9.10 Quantities and mathematical entities

The DOLCE ontology's approach to units of measure is closely linked to its treatment of qualities and quality spaces. Mass, length, volume, etc. are physical qualities of physical objects, and their quale are values in the quality spaces associated with each unit of measure. Those attributes which are represented using qualitative terms such as ‘temperature' are related to attributes represented using quantity expressions such as "63° Celsius" precisely through the relationship that holds between qualities and quale.

4.9.11 Processes and events

DOLCE distinguishes between processes and states — as perdurants, Process and State are disjoint subclasses of Stative, which in turn is disjoint from Events.

There is no explicit axiomatization of the distinction between processes which are instantaneous and processes which have duration.

As can be seen from the taxonomy, DOLCE does not make any commitment as to what kinds of processes exist; this is left to the choice of the domain ontology designer. Furthermore, there is no explicit connection between processes and changes in DOLCE. Endurants change through time by changing their properties, and an entity may play a role (e.g. Student or President) for a specific time period (or even multiple disjoint time periods) without changing its identity.

DOLCE does not explicitly axiomatize how such properties change, e.g. it does not commit to any solution to the Frame Problem. Thus, processes are not identical to changes, as is the case in some other process ontologies.

Processes can themselves have attributes — events can be sudden, brief or prolonged, fast or slow, etc. and can occur before, after, simultaneously to other events.