Integrated classification schemas to interlink cultural heritage collections over the web using LOD technologies

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Abstract: Libraries, archives and museum collections are now being published over the web using LOD technologies. Many of them have thematic intersections or are related to other web subjects and resources such as authorities, sites for historic events, online exhibitions, or to articles in Wikipedia and its sibling resources DBpedia and Wikidata. The full potential of such published initiatives using LOD rests heavily on the meaningful interlinking of such collections. Within these contextual vocabularies and classifications, schemas are important, as they provide meaning and context to heritage data. This paper proposes comprehensive classification schemas – a Culturally Relevant Relationships (CRR) vocabulary and a classification schema of types of heritage objects – to order, integrate and provide structure to cultural heritage data brought about with the publication of heritage collections as LOD.

Keywords: heritage objects; digital collections; classification; interlinking; culturally relevant relationships; linked data; LOD.

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1 Introduction

Since the 2000s, the cultural heritage collections of Libraries, Archives and Museums (LAM) have been published on the web. However, the web's cataloging technology separates these collections into information silos and prevents their digital objects from being interconnected. Although the collections are held by different institutions, many are complementary, with thematic intersections or relationships to other web subjects and resources such as authorities, sites for historic events, online exhibitions, or to articles in Wikipedia and its sibling resources DBpedia and Wikidata. If the digital objects in such collections can be interrelated, they can provide rich contexts for each other.

The emergence of the digital humanities poses new challenges for LAM (Zeng, 2019). The web interfaces used to seek information from such collections are very different from face-to-face reference services provided by many heritage institutions called 'disintermediation' in the literature, the loss of human connection seems to be irreversible (Brabazon, 2014; Burke, 2010).

Some of these collections are now being published as structured data using Linked Open Data (LOD) technologies. LOD technologies use RDF Primer (2004) to represent Heritage Object (HO) data, making the surrogates machine-processable. As more cultural heritage data sets are published using LOD technologies, the web of cultural data (The Linked Open Data Cloud, 2020) may be queried like a database with languages such as SPARQL (SPARQL Query Language for RDF, 2008). The publication of LAM digital collections using LOD technologies can achieve their full potential if the published resources become structured, interlinked, machine-processable, and queryable (Berners-Lee, 2006).

To fulfill LOD opportunities vocabularies and classification schemas are important, as they provide meaning and context to heritage data. Such vocabularies and classification schemas should be complementary, and, if integrated, have the potential to enrich digital HO collections. They can provide cultural curators with valuable tools to manually annotate and interlink HO, supplying rich contexts and narratives with great educational and cultural potential.

To address these issues, the following questions should be posed: What entities could be interlinked and integrated with HO to comprise the digital heritage landscape, useful for educational and cultural purposes? and What types of HO exist?

This paper integrates previous research on a Culturally Related Relationships (CRR) vocabulary (Marcondes, 2020) and a types of HO classification schema (Marcondes, 2019). Together they may provide a comprehensive digital heritage classification schema and tools to be used by both cultural curators and cultural heritage institutions to provide meaning and interlink their published data using LOD technologies.

The paper is organised as follows: After this introduction, Section 2 examines related works and previous research. Section 3 describes the material and methods used. Section 4 explains the results of the integrated system and Section 5 discusses the results and presents the conclusions.

2   Previous research and related work

To explore the synergies between LAM collections, and between the collections and other web resources, a research project proposed a vocabulary of Culturally Relevant Relationships (CRR) between HO with the intention of interlinking such collections using LOD technologies (Marcondes, 2020). The CRR vocabulary used examples suggested by cultural curators and other vocabularies (Marcondes, 2020) such as FRBR (IFLA, 1998), LRM (Riva et al., 2017), CIDOC (ICOM/CIDOC 2014), BIBFRAME (Library of Congress, 2016) and ICA (2016) RIC-CM, among others, as sources and inspiration for its relationship cases (Marcondes, 2019). Many relationships in these vocabularies are similar in intended meaning to the CRR relationships. Such relationships emerged from cases suggested by cultural curators, which then constituted the raw material for the development of the vocabulary; however, few have the same precise meaning as the relationships in those vocabularies. A comprehensive description of the CRR vocabulary, including the meaning of each relationship, relationships with similar meaning in other vocabularies as Dublin Core Metadata Initiative (2019); ICOM/CIDOC (2014) and namespace/URI specifications are detailed in a previous paper. A Table 1 with the CRR vocabulary relationships is included in Sub-section 3.1.

Several LAM projects use LOD technologies, but few of them interlink collections hosted by different institutions (Marcondes, 2019). Related works highlight the value of the initiatives to interlink LAM data and enrich metadata. These practices are increasingly being recognised as adding value to LAM data (Alemu and Garoufallou, 2020; Alexiev, 2018; Klein and Kyrios, 2013; McKenna et al., 2020; Volz et al. 2009; Zeng, 2019). The CRR vocabulary's purpose is to provide a tool to interlink and enrich LAM data. The proposed interlinking vocabulary could be used by cultural curators in their work of contextualising, commenting, evaluating, and making sense of HO, and improving the capacity for reuse. The CRR vocabulary now needs to be tested for its adequacy in interlinking several HO and interlinking them with other web resources that represent different relevant entities comprising the culture heritage landscape, including works, agents, and themes of cultural relevance, forming complex conceptualisations useful for cultural and educational purposes.

The annotation of digital objects can be used to enrich heritage collections (Manguinhas, 2016) using standards for annotation such as the Open Annotation Data Model (2020). The manual curation of digital collections by cultural curators through annotation is a significant way to enhance, enrich, and promote the reuse of heritage collections. The CRR vocabulary is proposed with this purpose, and as such, is an important initiative. Since its initial proposal, it has undergone several improvements (Marcondes, 2020). It was conceived to be simple and intuitive, used by cultural curators without any special training. Such principles guided its development.

However, to integrate a comprehensive HO management system, the CRR vocabulary should be complementary. A CRR relates two HO to each other, but the varied networks of museums and other heritage institutions challenges the integration of digital HO surrogates of heterogeneous collections. The emergence of LOD technologies enables both the publication and the interlinking of HO of different collections. Digital humanities studies stress the necessity of comparing digital HO according to different criteria (Zeng, 2019). Thus, a typology of HO would be useful in such cases. A cultural curator and a manager are both required to retrieve digital HO of the same type from different collections. To the extent of our knowledge, classification schemas of types of HO are limited to specific HO types, and a general classification schema of types of HO does not exist.

A classification schema for museum objects, the *Thesauros para Acervos Museológicos* (Ferrez and Bianchini, 1987), has existed in the Brazilian museum environment since the eighties. The original classification schema includes only artifacts. It does not include objects of scientific collections such as mineral, entomological, fossil, or botanic collections nor intangible heritage manifestations. This gap indicated a clear need to expand the original classification schema. Consequently, a comprehensive classification schema of types of heritage objects was developed based on the *Thesauros para Acervos Museológicos* (Marcondes et al., 2016) intending to encompass typical archives (documents, manuscripts, etc.), libraries (books, newspapers, etc.), scientific collections, and intangible heritage culture collections.

To achieve such objectives, the original classification schema needed be extended to become a comprehensive classification schema of types of HO. A criterion for distinguishing CRR is the 'expression form' of each HO participating in the relationship. Expression form is a property of HO defined as 'how each object is expressed or manifested 'to human senses' (Marcondes, 2020).

Expression form is an important criterion to distinguish between CRR such as '0011 Based_on' and '081 Inspired.' The Based_on relationship is defined as a relationship between two HO that have *the same* expression form, for example, the Da Vinci's *Mona Lisa* and the Dali's pastiche of *Mona Lisa* as his self-portrait. On the other hand, the 081 Inspired relationship is defined as a relationship between two HO which have *different* expression forms, e.g., the book *The Da Vinci Code* and the movie with the same title.

3   Material and method

This research is driven by the previously noted issues and attempts to integrate previous research efforts. The methodology for the development of the CRR vocabulary is described in detail in Marcondes (2020). As a vocabulary of relationships, each CRR relationship has an HO as both as domain and a range. The original proposal is not a classification of types of HO. However, some cases suggested the need to specify relationships between HO and external entities such as Agents, Concepts, Events/Processes, Time and Places (Marcondes, 2020, p.133). Such relationships are developed and detailed in this work.

The proposed classification schema of types of HO was developed in Marcondes et al. (2016) and Marcondes (2019). This classification schema was developed originally based on the *Thesaurus de Acervos Museológicos* (Ferrez and Bianchini, 1987), as previously noted, a museum classification schema largely used within Brazilian museum collections. The HO classification was developed, extending the *Thesaurus de Acervos Museológicos* with a bottom-up approach (all the thesaurus classes of objects are artifacts), to support different types of museum objects *that are not* included within it, such as objects in scientific collections (fossils, minerals, botanic species) and intangible cultural heritage.

According to Guarino (1997, p.148), 'formal ontology can be intended as the theory of a priori distinctions.' Ontological analysis (Guarino and Welty, 2000), conceptual definitions (Dahlberg, 1981, 1983), Aristotelian classification theory, and the examination of different HO classification schemas were all used as a methodology to *distinguish* the different types of museum objects and to classify them into a unique general schema. As a requirement, such a schema should cover all classes of the thesaurus.

Conceptual models such as IFLA (1998) Chapter 5 Sub-section 5.3, LRM (Riva et al., 2017) Table 4.7, BIBFRAME, ICOM CIDOC CRM and ICA RiC-CM provide a set of important relationships both between individual HO and between HO and other relevant external entities such as Agents, Concepts, Events/Processes, Time and Places. Such relationships could enrich the CRR vocabulary, and together with a classification schema of HO, comprise a comprehensive culture heritage landscape model.

4   Results

4.1   The CRR vocabulary

A Table 1 with all of the CRR vocabulary relationships extracted from Marcondes (2019) follows. When the vocabulary was conceived, the intention was to reuse relationships from other vocabularies. Most of the time this intention was not carried out because the concepts in the original vocabulary had a slightly different meaning or were not relationships, e.g., the CRR relationships '0021 Created_by' and '0022 Creator.' These relationships are somewhat similar to the Dublin Core element dc:creator, but dc:creator is not a relationship. In such cases, similar concepts are annotated within the CRR relationships.

The CRR vocabulary has been updated with the results obtained by testing, as shown in Marcondes (2020).

Table 1   CRR vocabulary relationships

RELATIONSHIP	INVERSE RELATIONSHIP
Id: 0001 Associated_wih	
Id: 0011 Based_on	Id: 0012 Base_for
Id: 0021 Created_by	Id: 0022 Creator
Id: 0031 Design_or_ Procedure_for	Id: 0032 Design_or_Procedure
Id: 0041 Documents	Id: 0042 Documented_by
Id: 0051 Has_Contribution_of	Id: 0052 Contributor
Id: 061 Has_Subject	Id: 0062 Is_Subject
Id:065 In_collection	
Id: 0071 Influenced	Id: 0072 Influenced_by
Id: 081 Inspired	Id: 0082 Inspired_by
Id: 0091 Is_Illustrated_by	Id: 092 Illustrated
Id:0101 Link_to_Agent	Id: 0102 Link_Agent_to_ Object
Id: 0121 Link_to_Event_ Process	Id: 0122 Link_Event_Process_ to_Object
Id: 0125 Link_to_Artistic_Mov/ Period	Id: 0126 Link_Artistic_Mov/ Period_to_Object
Id: 0127 Link_to_Download	
Id: 0131 Mentioned_by_in	Id: 0132 Mentions
Id: 0141 Part_of	Id: 0142 Has_part
Id: 0151 Portrays	Id: 0152 Is_Portrayed_by
Id: 0161 Provenance	Id: 0162 Place_of_Provenance
Id: 0171 Similar_item	

4.2   What types of heritage objects are there?

Museum collections typically hold three-dimensional objects. According to Van Mensh (1992, p.104) 'Museum objects are objects separated from their original (primary) context and transferred to a new, museum reality in order to document the reality from which they were separated,' adding,

'As documents museum objects (in the sense of primary museum material) are direct (authentic) witnesses of cultural and natural phenomena' (Van Mensh, 1992, p.106). This paper adapted these definitions to HO in general.

HO are heterogeneous, and typical museum object collections are far more heterogeneous than archive and library object collections. Although there is not a limitation, and many archives and libraries hold three-dimensional or iconographic objects, archive and library object collections are typically made of textual documents. Thus, the search for a classification schema to encompass all types of HO should be based on existing attempts. We examine several museum objects classification schemas, beginning with the one that originally motivated the proposal for a general HO classification schema, the Brazilian *Thesauros para Acervos Museológicos* (Ferrez and Bianchini, 1987).

The 16 classes of the *Thesauros para Acervos Museológicos* are: 1. Hunting and War, 2. Visual Arts, 3. Pecuniary Objects (coins, etc.), 4. Building, 5. Interior Decoration Objects, 6. Work, 7. Recreation, 8. Insignia, 9. Ceremonial Objects, 10. Communication, 11. Transport, 12. Personal Objects, 13. Penance and Torture Objects, 14. Measurement, Recording, 15. Packing, 16. Samples, Fragments (Ferrez and Bianchini, 1987). All types of objects are *artifacts*, or man-made objects. This limits the thesaurus as a classification schema for all types of HO. What is an artifact?

Borgo et al.'s (2011, p.1) definition:

> technical artifacts are objects that exist by human intervention; and that technical artifacts are to be contrasted to natural entities. Yet the perspectives are different in the way they spell out these intuitions: the relevant human intervention may range from intentional selection to intentional production.

Hilpinen (2011) proposed a synthetic definition: 'an artifact may be defined as an object that has been intentionally made or produced for a certain purpose.' The necessity to include HO from scientific collections (fossils, minerals, botanical species) and intangible cultural heritage during the reengineering process of the *Thesaurus para Acervos Museológicos* resulted in the following questions: A) *Are any classes of artifacts not included in the 16 original classes of the Thesaurus?* B) *What classes of HO are not artifacts?* These questions are addressed as follows:

A) The thesaurus class 10. Communicação (communication), has a subclass 10.1 Documentos (documents) for documents in museum archives and libraries, according to its scope note (Ferrez and Bianchini 1987, p.60). In the online version of the thesaurus – The Tesauro de Objetos do Patrimônio Cultural nos Museus Brasileiros – a similar class, Communicação, is substituted by Equipamento de Comunicação (communication equipment), and its former sub-class, Documento (document), is excluded. Classes for these types of objects are necessary for a general classification of HO. Thus, in addition to question A, another issue must be addressed: which classes for typical archives and libraries objects must be developed.

B) The answer to this question, according to the previous definitions of artifacts, is that classes must be developed for the objects that are not man-made, i.e. natural, living creatures, such as entomologic, taxidermic or fossil collections, or inanimate natural objects such as mineral samples. How are these types of HO addressed in different HO classification schemas?

Another major reference for HO is UNESCO. The UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage classifies HO into two broad classes, Cultural Heritage and Natural Heritage. The HO classification established by UNESCO World Heritage Conferences are further synthesised by many scholars (Hua, 2010; Kurniawan et al., 2011; Petti et al., 2020) into the following subclasses: Cultural Heritage is subdivided into Tangible Heritage and Intangible (Immovable) Heritage; this last sub-class is subdivided in Tangible Cultural Heritage and Intangible Cultural Heritage (Isa et al., 2018). As previously mentioned, this last subclass is of special interest, as it was a requirement for the extension of the thesaurus.

Other general classification schemas were also examined. Natural heritage objects are addressed in several schemas. *The Art and Architectural Thesaurus* (Getty Foundation, 2016a), from the Getty Foundation, distinguishes between man-made objects and natural objects. The three top terms of the British Museum Materials Thesaurus (2018) are: 'Organic,' 'Inorganic' and 'Processed Material.'

In recent years, the heritage community has emphasised the importance of immaterial heritage. UNESCO broadened the meaning of the term 'cultural heritage,' adding *immaterial heritage*, or 'traditions or living expressions inherited from our ancestors and passed on to our descendants, such as oral traditions, performing arts, social practices, rituals, festive events, knowledge and practices concerning nature and the universe or the knowledge and skills to produce traditional crafts.' Immaterial heritage manifestations pose new challenges to its patrimonialisation as HO due to their procedural or performative character.

Conceptual models such as IFLA's FRBR and LRM and CIDOC CRM provide concepts such as 'manifestation,' defined as 'the physical embodiment of an expression of a work' (FRBR 1998, p.20). Manifestations are especially suitable to conceptualise works of the performing arts (Doerr et al., 2008). Examples follow (FRBR, 1987):

> w1 J.S. Bach's Six Suites for Unaccompanied Cello
>> e1 performances by Janos Starker recorded in 1963 and 1965
>>> m1 recordings released on 33 1/3 rpm sound discs in 1965 by Mercury
>>> m2 recordings re-released on compact disc in 1991 by Mercury
>> e2 performances by Yo-Yo Ma recorded in 1983
>>> m1 recordings released on 33 1/3 rpm sound discs in 1983 by CBS Records

Manifestations apply to works such as the 1970 specific performance by Karl Richter of Bach's Goldberg Variations,

recorded in Munchen, Germany, Plenarsaal der Akademie der Wissenschaften, 4/1970, or the 1957 Maya Plisetskaya performance of *Swan Lake* at the Bolshoi Theatre recorded as a DVD.

'In the case of performing arts, the process of perception necessarily covers in time and space the process of performance: if there is no performer involved in an activity of performance when I am willing and ready to perceive, I cannot perceive anything at all, because there is nothing to be perceived.' (Doerr et al., 2008, p.12). To be memorialised, immaterial heritage manifestations, as well as performative arts, have to be recorded or documented.

The proposed classification schema follows (Marcondes et al., 2016; Marcondes 2020):

– Heritage objects

   – Natural objects
      – Inorganic objects inorgânicos (originally)
      – Organic objects orgânicos (originally)
   – Products of human culture – man-made objects
      – Material objects or artifacts[1]

Here are the 15 categories of the thesaurus, except Category 15 – samples/fragments (Ferrez and Bianchini, 1987). The Material objects or artifacts class holds also an additional class for documents in archives and library collections, Textual documents.

      – Textual documents

         – Large print documents
         – Single print documents
         – Manuscripts
      – Immaterial culture objects (their records)
         – Performance objects of immaterial popular culture
         – Performing arts objects

4.3   Heritage objects and their relationships to other entities

The CRR vocabulary contains the relationships '0021 Created_by,' '0051 Has_Contribution_of,' '061 Has_Subject,' '101 Link_to_Agent,' '0121 Link_to_Event_Process' and '0161 Provenance' between HO and non-HO entities. Such entities and relationships are inspired by the FRBR and LRM conceptual models. Similar relationships can be found in other conceptual models such as CIDOC CRM, BIBFRAME and RiC-CM. The Dublin Core element dc:date may also be used to assign a creation date to an HO. HO and other non-HO entities comprise the cultural heritage landscape, which is of great interest for culture and education. Since the publication of the FRBR conceptual model in 1998, there has been a nascent process for identifying, conceptualising, and formalising digital

representations of entities of interest to heritage and culture. This process has accelerated with the rise of the Semantic Web and LOD technologies. When several heritage institutions such as archives, libraries and museums publish their collections as LOD, and different vocabularies have been developed to support LOD technologies, a comprehensive LOD cloud will develop with a great impact on culture and education. The different culture and heritage conceptual models agree that entities such as agents (e.g., BIBFRAME Agents, CIDOC CRM E39 Actor, FRBR and LRM Agent, RiC-CM Agent), subjects (e.g., BIBFRAME Subjects, CIDOC CRM P 129 is about [is subject of], FRBR Group 3 entities, LRM Res, RiC-CM Subject relations), places (e.g., CIDOC CRM E 53 Place, LRM Place, RiC-CM Place) and time (e.g., CIDOC CRM E 52 Time-span, LRM Time-span, RiC-CM date) exist, which have important and significant relationships with HO by providing context for them. Thus, there are the following relationships between external entities and HO:

- *HO/Agent relationships*: An Agent may be the subject of an HO – 061 Has_Subject – or, in some way, the HO may be associated with an Agent as the 0021 Created_by, 0051 Has_Contribution_of, or the most generic 101 Link_to_Agent (HO is associated with an agent).

- *HO/Subjects relationship*: A HO has a subject, Id: 061 Has_Subject.

- *HO/Places relationship*: A HO has as a subject a Place, Id: 061 Has_Subject, or a HO is associated to a Place as contextual information, Id: 0001 Associated_with, Id: 0161 Provenance

- *HO/Date-event relationship*: A HO has a date property, dc:date; a HO has as subject a date, Id: 061 Has_Subject, or is associated to a Date as contextual information, Id: 0001 Associated_with, the 0121 Link_to_Event_Process relationship.

4.4   Heritage objects according to their expression form

An additional complication associated with integrating a comprehensive digital heritage collection classification schema is associating each class with a property, along with identifying the possible expressions of each.

Types of expressions proposed for HO are: 'three_dimensional objects (perceived mainly by sight and touch: physical objects such as a sword, a chair, a sculpture), two dimensional objects (perceived mainly by sight: objects frequently classified as iconography such as a painting, a drawing, an engraving, an illustration, a poster, a photograph, maps), text_objects (perceived mainly by sight: books, letters, manuscripts), moving_images objects (perceived mainly by sight: films), sound objects (perceived mainly by hearing: recorded music), three_dimensional_image objects (perceived mainly by sight: photogrammetry images)' (Marcondes 2020).

The schema integration is shown in Figure 1.

Figure 1 Heritage objects and their relationships with other entities
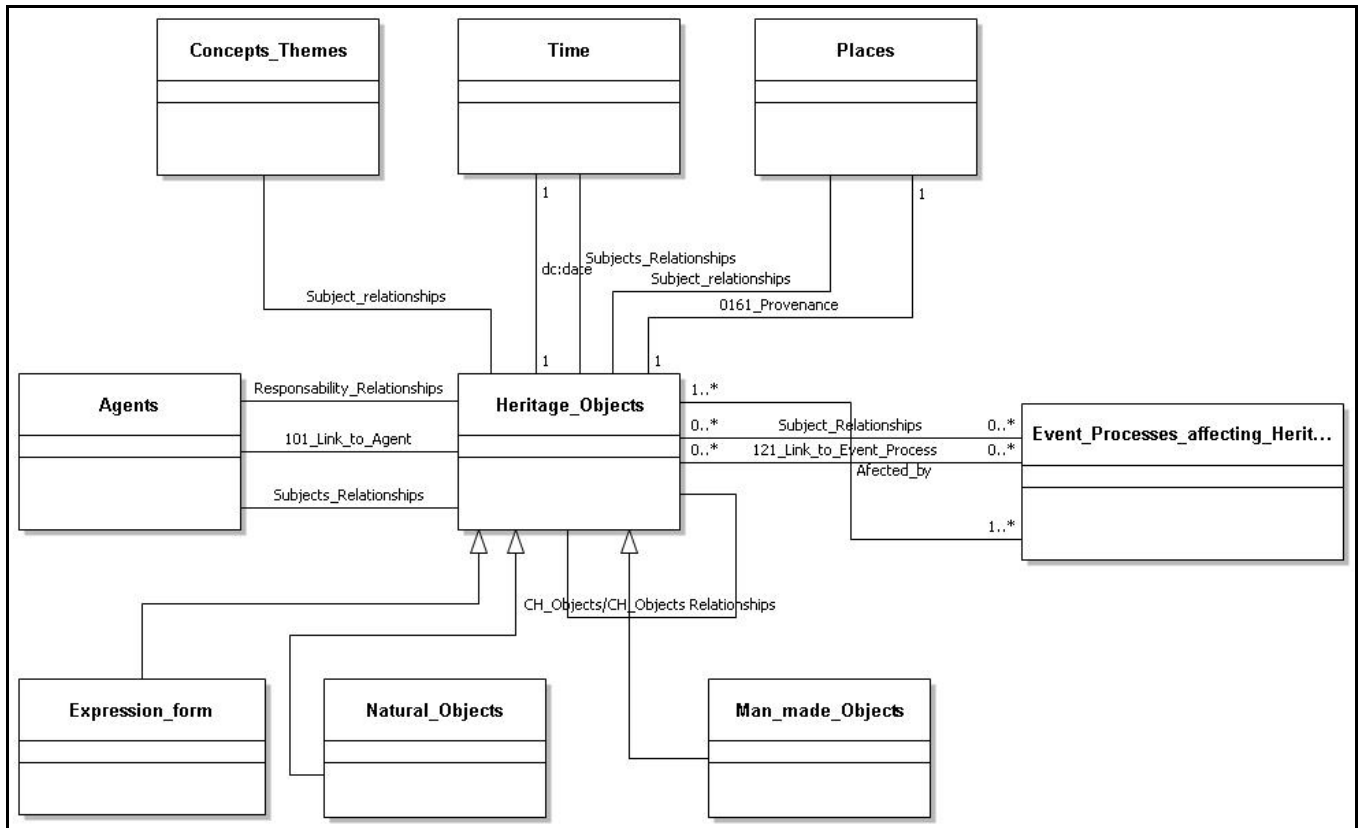
5 Conclusions

Once the class 'material objects or artifacts' has a precise ontological definition, different specific schemas of material objects or artifacts can be subsumed into this class to accommodate specific domain needs without losing compatibility with the general classification schema.

There is also a need for agreed-upon classification schemas for HO like historical and geological periods and art movements.

Most historical period classification schemas are specific or regional (see Cultural/Historic periods 2019; Misra, 2001; Prehistoric Art Wikipedia, n.d.; Foor, 1985), as are the art movements (see Classical, Modern and Contemporary Movements and Styles, 2019), and their chronologies (see Art History Timeline: Western Art Movements and Their Impact, Getty Foundation, 2016b). To interlink and integrate cultural heritage objects of different kinds and originating from different heritage institutions, general and agreed-upon classification schemas on different topics are needed. To arrive at such classification schemes, coordination, debate and consensus are necessary. Yet there is no requirement that such alignment must be achieved; vocabularies are very important to reach such objectives. Vocabularies within LOD technologies that cover such themes may be established and partial agreement may be reached. The publication of HO collections over the web is an iterative process.

This paper proposed two vocabularies: a Culturally Related Relationships (CRR) vocabulary and a type of HO classification schema, aimed at providing structure, semantics and context to heritage data published as LOD. Both vocabularies must be tested and enhanced to reach their full potential. The proposals in this work are unfinished ideas to be discussed and improved upon by the curatorship community of collections of memory and culture.

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Note

1 The 15 categories of Thesaurus for Museological Collections (Ferrez and Bianchini, 1987) that fall within the category 'Material objects or artifacts' are not exactly suitable for HO objects/products in fine arts and crafts. More suitable categories or classification schemes could be included in such categories.