A Parthood Approach for the modeling Tangible Objects Composition (TOC) - an application on Cultural Heritage (CH)

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1. Context

Goal?

Studying the representation of a tangible cultural heritage object and its evolution with time to build the complete information needed for its preservation and restoration.

- For its representation: modeling the composition of a tangible object using part-whole relations between entities (presented here).
- For its evolution: modeling changes that alter tangible objects, taking into consideration its composition, concerning spatial and temporal constraints (future work).

The approach is proposed in general, with the application on CH objects in particular.

Existing work in the CH domain

CIDOC CRM
- A formal ontology intended to facilitate the integration, mediation and interchange of heterogeneous CH information.[1]

European a Pro
- An object-centric and event-centric approach towards structuring and representing data delivered to Europeana by the various contributing CH institutions.[2]

FRBRoo
- A joint effort of FRBR and CIDOC CRM to merge the 2 object-oriented models within a formal ontology to represent the underlying semantics of bibliographic information.[3]

INSPIRE
- An EU initiative framework for spatial data infrastructure to make spatial/geographical information more accessible and interoperable. Integrating CH INSPIRE created an abstract model.[4]

ABC Ontology
- A metadata model and ontology for library data with the goal to research models and methods for describing the variety of rich content, mainly the CH content.[5]

Culture Sampo
- Finnish Culture on the semantic web 2.0: the application of the FinnOnto infrastructure (subject-matter ontologies based on existing Finnish keyword thesauri in use) in e-Culture.[6]

Problem statement

- Give no importance to the cultural heritage object itself, as a tangible object, neither to its composition elements.
- Poor in illustrating the components needed for its history, preservation, and restoration.
- Most are domain-specific.
- Some focus on certain object types and neglect others.
- Poor in describing the family relations between concepts, rights, and intellectual processes.[7]

2. Approach

Why?
« Several points of view, several cultural interests towards the object/parts of the object… However, the same composition, and the same whole and parts »

What?
« Understand the object itself, in all its composition levels and at its different extents »
Why the choice of object's composition? To build the information needed for building the history of a cultural heritage object and for its restoration and conservation.
Study this composition according to part-whole relations using a logical, ontological and linguistic parthood approach.[8][9]
Taking into consideration the present work in part-whole studies, this work has started from it, used it and added to it.

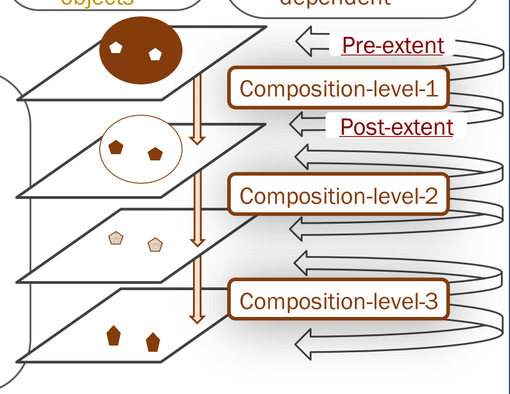
Categories of our approach:
- Part-whole relations
- Composition
- Tangible objects

New notions:
- Object's extent
- Composition level

New relations:
- Place-object
- Sequence-Unit

New parthood relation property:
- Existentially dependent

How?
Using the preceding categories, our main contributions are:
- The 7 possible cases of tangible objects, including:
  - 7 possible different part/whole relations, linguistically, ontologically and logically
  - Building a hierarchy of tangible object types according to our context's needs
  - Introducing 2 part-whole relations to the literature, and a property of parthood relations
- The modeling of the composition of a tangible object using part-whole relations, including:
  - New parthood concepts, properties, and relations hierarchy



Categories

Composition
- ⊕ Parthood composition concepts and properties for the TOC model
- ⊕ Parthood composition automaton

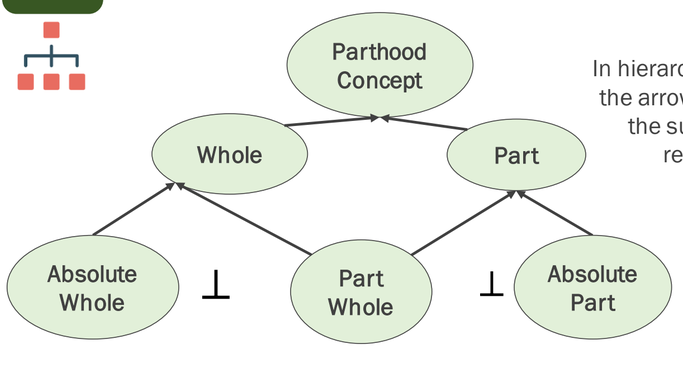
Tangible Objects
- ⊕ Tangible object types hierarchy

Parthood relations
- Linguistic:
  - ⊕ Winston's taxonomy of part-whole relations [10]
  - ⊕ 2 additional parthood relations and 1 relation property
- Logical/ontological:
  - ⊕ Combination of usage of parthood relations in one approach according to the tangible object's type

3. Propositions

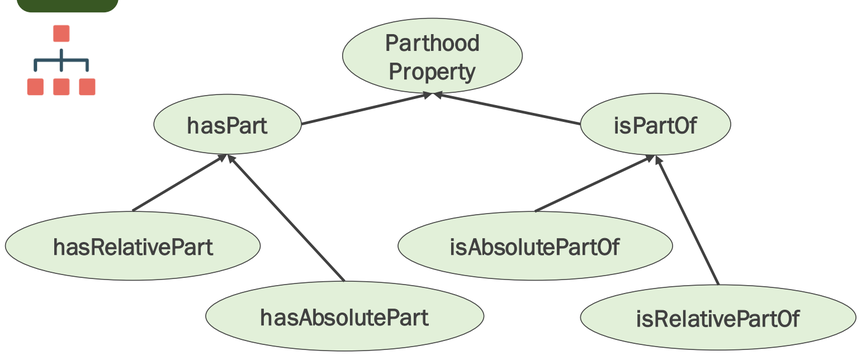
Components of the TOC Approach

3.1 PARTHOOD CONCEPTS HIERARCHY

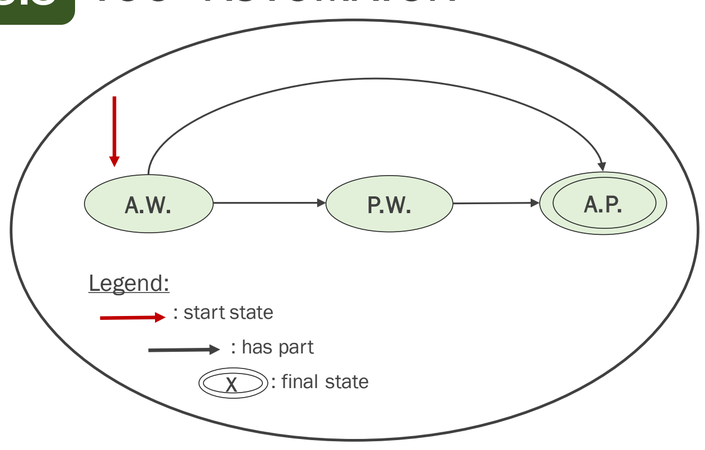


In hierarchical graphs, the arrow represents the subClassOf relation.

3.2 PARTHOOD PROPERTIES HIERARCHY



3.3 TOC - AUTOMATON

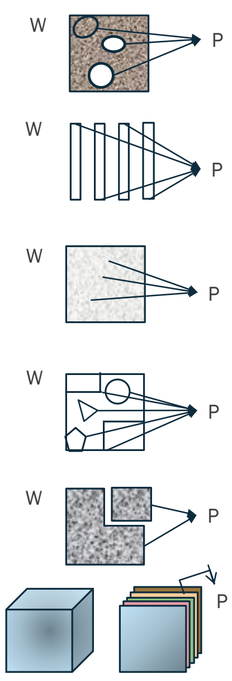


Formal Definitions

- P: Part ≡ Γ ∩ ∃isPartOf . Γ
- W: Whole ≡ Γ ∩ ∃hasPart . Γ
- AW: Absolute-Whole ≡ W ∩ ¬P
- AP: Absolute-Part ≡ P ∩ ¬W
- PW: Part-Whole ≡ W ∩ P
- hasAbsolutePart(x,y) ≡ W(x) ∩ AP(y)
- hasRelativePart(x,y) ≡ W(x) ∩ PW(y)
- isAbsolutePartOf(x,y) ⊆ hasAbsolutePart(x,y)⁻
- isRelativePartOf(x,y) ⊆ hasRelativePart(x,y)⁻

Note: isPartOf(x,y), hasPart(x,y) are considered to be atomic roles.

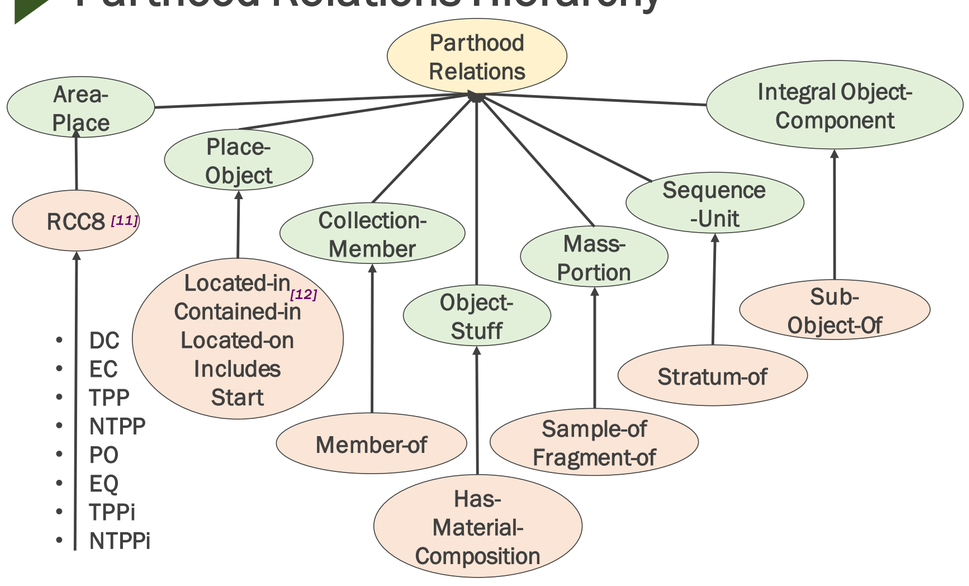
3.4 THE 7 CASES OF PARTHOOD RELATIONS IN TANGIBLE OBJECTS



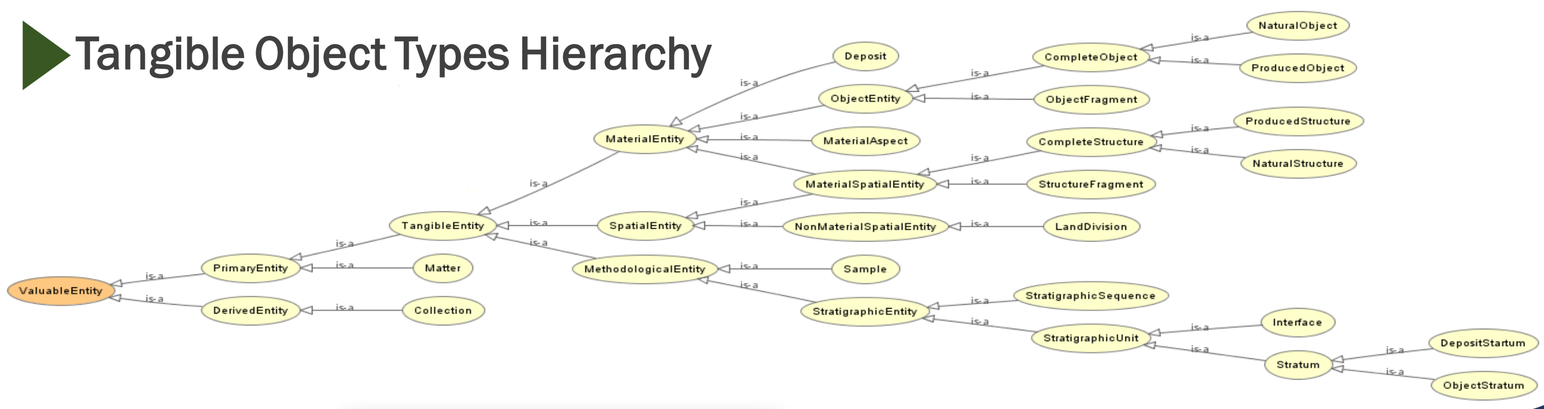
Whole entity	Part entity	Parthood Relation (Linguistic)	Properties	Logical/ ontological relation to be used	Examples of CH objects
Spatial entity	Spatial entity	Area-place	¬S, ¬F, H, E	RCC8	Cultural site, lake
	Material/ Methodological entity	Place-object	S/¬S, ¬F, ¬H, ¬E	located-in/ located-on/ contained-in/ includes-Stratigraphy	Cultural site, cultural object
Abstract group of entities	Tangible entity	Collection-member	S, ¬F, ¬H, ¬E	member-of	Collection of cultural objects (collection of stones)
Tangible entity	Matter	Object-stuff	¬S, ¬F, ¬H, ¬E	Has-Material-Composition	Piece, materials composing it
Object entity	Object entity	Object-component	S, F, ¬H, ¬E	Sub-Object-Of	Statue, a brocart on it
Tangible entity	Sample entity	Mass-portion	S, ¬F, H, E	Sample-of/ Fragment-of	homogenous cultural object, piece of it
Stratigraphic Sequence entity	Stratum entity	Sequence- Unit	S, F, ¬H, E	Stratum-Of	Group of layers, 1 layer

Legend:
- W: whole
- P: part
- F: functional
- S: separable
- H: homeomerous (from Winston's approach: part-whole relation properties) [10]
- E: existentially dependent: the existence of the parts is dependent on that of the whole

Parthood Relations Hierarchy



Tangible Object Types Hierarchy



Usage?

To describe the composition of an entity with TOC according to the TOC automaton in section 3.3:

1. Classify each entity, according to its nature, to a valuable entity type, using the hierarchy of tangible object types in 3.4
2. Use the Part-Whole relation that corresponds to the entity types, using the hierarchy of parthood relations in 3.4
3. Infer the compositional function of each entity, according to the occurrences of part-of and has-part relations, using the parthood concept and relations hierarchy in 3.1 and 3.2

4. Next Steps

TOC Model
Build the TOC ontology that encompasses all the TOC components in one complete approach, **based on the best practices and principles of the Semantic Web and Linked data efforts,** using OWL2.

Apply the TOC ontology on present datasets in CH for studying its applicability and genericity.

Modelling Changes
Identify the possible changes that alter a tangible object in a hierarchy of changes.

Model changes using the TOC model, taking into consideration its effects at the different extents of all the object's composition levels.

Link the changes semantically according to a cause and effect relations where for every change, a pre-change and post-change can occur.

Spatiotemporal Evolution
Modeling a tangible object's lifetime, including all the changes that altered it and it's different composition levels, concerning space and time constraints.

Being able to inference and reason i.e. add new knowledge to existing knowledge about the possible changes that altered an object according to its new characteristics and composition.

5. Bibliography

[1] *Le Boeuf, P., Doerr, M., Ore, C.E., Stead, S. Definition of the CIDOC Conceptual Reference Model, version 6.2.6*
[2] *The Europeana Data Model EDM*
[3] *Le Boeuf, P., Doerr, M.: The FRBRoo, version 0.8.1, https://web.archive.org/web/20070616033312/http:/cidoc.ics.forth.gr/frbr_inro.html*
[4] *Parcero-Oubiña, C., Fábrega-Álvarez, P., Vicent-García, J.M., Uriarte-González, A., Fraguas-Bravo, A., del-Bosque-González, I., Fernández-Freire, C., Pérez-Asensio, E. Conceptual basis for a cultural heritage data model for INSPIRE*
[5] *Generic Conceptual Model of the INSPIRE data specifications, Version 3.4rc3*
[6] *Lagoze, C., Hunter, J. The ABC Ontology and Model, DC-2001, October 24-26, 2001, NII, Tokyo, Japan*
[7] *Doerr, M. Ontologies for Cultural Heritage, ICS-FORTH*
[8] *Keet, M. Introduction to part-whole relations: mereology, conceptual modelling and mathematical aspects, KRDB06-3*
[9] *Vieu, L., Aurnague, M. Part-of relations, functionality and dependence, Human Cognitive Processing, 978 90 272 2374 6. 10.1075/hcp.20.18vie. hal-01078739*
[10] *Winston, M.E., Chaffin, R., Herrmann, D. A Taxonomy of Part-Whole Relations, COGNITIVE SCIENCE 11, 417-444 (1987)*
[11] *Randell, D.A., Cui, Z., Cohn, A.G. A Spatial Logic based on Regions and Connections, 3rd Int. Conf. on Knowledge Representation and Reasoning, Morgan Kaufmann, 1992*
[12] *Bittner, T., Donnelly, M. Computational ontologies of parthood, componenthood, and containment, In: Proceedings of the Nineteenth International Joint Conference on Artificial Intelligence 2005 (IJCAI05). Kaelbling, L. (ed.). pp382-387*

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