INTERNATIONAL STANDARD

ISO/IEC 21838-4

First edition

Information technology — Top-level ontologies (TLO) —

Part 4: TUpper

PROOF/ÉPREUVE

Reference number
ISO/IEC 21838-4:2023(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

ISO and IEC draw attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO and IEC take no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO and IEC had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents and https://patents.iec.ch. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

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

A list of all parts in the ISO/IEC 21838 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

 PROOF/ÉPREUVE

Introduction

TUpper is a top-level ontology (TLO) conforming to ISO/IEC 21838-1. It contains definitions of its terms and relational expressions and formal representations in OWL 2 and in Common Logic (CL).

Top-level ontologies have traditionally arisen from the approach in which concepts that are common across a set of domains can be axiomatized at a general level. The rationale is that reuse across domains is to be supported through specialization of the general concepts from a top-level ontology. Similarly, semantic integration between ontologies is to be achieved through the general concepts they specialize. The TUpper ontology follows an alternative approach (referred to as the sideways approach) to the conventional top-level ontology paradigm. Rather than think of a top-level ontology as a monolithic axiomatization centred on a taxonomy, the sideways approach considers a top-level ontology to be a modular ontology composed of ontologies that cover concepts including those related to time, process, and space, from which any underlying taxonomy can be inferred. Each module within TUpper is a set of axioms from an existing ISO standard. The central claim is that a top-level ontology is an ontology that has a reduction whose modules are all ontologies that satisfy a subset of the requirements for a top-level ontology in ISO/IEC 21838-1:2021. New top-level ontologies can be designed by the union of different ontologies that already exist rather than harmonizing different ontologies.

The TUpper ontology is designed as a top-level ontology that contains modules from the ontologies within existing international standards, and that extends these modules so as to satisfy the criteria for top level ontologies in ISO/IEC 21838-1. The modules of PSL appear in ISO 18629. The modules for mereotopology and location arise from ISO 19107 and ISO 19150-1. Modules related to units of measure arise from ISO 80000.

TUpper-terms, the natural language specification of TUpper, supports human maintenance and use of the ontology, including use in development of conformant domain ontologies.

Tupper-OWL, the OWL 2 formalization of TUpper, enables TUpper to be integrated with other ontologies expressed in OWL and in related languages, and supports the use of OWL automated reasoners.

TUpper-CL, the CL formalization of TUpper, provides the axiomatization of the intended semantics of TUpper.

This document conforms to ISO/IEC 21838-1.

Information technology — Top-level ontologies (TLO) —

Part 4:
TUpper

1 Scope

This document describes TUpper as an ontology that is conformant to the requirements specified for top-level ontologies in ISO/IEC 21838-1.

This document describes TUpper as a resource designed to support ontology design, ontology integration, automated reasoning, 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 TUpper;

— axiomatizations of TUpper in OWL 2 and CL;

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

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

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 some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (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, adj
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

3.5
reduction
set of logical theories whose union is *logically synonymous* (3.3) to the ontology

4 Conformance of TUpper to ISO 21838-1

4.1 Overview

TUpper has three elements the documentation of which is provided in the file Tupper-Terms at https://standards.iso.org/iso-iec/21838/-4/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 TUpper

The natural language representation of TUpper, provided in the file TUpper-Terms at https://standards.iso.org/iso-iec/21838/-4/ed-1/en/, establishes conformance of TUpper to ISO/IEC 21838-1:2021, 4.1.

4.3 OWL 2 formalization of TUpper

The OWL 2[15],[16],[17] formalization of TUpper, provided in the file TUpper-OWL at https://standards.iso.org/iso-iec/21838/-4/ed-1/en/, establishes conformance of ISO/IEC 21838-1:2021, 4.2.

4.4 Common Logic axiomatization of TUpper

4.4.1 General

The CL formalization of TUpper (provided at https://standards.iso.org/iso-iec/21838/-4/ed-1/en) to ISO/IEC 21838-1:2021.

TUpper is available in the following formats:

— axiomatization in Common Logic Interchange Format (CLIF) as specified in ISO/IEC 24707 provided in the **common-logic** directory;

— axiomatization in standard first-order predicate logic notation is provided in the **pdf** directory.

4.4.2 Modularity

The axioms in TUpper-CL are divided into the following modules in accordance with the requirement of explicit modularization in ISO/IEC 21838-1:2021, 4.1.

PSL-Core	Duration of Objects and Activity Occurrences	Length
PSL Subactivity	Duration Ontology	Area
PSL Occurrence Trees	Timedurations	Volume
PSL Discrete States	Physical Mass	Density
PSL Atomic Activities	Constitution	Velocity
PSL Complex Activities	Mass	
PSL Activity Occurrences	Chunks of Matter	
PSL Interval Time	Amounts of Matter	
PSL Actors	Multidimensional Mereotopology	
Location Ontology	Shape	
Mereology for Location	Multidimensional Location Ontology	
Topology for Location	Length of Physical Objects	
Physical Mereology	Area of Physical Objects	
Physical Topology	Volume of Physical Objects	
Spatial Topology		

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

The TUpper ontology is designed as a top-level ontology that consistently combines the ontologies within existing international standards[1],[2],[3],[4],[5],[6],[7],[8],[9],[10],[11],[12],[13],[14]. Such an ontology enables applications that require the use of the multiple standards that are conformant with TUpper.

— ISO 18629-11: PSL-Core

— ISO 18629-12: PSL-Subactivity, PSL Occurrence Trees, PSL Discrete States, PSL Atomic, PSL Complex Activities, PSL Activity Occurrences, PSL Interval Time

— ISO 18629-13: PSL Duration

— ISO 19107: Multidimensional Mereotopology

— ISO/TS 19150-1: Occupy Root, Physical Mereotopology, Spatial Mereotopology

— ISO/IEC 80000: PSL Duration, Physical Mass, Spatial Units of Measure

4.6 Conformance of a domain ontology to TUpper (in conformance to ISO/IEC 21838-1:2021, 4.4.3)

A domain ontology conforms to TUpper 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 TUpper as specified in the same CL dialect.

4.7 Consistency of the CL axiomatization of TUpper (in conformity to ISO/IEC 21838-1:2021, 4.4.4)

The logical consistency of TUpper follows from the verification of the ontology, in which TUpper is shown to be logically synonymous with the union of a set of mathematical theories. The verification is done on the set of modules in TUpper and is provided at https://standards.iso.org/iso-iec/21838/-4/ed-1/en/verification/.

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

Interpretability of the OWL 2 axiomatization described in TUpper-OWL in the CL axiomatization (provided at https://standards.iso.org/iso-iec/21838/-4/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 TUpper (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 TUpper.

4.9.2 Space and time

TUpper posits two classes of temporal entities – timepoints (over which an ordering relation is axiomatized) and time intervals (which extend in time and over which an ordering and a mereology are defined).

TUpper recognizes entities that persist in time – an object exists at timepoints between the timepoint at which it starts to exist and the timepoint at which it ceases to exist.

TUpper recognizes entities that occur in time – each activity occurrence occurs at timepoints between the timepoint at which it starts to occur and the timepoint at which it ceases to occur.

TUpper axiomatizes a mereotopology over the set of spatial regions.

4.9.3 Actuality and possibility

Models of psl_occtree.clif are occurrence trees, which consist of all possible sequences of atomic activity occurrences. The set of activities that actually occur in a model are elements of one branch of the occurrence tree. Models consist of subtrees of the occurrence tree that correspond to possible occurrences of complex activities. A legal occurrence tree is the subtree of an occurrence tree in which all activity occurrences satisfy precondition axioms that specify the conditions under which an activity can possibly occur. Dispositions are treated via such precondition axioms.

4.9.4 Classes and types

Classes of activities are definable within TUpper. 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

Within TUpper, changeable properties are represented by states. States are achieved and falsified by activity occurrences.

Modules of TUpper that axiomatize domain process ontologies classify the activities that change states that are associated with different domains. The module motion.clif within TUpper classifies all activities that can possibly change the location of an object. It is consistent with TUpper for more than one material object to occupy exactly the same spatial region at the same time. The module matter.clif within TUpper all activities that can change the mereology of matter and that can change a material object by changing the matter that constitutes the object.

 PROOF/ÉPREUVE